Department for
Business, Energy
& Industrial Strategy

Towards Fusion Energy

The UK Government's response to the consultation on its proposals for a regulatory framework for fusion energy

Annex A – Consultation Responses

June 2022

© Crown copyright 2022

This publication is licensed under the terms of the Open Government Licence v3.0 except where otherwise stated. To view this licence, visit nationalarchives.gov.uk/doc/open-government-licence/version/3 or write to the Information Policy Team, The National Archives, Kew, London TW9 4DU, or email: psi@nationalarchives.gsi.gov.uk.

Where we have identified any third-party copyright information you will need to obtain permission from the copyright holders concerned.

Any enquiries regarding this publication should be sent to us at:
fusionregulation@beis.gov.uk

Contents

1. Overview

This annex supplements Towards Fusion Energy, The UK Government’s response to the consultation on its proposals for a regulatory framework for fusion energy, available at: www.gov.uk/official-documents

The Government is grateful to all respondents to the consultation.

All responses to the UK Government’s consultation on fusion regulation with permission to be published are included in this annex. The responses are published exactly as they were received.

Responses that provided individual answers to the consultation questions are included in Section 2. All other responses to the consultation are in Section 3.

Individual respondents are not named; their responses are in the ‘responses received from individuals’ section. Responses from respondents who asked for their response to be shared without identifying information are found in the ‘anonymised responses’ section.

2. Responses to consultation questions

2.1 Groups

Assystem Energy and Infrastructure Limited

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

The report addresses all of the critical areas for a fusion regulatory framework. Assystem would like to see the UK take a leading role in shaping the international regulatory framework to promote alignment, and ideally adopt international standards.

The IAEA and NEA are progressing in this area. The IAEA is expected to publish an initial Fusion safety standard draft in 2025 – see https://nucleus-new.iaea.org/sites/fusionportal/Shared%20Documents/DEMO/2021/13.Vives.pdf

This approach has been successfully adopted in other highly regulated industries such as aerospace, enabling international collaboration and export markets to develop.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Don't know

The regulatory framework references a report by the UKAEA ‘’ Technology Report –Safety and Waste Aspects for Fusion Power Plants’’ as their main supporting evidence for developing the three hazard scenarios. The accident scenario modelling supports the view that there is a low risk of moderate to high radiation exposure.

However, there are additional hazards in a fusion plant, which are not acknowledged in the UKAEA’s report. Sources of hazards can be

- extensive use of lithium – which can cause fires and explosions
- human errors during normal operations or maintenance
- unexpected coincidental failure of multiple radiation shields
- external hazards like flood or fire affecting plant systems and operations.

The hazard analysis should also consider accidents occurring during operational phases with reduced confinement barriers available. For example, during planned maintenance when the first confinement and cryostat barriers are not active.

In addition, there is uncertainty on the inventory of radioactive nuclides in a full-sized fusion plant, which will depend on the structural materials, the type of breeder blanket and cooling systems and the size of the fusion power station.

Assystem believes that the UKAEA should present the sources of uncertainty in the current hazard analysis. This might include developing a simple probabilistic scenario to quantify the uncertainties around the hazards.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

The existing regulatory approach is pragmatic. However, relevant expertise and learning must be captured from both the nuclear and other highly regulated industries.

The ONR has extensive experience managing radiological hazards including non-fissile materials, which can be leveraged to support the development and governance of fusion regulations.

If there is a time lag in developing specific regulations for fusion then the industry may default to following existing regulations from fission nuclear. This could drive cost and/or set precedence that influences design decisions during the critical early phases of the projects.

. The government must carefully consider the two risks:

- Risk of the duplication of effort – as the design and planning of full-scale fusion power stations develop, it is likely that the process for gaining consent and permission to build and operate a station will increase in complexity. There is a risk that developing tailored processes and training regulators to oversee the fusion industry regulatory framework would in effect constitute a duplication of the capabilities already available at ONR, delivering poor value for money for the taxpayer.
- If there is a lag in adapting the existing regulatory framework as the fusion plant design develops, there is a risk of designers and manufacturers defaulting to nuclear fission standards and regulations to ensure their project is able to progress and to limit the risk of dealing with underdeveloped regulatory framework.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

Assuming the hazard analysis is appropriate and that the inventory of radionuclides at the site will be fairly low then the current approach is fit for purpose. The risks of this approach are outlined above.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit

of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

Assystem believes that fusion power plants should not be considered under the Nuclear Installations Act 1965 as long as the overall amount of radionuclides at the site does not exceed the bulk quantities that would cause the site to fall under the Act. Fusion can still benefit from adopting ONR best practice, for example, using a graded approach that should be used by the fusion regulators.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

The Government’s proposal of an application of regulatory justification that covers the generation of net energy from fusion (including H2 generation, electricity generation or generation of high-grade heat) devices is sensible.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

Adopting a legislative approach to clarify that nuclear fusion plants will not fall under the Nuclear Installations Act would provide confidence and certainty to UKAEA and the private sector fusion developers.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

The establishment of a Fusion NPS would align fusion plants with other power generating plants and make clear that government is supporting the development this unique source of low carbon energy generation.

9 What other issues should a Fusion NPS address?

Nothing to add.

10 Do you believe that a third party liability regime is required for fusion?

Don't know

If there are no credible accident scenarios for a catastrophic incident then it could be argued that there is no need for the Government to act as the insurer of last resort.

However, for the first generation of commercial fusion power plants it may be difficult to obtain commercial insurance due to the unproven nature of the technology and potential accident scenarios.

Assystem would like to see developers of fusion technologies and the insurance industry engage and collaborate to determine the appropriate liability regime.

11 What are your views on the principles and issues around third party liability as set out in this paper?

Assystem believes that it is too early in the development of commercial fusion to define a liability cap or to define whether the intermediate or low-level categorisation applies. If the government were to make a decision on the maximum value of the liability cap in the next two to three years, they should be open to review every five years as the technology evolves.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

For the first generation of commercial fusion plants loss of the asset (investment protection) is likely to drive insurance risk appetite and cost as much as potential safety hazards. For any experimental technology the risk of an accident, which renders the plant inoperable, but not unsafe, will be a key factor in the commercial viability of the plan and the cost of insurance.

13 How can the Government promote the development of suitable commercial fusion insurance?

Significant learning can be taken from existing insurance markets for large-scale new technology projects including nuclear new build, commercial aircraft, and new energy technologies such as hydrogen generation.

The Government must also encourage the fusion industry to show that exotic risks like radionuclides or loss of control of plasma have been fully understood and have been reduced to levels consistent with conventional plant.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

Fusion power plants should be subject to a high level of cybersecurity regulations, both for protection of the asset itself and to protect IP during the development phases.

Even for low energy / experimental fusion plants security of information is key to protecting the asset itself and any IP.

15 What in your view should cyber security regulations for fusion cover?

The UK has a well-established cyber security set up, which should be easily transferable to the fusion industry. The cyber security regulations must be fit-for-purpose and proportionate to the consequence of a data loss/breach.

Protection of UK-owned IP will be an important requirement for cyber security, in addition to the protection of sensitive information such as potential dual-use technologies.

It is likely that fusion will require the adoption of emerging technologies such as Artificial Intelligence and big-data management. The cybersecurity regulations should take into account the potential evolution of the project information during the potential 50+ year life-span of a project.

The cyber security regulations for fusion will need to evolve during the lifetime of any respective project.

Aggressive and thorough implementation of functional safety protocols, taking explicit account of cyber security risks should be enforced.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

Facilities that produce more than 50 MWth of energy or handle over 7*1016 Bq of tritium should be classified as power generating facilities rather than R&D facilities and therefore:

- have early engagement with the regulator during the design phase
- comply with cyber security regulations
- be classified as NSIP in England and therefore use the NSIP route to obtain development consent.
- be subject to the third-party liability cap

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

Early engagement between regulators and developers allows developers to tailor their design solutions to the UK regulatory environment, thereby reducing the need for redesign and review.

A formal engagement plan allows for a reduction of uncertainty in the timings and manners of regulatory input. This allows developers to plan and prepare for regulatory scrutiny and adapt the design to regulatory input. It reduces uncertainty from a project management and project finance perspective and enables engineers and designers to adjust their design.

18 What are your views on how such engagement should work?

Fusion developers should engage directly with the regulator(s) early in the concept phase to agree the overall approach to demonstrating regulatory compliance.

This is particularly important for the first generation of fusion power plants where the regulatory environment will be evolving in parallel with the project development. Clear communication and seeking the engagement of developers in the formation of new fusion regulations is key.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

The overarching regulatory guidance document will be useful and it should

- provide international context for the fusion regulations, explaining why the UK has made different choices from other countries.
- clarify which of the existing relevant regulations are applicable to fusion power plants (this includes design, building, operations and decommissioning),
- clarify which bodies are responsible for the oversight - explain at what points of the lifecycle of a fusion plant the developers/owners are expected to interact with the regulators,
- clarify the timeframe for regulatory framework review

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

Current best practice of voluntary engagement adopted by the wider nuclear industry is sufficient at this stage for ensuring public engagement and response. The Government should not mandate additional public engagement.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

The EA and HSE could develop a similar up-skilling scheme to how the ONR trains regulators in fission nuclear, leveraging expertise from UKAEA and industry fusion safety specialists to develop and deliver training.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

UKAEA should engage directly with the regulator as both the leading authority in the UK on fusion technology and as the current developer for the STEP project.

The regulator should engage with private fusion technology developers to ensure the regulatory regime covers all viable fusion technologies currently under development.

The regulator should also engage directly with fusion safety specialists who are wholly independent of UKAEA and the other developers, for example from industry and academia.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

It is expected that fusion power plants will produce intermediate and low-level waste. A certain level of reprocessing of waste will be needed to ensure that radionuclides are stripped from activated materials and components.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

It is anticipated that that radioactive waste from fusion should be treated and managed as with the same approach used for intermediate and low-level radioactive waste produced by other facilities. As the nature and amount of waste produced by mature fusion power plants is still unknown, Assystem believes that the Government should set an expectation that all the waste will be disposed in near surface disposal facilities.

25 What are your views on how a fusion facility should be decommissioned?

As for new nuclear facilities, new fusion facilities should also have to include plans for decommissioning and waste treatment in the design phase. A plan for funding decommissioning should also be included in the design phase. I don't think decommissioning of fusion nuclear facilities should differ from those of other nuclear facilities that have produced the equivalent type of waste during their lifecycle.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

The decommissioning of fusion power plants should not differ from decommissioning of any facility producing the same type of waste. The government should avoid duplication of effort in this area and should ensure close co-operating with the fission nuclear regulator and industry in this area.

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

Assystem believes that the current Government proposal is sensible.

28 What should the Government consider when developing guidance for export controls and technology licensing?

Assystem believes that a 10-year time frame for reviewing the regulatory framework is too long due to the current state of rapidly evolving technology. As many concurrent technological advancements will be required to deliver the first new fusion power plant, Assystem expects that the safety framework will be tested and become needed in the latest design phases, in the construction and the first years of operations. Assystem recommends that a light touch review should be performed every five years. The five-year review should consider whether in depth changes to the framework will be required to ensure safety following new technological updates or if the existing framework is still fit for purpose.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

Supporting and pushing for a harmonising of regulations internationally by increasing the involvement with relevant international agencies (IAEA, NEA).

Supporting the development of internationally accepted quality standards for the fusion supply chain. This would encourage the development of a UK based supply chain which can also supply international clients.

Supporting UK supply chain development of expertise in fusion regulations to support UK and export projects.

Ensure fusion regulations are flexible to cover all viable fusion technologies under development. While the technology differs between for example internal fusion and magnetic confinement, the fundamental regulatory, export and safety objectives are the same.

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

Atkins

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

The UK government should consider regulations around sustainability, perhaps specifically for fusion facilities. Given the proposed regulatory regimes proposed in this paper and foreseen to ensure the safety of fusion facilities, then legislation needs to be considered related to how regulatory oversight will be paid for. As has been proposed for other aspects of the Net Zero transition in the UK, financial regulations and business case models need to be clarified given the significant investment required for fusion facilities. The government should assess whether existing financial regulations and business case models for nuclear and renewable facilities actually encourage the level and speed of innovation required to make the successful transition to Net Zero by 2050. Learning lessons from those industries' financing and business models should happen very quickly in order to facilitate development of fusion facilities.

Regulations related to the disposal of wastes, specifically radionuclides, should be reviewed and updated to facilitate fusion. An activity based disposal requirement, as is currently the case, may create unnecessary burdens and may preclude regulation and policy that enables and encourages innovation, which in turn will be seen as barriers to investment given the potentially prohibitive backend costs that need to be accounted for early in project development. The adoption of the EU Basic Safety Standard Directive related to wastes may provide a more enabling framework, allowing disposal according to nuclide rather than activity.

The development of fusion facilities will be a long term process, happening over the next 30 years before fully operational facilities are realized. Although not necessarily related to regulation, additional guidance is needed given that long time horizon on the application of BAT and ALARP requirements throughout the design development, approval process and life of the facility. As this fledgling technology develops and progress is made, we must be wary of "moving the goalposts" during this 50-80 year timeframe. Lessons can be learned from other international regulators with regard to this issue (e.g. "backfitting" in the US, and the concept of "safe today, safe tomorrow").

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

It is clear that for operational hazard cases there is the potential for offsite releases and even an EPZ, albeit potentially relatively small. Fundamentally, this potential for offsite release dictates a higher regulatory regime. We would tentatively agree with the bounding cases proposed for fusion facilities, particularly for operational cases. We also recognize that there are still design decisions to be made for fusion facilities that would impact the scale of the potential release, so these estimates need to evolve in line with design evolution. Indeed the design should be iterated based on the release calculations.

However, we would make two additional points:

- We would expect some more detailed assessment on the potential of loss of waste inventory/storage, if only to demonstrate the scale of that hazards relative to operational hazards. We would suspect the loss of storage is of significant interest to the assessment of environmental consequences, and therefore equally important as operational cases.
- While we recognize that the design of fusion facilities is in the very early stages, it does still seem like the non-nuclear hazards posed by a fusion facility are not being given sufficient attention—indeed less than half a page of 101 pages of the UK government's white paper is used to discuss non-nuclear hazards. It is recognized that the UK does have the knowledge and experience to deal with the individual hazards expected (toxic materials, extremely high temperatures, extremely low temperatures, etc) . However, the combination of these individuals hazards within one facility as in a fusion facility will be new and there will be the potential need for trade-offs in terms of protections. Extremely clear policy, regulatory positions and guidance are necessary in the case of trade-offs, so it is imperative to understand these non-nuclear hazards in combination.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

We fundamentally agree that a new regulatory regime is not required for fusion. The existing approach has been successfully (ie no major incidents) applied to fusion facilities in the UK. As suggested in the white paper, further clarifying legislation and guidance is still necessary, but the overall regime is appropriate for the hazards as we currently understand them.

Our organisation has supported vendors and developers of both fusion and fission facilities in the UK and overseas, including the ITER project. This experience has given us useful insight into what works and doesn't work in terms of enabling projects and realizing projects. In many instances, the nuclear fission regulatory regime has played a significant role in the delay or failure to deliver major Net Zero infrastructure in the UK.

Finally, a word of caution: the UK government must not forget lessons learned throughout history. Specifically, there is a cautionary tale from the USA in the early development of commercial nuclear fission reactors in the 1970s. There was obviously a rapid development of technology at that time, along with equally fast paced commercialisation goals. The pendulum at that time was on the side of commercialisation so legislation and regulation were light, which tried to serve an apparent self-conflicted mission of fostering commercialisation of rapid technology development that is "safe enough". The unfortunate result was a series accidents and significant events that resulted in the pendulum swinging to the opposite side, which many people see as stifling further development of the industry.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

The IRR and EPR legislation and enabling regulations theoretically provide for proportionate consenting and permitting. However, as discussed, further clarification and guidance will be necessary to ensure the pragmatic application of these for fusion facilities.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

We think fusion facilities should not be considered “nuclear installations” under NIA 1965. As discussed above, the existing regime for regulating fusion is sufficient when considering the hazards as discussed in the white paper. Oversight from the ONR would be unnecessary (apart from transport and safeguards) given the relevant history and experience EA/HSE have in oversight via the enabling legislation for fusion.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

We agree with the Government’s proposals in relation to the regulatory justification of fusion. We particularly agree with the approach of “generation of energy” rather than the historical “generation of electricity”. In our work with UK AEA and other fusion vendors, we see multiple commercial pathways for fusion that do not necessarily include production of electricity. Where possible in terms of hazards, the Government should strive to have a justification that is generic for fusion, covering the different potential technologies.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

No

Preferably, a legislative approach would not be needed for this clarification. It is understood that while a legislative approach will provide clarity, it also potentially politicizes the issue. This of course creates additional uncertainty, and the potential for this technical clarity to be tied to, or held hostage to other issues that are not as technical. Avoiding further legislation, while providing clarity in other ways would be preferred.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

We agree with the proposal to establish a fusion NPS to facilitate the development consent for new facilities. It seems likely that the development consenting process for a new large fusion facility will be the “critical path” of any new development and require the biggest investment prior to final approvals. Therefore, it is imperative that the UK GOV enable expediting the process in order to meet their stated goals related to innovation.

9 What other issues should a Fusion NPS address?

In relation to question 7, the Fusion NPS could directly address the issue of nuclear site licensing requirements for fusion facilities. This seems like a more appropriate route, and will also allow for public consultation on the issue, which may be better than the legislative process.

10 Do you believe that a third party liability regime is required for fusion?

Don't know

While we understand the importance of the insurance issue, we do not have strong views. It would seem logical that fusion be treated, from an insurance perspective, in the same ways facilities that have similar hazard/risk profiles. Our opinion is that those profiles are not different from nuclear fission.

11 What are your views on the principles and issues around third party liability as set out in this paper?

see above

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

see above

13 How can the Government promote the development of suitable commercial fusion insurance?

see above

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

Our view is that fusion facilities should not be treated differently from other non-fission, critical infrastructure facilities in terms of cyber security regulations. It is likely the fusion facilities will be classed as “critical infrastructure” due to the potential reliance on the output of those facilities for the basic needs of the country. They should therefore be regulated as such.

15 What in your view should cyber security regulations for fusion cover?

see above

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

We agree with the definition proposed by the government. The explanation seems reasonable. However, where vendors/developers of facilities do not meet this definition, it should be clear that they would also be entitled to receive and/or participate in enhanced regulatory engagement. Returning to the first question, this question should be clarified in legislation/regulation related to offsetting the costs of this regulatory engagement.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

We agree that there should be formal engagement between developers and regulators during the design process. However, this engagement must be clarified to a much greater degree. This engagement has to be relied upon by the developers to reduce overall regulator burden and particularly reduce downstream regulatory risk. This has not always been true in a variety of industries in the UK. As suggested before, further clarification and guidance related to BAT/ALARP will be necessary along with the clarification on this formal engagement process. And again, the long time periods for the implementation of fusion will require the appropriate recording of engagement and decisions to ensure certainty and reduce risk to developers. The regulatory engagement process should strive to make major decisions early in the process to allow developers to proceed at the pace needed to increase the chances of success.

18 What are your views on how such engagement should work?

see above

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

We support additional guidance development for application of existing regulation for fusion energy. We have already suggested further guidance development on the regulatory engagement process and application of BAT/ALARP. To improve transparency and enable fusion development, guidance should also be developed that provides specific templates for required submittals, similar to US NRC’s Standard Review Plan (NUREG-0800) and Regulatory Guide 1.206. We would expect that further technical guidance would be developed specific to fusion, similar to TAGs and ACoPs, and that TAGs, ACoPs and other existing guidance would be reviewed to determine applicability to fusion facilities, with amendments as required. Specifically, new guidance related to tritium management and handling will be important for fusion facilities.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

If yes, what are your suggestions for how this could be achieved:

We think the government should clarify what "greater opportunity" actually means. We think the public should be fully engaged in the regulatory process for fusion. The public should be engaged at least for the consultations currently required through existing legislation. However, we think the public should be afforded further opportunity to monitor the process during the intermediate periods. Again, the US can be cited as an example in terms of availability of information provided to the public throughout the regulatory engagement process. We believe the regulators and the developers should provide more information for public consumption throughout the regulatory engagement process so as to support and get the best out of the formal public consultation periods.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Our simple answer: start now!!! The government should invest in building this capability in the regulators now. Investments in recruitment and training for regulators are key to giving the early developers confidence, which then snowballs to other potential developers. There should be a concerted effort to engage in meaningful ways other international regulators. Development of joint training programmes, sharing staff across agencies, more regular interactions can make a difference. In addition, Technical Support Contractors have capability and experience and can support the regulators—this is a model the UK is very familiar with so should have no problem engaging it.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

The Fusion Safety Authority should continue to be developed and receive investment to spearhead the above. The ultimate final state of the FSA could be as a TSC directly supporting EA/HSE under the regulatory regime described in the white paper.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

As discussed in response to question 1, there may be an opportunity to reduce regulatory burden for fusion developers by adopting the EU's Basic Safety Standard approach to dealing with waste, and move away from an activity focused disposal strategy to one that addresses specific radionuclides. As cost is the overarching driver, and the cost of dealing with waste must be included in the overall cost of the facility, fusion developers have the incentives to optimize how they deal with waste. The legislation and enabling regulations should allow this as far as possible, and not put up unnecessary constraints.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

No

We do not believe Government policy should reflect an expectation that waste be disposed in near-surface disposal facilities. Government policy should not put unnecessary constraints on developers. If it is optimal to dispose of waste at other than near-surface facilities, then developers my face unnecessary hurdles to optimizing their facility. We think the cost drivers sufficiently incentivizes developers without the need for government policy statements in this case.

25 What are your views on how a fusion facility should be decommissioned?

We think existing regulations and guidance for decommissioning similar facilities is sufficient for fusion facilities. Appropriate consideration of decommissioning during the design process should be demonstrated, in a proportionate way, particularly given the long time frames and future development of fusion.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

As no one has dealt with waste or decommissioned fusion facilities up to this point, any guidance must be flexible. Not only does the guidance need to be flexible, but also the regulations and regulators responsible for looking at waste disposal and decommissioning. There is significant uncertainty related to these topics so all parties must remain open-minded so as not to introduce constraints unwittingly.

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

We agree with the Government related to safeguards. No new regulations seem to be required, and ONR as the most competent authority is in good position to be accountable. One alternative proposal could be that part of the ONR's safeguarding function/resources be transferred to HSE to account for safeguarding directly within in a single regulatory body. We believe a similar transition has occurred in reverse with regard to conventional safety at new nuclear fission power plants, whereby HSE detailed/transferred staff directly to ONR to provide the review of conventional safety submissions.

28 What should the Government consider when developing guidance for export controls and technology licensing?

The government should consider the burden of accounting for export controls within the supply chain, particularly when the supply chain includes organisations outside of the UK. Gaining licenses to facilitate the export of information and technology can take significant periods of time due to the requirement of G2G engagements. In our experience in nuclear fission on export controls, very little of the nuclear fission plant technology is technically export controllable, but vendors and developers take very conservative positions with regard to exporting information and technology and generally overclassify, increasing the burden. Very clear guidance with extensive specific examples should be given by the government after engaging with other governments.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

Of course keeping the proposed approach for fusion under review is sensible. Considering the time horizons of realizing fusion facilities, this is the appropriate position so learning from developments in the UK and other countries can be accounted for.

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

35 What is your country's / organisation's planned approach to regulating fusion energy?

As a UK organisation, we will comply with the laws, regulations and guidance in the UK. Our business is also working on fusion developments around the world and will comply with law, regulations and guidance relevant to those facilities. As such, and to support the export of fusion from the UK around the world, it is extremely important for the UK Government to work with other governments around the world to ensure consistency in approach to facilitate our business success.

Clean Air Task Force

1 Are there other critical regulatory areas that the government should address when considering the regulatory framework for fusion energy in the U.K.?

The regulatory framework touches on this, but it should be emphasized that waste generation and disposal needs must be well understood and dealt with up front – not just for the DT tokamak/STEP concept but for other fusion technologies, as well. Another question is whether the U.K.'s proposed approach of focusing on STEP will deter the developers of other, potentially less hazardous/lower waste producing fusion concepts.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

DT concepts involve radiation and ILW issues, which the framework recognizes. Additionally, the use of Li-6, deuterium, and tritium for fusion energy production is not without non-proliferation considerations. That said, the framework's intention to keep the current regulatory framework in place for STEP makes some sense, so as not to lose expertise, and to the extent that STEP is more potentially hazardous than other fusion options under consideration (aneutronic concepts relying on other substances), it also makes sense so as not to discourage development of those alternatives as well.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Please see answers 1-2 above. CATF agrees with the arguments made in the report for staying with expertise developed over years among the regulatory players. It also makes sense to pull all fusion energy requirements under a new guidance document. Shifting responsibility to the nuclear regulator does seem unnecessary.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

CATF has nothing to offer on this.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Please see our answers above at questions 2 and 3.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

CATF agrees that this technology should be justified, particularly as a power source, as the costs will be transferred to ratepayers, and the benefits should be quantified.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site license would not be needed for fusion power plants?

CATF has nothing to offer on this.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined above?

CATF agrees that fusion energy plants with energy output over 50 MW are significant infrastructure projects, and that it is appropriate to consider them that way. We understand that establishing a National Policy Statement (NPS) published by the U.K. Government would streamline that process by setting out all of the Government's policy on, and establishing the need for fusion energy. A Fusion NPS would enable applications for a development consent examination to focus on specific planning issues, not on broader policy questions such as whether there is a need for such infrastructure. We are of the view that the need for firm, zero-carbon energy resources in response to the climate change crisis is itself a justification of need.

9 What other issues should a Fusion NPS address?

It is important that the NPS not be limited only to STEP technology but also other potentially less hazardous, although less-well developed, concepts.

10 Do you believe that a third party liability regime is required for fusion?

CATF agrees that it is important that the fusion operator bears some responsibility for any problem/accident that may arise, and that the costs of insurance should be related to the extent of the potential damages.

11 What are your views on the principles and issues regarding third party liability set out in this paper?

Please see our response to question 10 above.

12 What issues in addition to those described in this paper should any fusion third party liability regime address?

Liability for waste disposal.

13 How can the Government promote the development of suitable commercial fusion insurance?

CATF has nothing to offer on this.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Any facility that involves nuclear material should be subject to cybersecurity rules.

15 What in your view should cyber security regulations for fusion cover?

CATF has nothing to offer on this.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

CATF's view is that it is important that whatever the U.K. Government does here does not provide a disincentive to those looking beyond tokamak/STEP concepts to other technical approaches to fusion energy that are potentially less hazardous. It should be very clear that the U.K. Government hasn't made a technology choice by supporting STEP.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes, as both developers and regulators will be learning while doing with this new technology.

18 What are your views on how such engagement should work?

CATF has nothing to offer on this, not having sufficient understanding of how these relationships work in the U.K. presently.

19 Do you agree that additional guidance should be developed on fusion energy regulation?

CATF agrees that it will be beneficial to have all the environment, workplace health, and other regulatory requirements relevant to fusion energy production available together under one cover.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion? If yes, what are your suggestions for how this could be achieved?

CATF has nothing to offer on this, as answering this question requires more knowledge of the U.K. Government's standard setting process than we have.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

By working with researchers and developers of the prototypes, and then being involved as projects move forward.

22 What are your views on how the technical expertise of U.K.AEA could best be used to support the development of a regulatory framework for fusion energy in the U.K. and around the world?

CATF has nothing to offer on this.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

ILW needs isolation for 100 years, and LLW volumes from fusion energy production will not be insignificant and should be estimated and sufficient proper disposal sites identified, and, if need be, permitted.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

CATF strongly agrees with the statement in the framework report that says: "There should be an emphasis on designing fusion power plants with radioactive waste management and decommissioning in mind from the outset, and, as with any energy generating plant, a funded plan for decommissioning would be expected before any application for [] development consent...."

25 What are your views on how a fusion facility should be decommissioned?

CATF has nothing to offer on this.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

The guidance should be comprehensive, including all aspects of fusion energy regulation and direction, from development through retirement and waste disposal.

27 Do you agree with the Government's proposals on safeguards for fusion?

Please explain your response. Currently the most advanced fusion energy options use Li-6, deuterium, and tritium in relatively large quantities. There are supply, use, and handling issues related to these substances, which are currently export controlled and produced largely for non-civil applications. Those issues must be addressed, and not minimized.

28 What should the Government consider in developing guidance for export controls and technology licensing?

CATF has nothing to offer on this.

29 Do you agree with this proposed approach for keeping the fusion regulatory framework under review?

A review at least every 10 years seems about right, beginning at the point when STEP is online.30.Do you believe there is anything else the Government should consider in regard to fusion energy regulation? CATF has nothing further to offer at this time.

31 Before today, how much did you know about fusion energy?

A. Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the U.K. developing this technology?

E. Support

33 What is your level of knowledge about fusion after reading this paper?

A. Knew a lot

34 What is your level of support for the development of fusion energy technology in the U.K. after reading this paper?

E. Support

Committee on Radioactive Waste Management (CoRWM)

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

CoRWM considers that government has identified the critical regulatory areas of importance to fusion energy in the UK.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

CoRWM is in agreement that the currently identified / known hazards of fusion energy are as not the same as those of nuclear fission. It would appear that Beyond Design Basis (catastrophic) Accidents are not considered feasible at the present level of knowledge. However, it is felt that it is best practice to keep an open mind and keep the technology and its regulation under review. Of significant importance here is the potential need for a liability management / insurance scheme to provide investor and commercial confidence that a "belt and braces" approach is in place to protect their interests as the technology develops and matures.

CoRWM notes the reasonable use of representative worst case and a hypothetical catastrophic accident scenario in evaluating the expected hazards of fusion power plants, given the significant uncertainty around the radiological inventory. Nevertheless, CoRWM is of the view that public confidence in regulating the hazards of fusion power plants will be strengthened by evaluation of more realistic accident scenarios.

Further comments specific to radioactive waste management are given below.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

CoRWM considers that it is not necessary to make a decision to alter the approach at this relatively early point in the development of fusion energy technology. CoRWM is of the view that it is better to maintain current approaches that command public and key stakeholder confidence as and until the level of uncertainty about the risk profile of fusion technologies is better understood. Notwithstanding, the full nuclear regulatory regime currently applied to nuclear fission technology may prove to be overly burdensome in the long term, given the likely level of potential hazard presented by fusion energy. However, it is too early and arguably unnecessary to make that determination at present.

CoRWM opines that public and investor confidence is an important consideration. The significant "big picture" potential societal benefits of fusion technology – in sustainable energy provision; in underpinning action to reduce greenhouse gas emissions and the rate of global warming, and hence climate change; and in the potential for the UK to take the lead in an international market in fusion technology; would appear to justify maintaining trusted regulatory approaches in the medium term. The current approach to nuclear regulation relies upon an established system of nuclear liability insurance and an independent regulatory regime that underpins public assurance and reassurance, and investor confidence. Regulator competence and independence from the technology provider / system operator is also fundamental to that process.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

CoRWM recognizes that IRR 2017 and EPR 2016 provide an option for regulation of fusion power plants but believes that the government should keep their options open for managing future hazards from fusion appropriately.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

CoRWM emphasises its advice that the risks of nuclear fusion technology need to be seen to be managed carefully, openly and by public bodies that are accountable and carry public and investor confidence. Seeking to disassociate fusion energy from nuclear fission by defining fusion power plants not as nuclear installations but as some other category of installation could be interpreted as attempting to loosen controls prematurely and for the wrong reasons.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

CoRWM considers that the regulatory justification process is essential. We know there are huge potential benefits associated with fusion energy, but the full costs and long-term risks are less well understood. In other words, the societal risk / benefit trade-off needs to be fully investigated through a risk / benefit informed process. Concrete questions remain regarding the future implementation of the technology. With regard to waste products, a full assessment of the management options, including possible consignment to a Geological Disposal Facility, should be part of that justification process.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

CoRWM believes a legislative approach is important for reasons of clarity and to avoid parliamentary, media and public misunderstanding. Sufficient and transparent regulation is important for public confidence and that can be provided without recourse to requiring a nuclear site licence. However, we would caution against making premature decisions, because current licensing arrangements are well understood. This a matter for future establishment of facts and arguments regarding the societal advantages and disadvantages of nuclear site licensing.

CoRWM notes that other major industrial countries are considering the most appropriate form of regulation for fusion power plant and this offers the potential to inform UK decisions. There may also be lessons from decisions in other countries on liability.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

CoRWM agrees with the proposal to establish a fusion energy NPS. We believe it is essential to give careful thought as to what this says about radioactive wastes, and how that fits into an overarching policy.

9 What other issues should a Fusion NPS address?

CoRWM advises that the fusion energy NPS should consider the whole “nuclear island”, since the breeder and fuel production plants are an integral part of the fusion power plant.

10 Do you believe that a third party liability regime is required for fusion?

Yes

CoRWM has emphasised the importance of investor confidence. It is possible that a lower intensity liability regime – to reassure foreign vendors – may be appropriate but this requires careful prior investigation and appraisal.

11 What are your views on the principles and issues around third party liability as set out in this paper?

CoRWM agrees with the consideration of decommissioning and radioactive waste management within the proposed nuclear fusion NPS. This may be an issue for third party liability.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

CoRWM suggests that it would also be appropriate to consider issues of commercial viability.

13 How can the Government promote the development of suitable commercial fusion insurance?

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Not Answered

15 What in your view should cyber security regulations for fusion cover?

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

CoRWM considers that an enhanced regime for early engagement between developers and regulators for proposed fusion facilities is highly desireable. It will help to clarify uncertainties as to design, operation and types of hazard. Importantly, it will help to ensure that decommissioning and radioactive waste management are addressed at an early stage of design and minimize the likelihood of costly mistakes. It should also help to give confidence to the public and to investors in the technology. Plainly, the type of facilities subject to such a regime will need to be defined clearly so as to ensure transparency. While the proposed 50 MW / 7 x 1016 Bq Tritium definition seems logical, in terms of what is currently known about the technology, it will be important to keep this under review as any hazards associated with different designs become clearer and as more is known about the types of wastes which these facilities may produce. CoRWM advises that it is important to keep an open mind as to whether scale and tritium inventory are the only factors which may justify early and enhanced engagement, or whether there may be others – for example the radioactivity of components which are to be replaced or decommissioned. For that reason, it would be best if the definition is in policy, rather than in legislation, to allow for relatively easier modification.

CoRWM notes that there may be lessons on enhanced regulatory engagement from other major industrial countries as fusion power plants are developed over the coming decade.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Not Answered

18 What are your views on how such engagement should work?

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Not Answered

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Not Answered

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

CoRWM considers that the expertise of UKAEA places the organization in prime position to help create and lead a strong UK PLC presence in a future international fusion market.

However, CoRWM believes it is important for a UK regulator to have an independent source of technical support. CoRWM notes that the potential for UKAEA to contribute internationally might be limited by the tendency of governments to invest in and rely on their own national institutions.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

CoRWM has recently set out its initial position of managing radioactive wastes from fusion energy, in a Preliminary Position Paper on Radioactive wastes from fusion energy:

https://www.gov.uk/government/publications/radioactive-wastes-from-fusion-energy-preliminary-position-paper

CoRWM is of the view that radioactive wastes from nuclear fusion should be controlled in the same way as all radioactive wastes: they should be safely managed and in a manner that is sustainable in the long term – no matter what the source. The UK policy framework for managing radioactive substances and radioactive wastes should be applied to management of radioactive wastes from nuclear fusion. CoRWM notes that toxic waste streams, in particular significant quantities of beryllium, will also require management in addition to radioactive wastes.

CoRWM emphasises the importance of ongoing research and development to minimise radioactive waste arisings from fusion energy, by reducing activiation through judicious materials design and selection. As part of the application of the broader waste hierarchy, minimizing such waste arisings is of fundamental importance in realizing a safe and sustainable regime for managing radioactive wastes. CoRWM notes that reuse or recycle of radioactive materials from decommissioning of fusion reactors in subsequent systems, within regulatory control, has been proposed, with the intention of waste minimisation. Remote handling and fabrication techniques will be needed if the dose rate or inventory of the materials demand. It is recognised that there is considerable experience and capability in remote handling developed through operation and maintenance of the JET platform, however, it will be necessary to further innovate and optimise such technology for deployment in waste recycle and reuse applications, which may require considerable innovation and prove uneconomic.

Moreover, the materials and design considerations of future nuclear fusion systems have yet to be conceived, and it would be reasonable to assume they will evolve in an effort to improve performance. CoRWM considers that in the absence of enabling technologies and even a conceptual market, reuse and recycle of materials must be considered hypothetical. CoRWM therefore advises that it would be prudent and transparent to plan a baseline scenario of disposal of such materials as waste, if free release cannot be reasonably assumed. Reuse and recycle within regulatory control should only be considered as a viable alternative waste minimisation strategy when any necessary enabling technology is sufficiently mature and there is confidence of uptake as a feedstock for future fusion reactors.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

CoRWM considers this question to be premature. CoRWM emphasises that radioactive wastes should be managed in a disposal setting at a depth and with containment appropriate to their radiological risk. CoRWM notes that there is currently considerable uncertainty in the radioactive waste inventory arising from fusion power plants and that this will be different for different technologies.

CoRWM considers that some radioactive wastes may potentially be suitable for disposal in a near surface facility. However, some key activation products of concern in radioactive wastes from fusion power, such as 14C and 94Nb, are long lived, and should be limited in near surface disposal facilities, given the reliance on engineered barriers to assure containment. CoRWM believes there is insufficient evidence and knowledge, at this time, to assure management of the radioactive waste inventory from fusion energy in only near surface disposal facilities. CoRWM therefore considers that geological disposal may be required for some of the longer lived waste inventory, to provide appropriate isolation and containment at depth. CoRWM advises that consideration will need to be given to the issue of near surface disposal of discrete items, in terms of waste acceptance criteria in the context of human intrusion scenarios. This is because design of fusion reactors for modular assembly and for decommissioning could yield large activated singe items which could be attractive for future recovery, if disposed in a near surface facility.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

CoRWM advises that decommissioning of fusion power facilities should be fully designed and costed in from the outset – including the potential disposal routes. Early discussion with regulators and other key stakeholders should form part of that design process.

CoRWM emphasises that the development of an integrated radioactive waste management strategy has enabled the development of more robust and cost effective decommissioning plans for nuclear fission reactors, through lifecycle management that accounts for the radiological, chemical and physical properties of the waste. This approach has also enabled development of the commercial environment to implement waste treatment technologies required to enable implementation of the waste hierarchy. CoRWM recommends that the development of a such a holistic planning strategy for management of waste from future expansion of nuclear fusion power would be advisable, such that the required waste treatment and disposal facilities can be planned and costed according to the projected volumes of waste arising, and the feasibility of reuse and recycle of activated materials assessed.

This could function as a projected radioactive waste inventory, periodically updated as uncertainties in fleet size, disposition and materials are constrained.

25 What are your views on how a fusion facility should be decommissioned?

CoRWM considers that the regulatory guidance should be clear, succinct, and communicated appropriately to engage public understanding and confidence.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

27 Do you agree with the Government's proposals on safeguards for fusion?

Not Answered

28 What should the Government consider when developing guidance for export controls and technology licensing?

CoRWM agrees that, as a matter of good regulatory practice and engagement, particularly in the context of a maturing technology, that the regulatory framework should be subject to periodic review, consultation, and update.

Commonwealth Fusion Systems

1 Are there other critical regulatory areas that the government should address when considering the regulatory framework for fusion energy in the UK

Commonwealth Fusion Systems (CFS) appreciates that the proposed regulatory framework for fusion addresses health and safety, land use planning, liability and insurance concepts, security, safeguards, and waste management. CFS considers these concepts to be critical to developing a comprehensive regulatory framework for new energy technologies like fusion. As the UK Government refines its proposed regulatory framework for fusion, CFS believes that considerations for efficient interconnection with the power grid and non-power applications of commercial fusion devices like hazardous waste digestion or industrial heat are appropriate. CFS also believes that additional clarity around the scope of environmental reviews for fusion systems in the context of a materials license would assist the regulated community and the general public to understand what to expect during environmental reviews of fusion energy systems.

2 Do you agree with the Government’s conclusions regarding the expected hazards of future fusion power plants?

CFS agrees with the UK Government’s analysis which indicates that expected hazards from fusion energy systems will be far lower than existing nuclear fission power plants. CFS also agrees that the risk profiles presented by fusion energy technologies are in line with risks presented by other industrial facilities, like aviation or oil and gas. Indeed the Fusion Industry Association offered a similar observation in its 2020 white paper Igniting the Fusion Revolution in Americaat page 12.

However, as noted in its cover letter, CFS hopes that the UK Government and the UK Atomic Energy Authority (UKAEA) will recognize that commercial fusion developers are not contemplating fusion systems on the scale of ITER or DEMO. Private fusion developers are using completely different engineering philosophies compared with the ITER science experiment or the DEMO design exercise. Private approaches like CFS's SPARC and ARC projects will use far lower inventories of fuel like tritium as compared to ITER or DEMO (see Attachments 3 and 4). Commercial facilities are anticipated to create far smaller amounts of activated waste as compared to ITER and DEMO. A more detailed discussion of these issues is provided in CFS's cover letter to this response.

There are other designs in the fusion industry that reduce tritium amounts even further by relying on different fuel cycles like deuterium-deuterium, deuterium-helium 3, or proton-boron 11. Finally, CFS agrees that existing nuclear fission regulations are appropriate to regulate fission-fusion hybrid devices

3 Do you agree with the proposal to maintain the existing regulatory approach?

CFS agrees with and supports the UK Government's proposal to maintain its existing regulatory approach to fusion energy systems. The UK has safely regulated fusion energy research and other activities for more than 60 years and the Joint European Torus for 40 years. CFS also agrees with the UK Government's continued use of its "goal setting" approach towards fusion energy systems.CFS particularly emphasizes the importance of permitting approvals early in the planning process, such as environmental permits from the Environmental Agency (EA), in order to minimize regulatory risks to fusion developments. CFS believes that permitting processes that are streamlined and efficient and reflect potential safety hazards associated with fusion energy machines, while still allowing opportunities for public engagement and education, appropriately balance assurances for safety with the need to develop this game changing energy technology.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

CFS is generally comfortable with the approaches taken in the Environmental Permitting Regulations 2016 and Ionising Radiations Regulations 2017. However, CFS has not had occasion to perform a complete review of these regulations as applied to either SPARC or ARC. When, and if, CFS considers a site in the UK for ARC, the company will develop a complete compliance strategy and engage with regulators at the appropriate time.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

CFS does not believe that fusion power plants or any other fusion energy machine should be considered nuclear installations pursuant to the Nuclear Installations Act 1965. According to the statute, a "nuclear installation" refers to a "nuclear reactor" or certain installations that can produce or use atomic energy. A "nuclear reactor" is defined as "any plant (including any machinery, equipment or appliance, whether affixed to land or not) designed or adapted for the production of atomic energy by a fission process in which a controlled chain reaction can be maintained without an additional source of neutrons." The Atomic Energy Act 1946 defines "atomic energy" as "energy released from atomic nuclei as the result of any process, including the fission process, but does not include energy released in any process of natural transmutation or radioactive decay which is not accelerated or influenced by external means."

Even if the fusion process could fit within the scope of these statutory definitions, the text of the statutes make clear that the legislation focuses on fission. And the regulatory system based on these legislative mandates, including oversight by the Office of Nuclear Regulation (ONR), has centered around fission systems. Fusion energy machines present no new risk that must be regulated by ONR under these statutes and there is no reason to force fusion into this fission-focused regulatory regime.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

CFS generally agrees with the proposed justification for fusion energy systems and appreciates that the proposed justification is intended to capture a broad range of applications of energy released from fusion energy reactions. Other applications of fusion energy would include district heating, carbon emission reduction, hazardous waste digestion, support for variable renewable energy generation systems, climate change mitigation (including mitigating geopolitical and socioeconomic effects of climate change), desalination of water, and the production of helium.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site license would not be needed for fusion power plants?

CFS would generally support changes to the underlying legislation to clearly and permanently remove fusion energy machines from the scope of facilities and sites regulated as nuclear installations if such legislation can be achieved easily and removes confusion for regulators, the regulated community, and the general public.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined above?

In addition to assuring safety and environmental protection, CFS believes that the goals of permitting should be predictability and efficiency of the permitting process. To the extent that a National Policy Statement for fusion would further the goals of predictability and efficiency, CFS could support this approach.

9 What other issues should a Fusion NPS address?

In addition to the applications of fusion energy referred to in the response to Question 6, CFS would emphasize the importance of providing a zero-carbon energy source that can support intermittent renewable energy generation systems.

10 Do you believe that a third party liability regime is required for fusion?

Commercial fusion energy facilities very likely will have risk profiles in line with existing energy industrial facilities like fossil fuel power plants and other facilities that use materials like tritium, such as medical irradiation or isotope manufacturing facilities.

Importantly, CFS hopes that the UK Government will recognize the importance of differentiating the risks presented by fusion energy machines compared with nuclear fission power plants. CFS does not believe that it is appropriate for fusion facilities to subsidize insurance or otherwise share risk with nuclear fission power plants. In the United States, fission power plant operators pool risks for significant radioactivity releases via the Price-Anderson Act. Just as it would not be appropriate to compel fusion operators to participate in the Price-Anderson Act, given the differences between the magnitude of risks presented by fission versus fusion, it would not be reasonable to require fusion operators to similarly subsidize the risks posed by nuclear fission power plant operators in the UK.

11 What are your views on the principles and issues regarding third party liability set out in this paper?

CFS is generally aligned with the principles outlined in the proposed regulatory framework for fusion energy, even though these principles are taken from the fission-focused Paris Convention. The risks associated with fusion energy machines are far different from the risks presented by nuclear fission power plants addressed by the Paris Convention. Therefore, the liability principles embodied by the Paris Convention should not be applied to fusion energy without critically evaluating each principle.

For example, the strict liability standard imposed by the Paris Convention may not be appropriate for activities involving fusion energy. Strict liability may be appropriate for activities associated with nuclear fission power plants given the risks associated with a release of radioactive materials associated with such facilities. Furthermore, by imposing a heightened liability standard on fusion energy that fusion’s risks do not merit, the UK Government may chill investment and innovation in the UK’s fusion energy sector. CFS does not agree with relying on the Paris Convention for establishing strict liability for all activity related to fusion energy. Likewise, given the comparatively low risks to on-site workers and the off-site public from fusion energy machines, CFS does not believe that it is appropriate to require that fusion energy machine operators maintain financial security up to the maximum liability amount. CFS submits that this principle imposes an unnecessary financial burden on fusion energy operators that the risks of fusion do not warrant.

12 What issues in addition to those described in this paper should any fusion third party liability regime address?

The issues discussed in the paper seem to cover the main important topics.

13 How can the Government promote the development of suitable commercial fusion insurance?

CFS encourages the UK Government to treat fusion energy machines in a manner similar to existing tokamaks, particle accelerators and fossil fuel power plants.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

CFS does not believe that special cyber security considerations are necessary for fusion energy machines. Operators of fusion energy machines should have cyber security standards and protections in line with other power generation and industrial facilities.

15 What in your view should cyber security regulations for fusion cover?

CFS believes that cyber security regulations for fusion facilities should be in line with the regulations applied to other similar types of power generation and industrial facilities.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

CFS is concerned that applying an arbitrary level of power generation capacity or tritium inventory to impose enhanced regulatory engagement does not improve safety or education of the public about fusion energy. CFS appreciates BEIS's commitment that no additional legal obligations would arise from a fusion energy project meeting this definition. However, CFS is concerned that imposing these arbitrary thresholds, which do not directly affect the risks that a fusion energy machine could present, establishes precedent that UK regulators could use to establish arbitrary thresholds that do trigger additional legal obligations. Instead, CFS believes that conditions for enhanced regulatory engagement should be more directly related to the risk a fusion energy machine creates, such as effective dose levels at the site boundary.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

CFS recognizes that early and effective engagement with regulators is an important part of efficient regulation. That engagement includes description of fusion energy machines during the development of the machine to uncover any significant regulatory challenges within the design and also to help build the regulator's familiarity with this new technology.CFS is also comfortable with, and indeed encourages, engagement with the public throughout the development and operational life cycles of fusion energy machines. During the development and permitting phase, much of this public engagement can be a part of the environmental approvals process.

18 What are your views on how such engagement should work?

Engagement with the regulator is critical to an efficient and enduring regulatory process. In order to provide the regulator with a detailed view of the proposed technology while also protecting proprietary intellectual property, these early meetings between applicant and regulator should not be public (particularly meetings prior to submission of a formal application).

However, CFS is committed to transparency and would like to encourage the publication of as much information as is reasonably possible. This transparency must protect proprietary information and, to the extent a fusion energy machine is used for electricity generation, security of important energy infrastructure.

19 Do you agree that additional guidance should be developed on fusion energy regulation? If you agree, what should guidance cover?

CFS appreciates that guidance can serve as helpful tools for the regulated community as well as the interested public. The US Nuclear Regulatory Commission (NRC) has created several guidance documents that provide predictability and context for regulators, project applicants, and the public. In particular, CFS has found the following guidance documents to be useful:

- NUREG 1556 Volume 7 (consolidated guidance about materials licenses for academic or research applications);
- NUREG 1556 Volume 21 (guidance for using radioactive material and accelerators); and
- NUREG 1748 (environmental review guidance for materials licensing).

In particular, CFS has found the flexibility built into NUREG 1748 to apply the appropriate scope of environmental review based on the level of risk that the licensed activities would present.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion? If yes, what are your suggestions for how this could be achieved?

As noted above, CFS is committed to transparency as it brings safe, carbon-free, economical fusion energy to communities around the world. CFS is encouraged by the polling results shared by the UK Government which indicates a positive correlation between increased knowledge of fusion energy and improved public opinions of fusion energy projects. This polling data tracks with CFS's own anecdotal experience in engaging with the local community in Devens, Massachusetts, USA, during the permitting and siting of its SPARC facility and headquarters campus. As members of the local community became better informed about fusion energy and SPARC specifically, the community welcomed CFS and has been very supportive since construction of the CFS campus began.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Building technical capacity around fusion energy topics is a challenge for all regulators around the world due to the novelty of the technology. Despite the game changing nature of the fusion power heat source, much of the plant will be familiar to engineers and regulators who have experience with industrial sites (e.g., heat transfer piping, structural engineering, etc.). Indeed, the vast majority of a fusion energy facility is steel and concrete which does not require exotic materials or new expertise to understand.

To the extent that some capacity building is required, CFS recommends that regulators rely on the experience of entities that have regulated fusion research and development devices for decades successfully. In the UK, that entity is UKAEA. In the US, those entities are so-called Agreement States, or states that have devolved authority from the NRC to regulate certain activities like the handling of some kinds of radioactive materials. Agreement States have also engaged external consulting firms with the specific expertise that the regulator wished to add to their review team.

Finally, CFS cautions against assuming that technical staff trained in the regulation of nuclear fission power plants can immediately shift to overseeing fusion energy licensing programs. Although interested engineers and scientists can certainly understand fusion concepts given enough time, direct transitions of fission regulators to fusion programs can lead to inappropriate application of fission regulatory strategies and concepts to fusion.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

In the UK, successful oversight of the Joint European Torus can serve as a useful benchmark of risks and efficient regulatory action. To supplement this experience, CFS recommends that UKAEA and the relevant regulator(s) engage with industry to ensure that government entities' understanding of fusion energy topics keeps pace with developments in the commercial sector. CFS has seen successful engagement with the NRC and the Massachusetts Radiation Control Program as those government regulators built their expertise on fusion energy issues.

Likewise, CFS has appreciated that a number of international standards organizations have engaged the private industry to build capacity around fusion energy topics.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

Projections for waste management demand an accurate understanding of project designs, fusion fuel cycles, and realistic waste profiles. As indicated in CFS's cover letter, CFS's waste estimates for SPARC and ARC are far smaller than the estimates for ITER or hypothetical projections for DEMO. See Attachment 3 at Slide 5.CFS anticipates that all waste, including any activated waste, from its fusion energy machines will be safely and suitably managed with existing regulations.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

CFS expects that activated material and other waste can be disposed of in the same manner as low-level waste in the US.

25 What are your views on how a fusion facility should be decommissioned?

CFS agrees with the UK Government's general principle that fusion energy machines should be designed to minimize activated waste streams and with decommissioning in mind. This principle follows the example of the Tokamak Fusion Test Reactor in the US, which as UKAEA noted, provides precedent for a comprehensive and safe decommissioning of a fusion machine that used a deuterium-tritium fuel cycle.In comparison to ITER and DEMO, CFS's fusion energy machines of SPARC and ARC will be far smaller devices occupying far smaller geographic footprints than those other machines. Therefore, these fusion energy machines, like all other commercial fusion energy systems that CFS is aware of, will have far smaller volumes of activated waste to manage and far smaller sites overall, so commercial fusion sites should be easier to decommission than anticipated for ITER or DEMO.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

With the understanding that regulations and guidance documents will apply differently to different fusion energy technologies, CFS does not see a need for additional guidance on these topics at this time.

27 Do you agree with the Government's proposals on safeguards for fusion?

CFS agrees that no fusion-specific safeguards for fusion energy machines and related activities or equipment are necessary. CFS does note that as it is designing a fusion energy machine that is far smaller than ITER or DEMO, so future CFS sites using that machine design will have a similarly smaller amount of material that may be subject to safeguards.

28 What should the Government consider in developing guidance for export controls and technology licensing?

CFS agrees that no specific changes to the UK's export policies are needed to accommodate emerging fusion energy technologies at this time. This conclusion no doubt reflects the decades of safe operation of fusion reactions around the world and the understanding that there are no reasonable weapons proliferation concerns with fusion energy machines.CFS also supports the UK Government's desire to foster a UK industry able to export fusion energy technology around the world. Given the global race towards fusion energy, it is likely that if the UK does not take a leadership role in establishing norms for exporting fusion technology, one or more other countries will take that leadership position.

29 Do you agree with this proposed approach for keeping the fusion regulatory framework under review?

CFS is concerned that revisiting and possibly substantially revising the regulatory framework after 10 years, and at least every 10 years thereafter, introduces unnecessary uncertainty into the fusion regulatory process in the UK. This uncertainty could chill investment in fusion energy projects in the UK, especially because the lifecycle of these projects will likely extend across multiple iterations of these review cycles. From a commercial perspective, substantially changing the regulations that apply to existing fusion energy systems following substantial capital investment would discourage any investment in the first place.

CFS recognizes that BEIS is attempting to balance the interests of the public and industry stakeholders as fusion energy technology matures. CFS also recognizes that as fusion technology matures, BEIS, EA, and HSE are likely to further streamline the regulatory programs for fusion to align regulatory obligations with the risks that fusion energy machines actually present. To this end, CFS suggests that BEIS base its review of the regulatory framework on evolution of the fusion energy industry, such as following the commissioning and operation of some number of fusion power plants for several operational and maintenance cycles, rather than on an arbitrary time period. If BEIS believes that it must have a date certain to revisit the regulatory framework, CFS suggests that a time period of 30 years would be more appropriate than 10 years.

CFS also requests that BEIS clarify that future changes to the regulatory program will not affect any fusion facilities or machines that the regulator approved under the prior regulatory regime. Without this assurance, commercial developers may not be willing to commit the capital necessary to construct and operate fusion energy machines in the UK.

30 Do you believe there is anything else the Government should consider in regard to fusion energy regulation?

CFS considers this proposed regulatory framework to be thorough and thoughtful.

One additional suggestion is that CFS recommends that regulators avoid assuming that standards developed for nuclear fission power plants apply directly to fusion energy machines (such as nuclear pressure vessel codes or seismic qualification to fission standards). In many cases, these standards are not proportional to the risks that fusion energy machines could present. Furthermore, applying these standards to fusion energy machines without adequate analysis would run counter to the goal-setting approach that serves as the foundation for this proposed regulatory framework.

As referenced in response to Question 22 above, CFS has appreciated the efforts of a number of international standards organizations in updating existing standards, or developing new ones, to address the particular needs for fusion energy machines. These standards, reflecting up-to-date understandings of fusion technology, would be appropriate starting points for regulating fusion energy machines.

31 Before today, how much did you know about fusion energy?

A. Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

A. Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

35 What is your country's / organisation's planned approach to regulating fusion energy?

Although CFS is conducting a global search for the site for its commercial scale fusion energy machine, called ARC, CFS is currently based in the United States. Regulators in the United States, including the NRC and state authorities, are conducting a similar exercise to address regulatory issues related to fusion energy. CFS is an active participant in these discussions.

EDF

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

No response.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Don't know

EDF agrees that the STEP reactor will be fall under the Radiation Emergencies Preparedness and Prior Information Regulations (REPPIR) as its tritium gas

inventory will be 4EE18 Bq. This is four times higher than the threshold requiring production of a REPPIR Hazard Evaluation (1EE18 Bq).

The initial analysis presented in the STEP technical report referenced by the consultation identifies a release of "a few mSv" at 1EE-6 per year at 1km.

Countermeasures are required under REPPIR at 3mSv. However, it should be remembered that the requirement for countermeasures is based on the dose at the site fence, not at 1km, hence the quoted accident frequency may be significantly lower than the frequency of accidents involving a dose of 3mSv at the site fence. For this reason, we are unable to say whether we believe the conclusions regarding the expected hazard are correct. Further work needs to be done in the context of REPPIR to better understand the likelihood of events requiring countermeasures at the site fence, and hence whether or not STEP would require a "detailed offsite plan" under REPPIR.

Additionally, the STEP Technical Report identifies a lower probability, higher consequence event in which a dose of up to 1 Sv at 1km is possible. This would automatically require an "offsite plan" under REPPIR. In addition, the requirement for an offsite plan necessitates an "onsite plan" under REPPIR.

While both HSE and ONR regulate sites under the REPPIR regs, those sites regulated by HSE do not currently exceed the threshold that would require them to have onsite or offsite plans.

Hence only ONR currently holds regulatory competence for this scale of hazard, and for determining the appropriate offsite zones, and for managing Local Authorities as duty-holders under REPPIR. For these reasons we would suggest that ONR should be considered as the regulator for the STEP Fusion demonstrator under REPPIR.

For comparison, it should be noted that the dose considered for an Advanced Gas Cooled Reactor (AGR) under REPPIR is “a few mSv” at at 1EE-5 per year at up to 2,000m.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Don't know

The existing regulatory approach relying on HSE and EA has served the fledgling fusion power sector well. However, as the sector moves closer to commercialisation it may be appropriate to consider if the ONR should have a greater role.

This is particularly true in relation to the Radiation Preparedness and Prior Information Regulations (REPPIR) – see question 2.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Don't know

A detailed exercise to review the quantities and nature of wastes from operation and decommissioning of STEP should help identify if this approach or the Site Licence approach is most appropriate.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Don't know

The Nuclear Installations Act Defines “installation” as site of a “Nuclear Reactor”, and it defines “Nuclear Reactor” as “…any plant…for the production of atomic energy by a fission process…”, hence by this definition fusion is not currently in scope of the Act.

However, the Act also allows for secondary legislation to identify “prescribed sites”. One of the reasons it allows for prescribing a site is “producing or using atomic energy”. The Act points to the definition of “atomic energy” in the Atomic Energy Act 1946: “atomic energy means the energy released from atomic nuclei as the result of any process”. Hence the Nuclear Installations Act provides an umbrella under which the production of energy by fusion could be included without any change to primary legislation.

EDF does not advocate either for or against using the Site Licence approach for fusion, but notes that a regulatory vehicle already exists for the licensing of such sites.

We would also add that greater involvement of ONR in the regulation of fusion sites as they move from the experimental to the commercial demonstration phase may be appropriate. In any case, ONR are already well-placed to deal with the scale of hazard to be regulated under REPPIR as mentioned in our response to Question 2.

A potential approach that may be worth consideration is some form of 'light-touch' regulation of fusion by ONR.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

We agree that all options are needed to help the UK reach Net Zero, and hence continuing to develop fusion as a viable zero-carbon generation technology is sound justification.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Don't know

We agree that there needs to be clarity on whether a nuclear site licence is required.

We have highlighted issues in this response that need to be considered to determine the appropriate legislative approach.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

Yes – we strongly agree that any nationally significant infrastructure such as the STEP demonstrator should be supported through the planning process with a National Policy Statement. This will enable planning inspectors to look to STEP's role in helping the UK to reach Net Zero and balance this against any local detrimental impact due to construction and operation of the facility.

9 What other issues should a Fusion NPS address?

Opportunity for fusion NPS, and for future nuclear NPS for large and small scale reactors to revisit the "semi-urban criteria" in regard to locations. The existing nuclear NPS uses the accident profile from a previous generation of commercial reactor - this is as inappropriate for GW scale and for SMRs as it would be for fusion.

10 Do you believe that a third party liability regime is required for fusion?

Yes

The purpose of the third-party liability regime for existing nuclear facilities is to provide financial compensation for damages caused by major accidents.

The fact that accident studies identify the potential for a low-probability accident with a dose of 1 Sv at 1km suggest that a third-party liability regime would be sensible.

11 What are your views on the principles and issues around third party liability as set out in this paper?

No response.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

Fusion sites could be incorporated in the existing liability regime in the UK through the identification of a new category in the Prescribed Sites Regulations. This would obviate the need for any new regulations or primary legislation.

13 How can the Government promote the development of suitable commercial fusion insurance?

No response.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

Yes – nationally significant infrastructure that the STEP Fusion demonstrator needs to be protected for two reasons:

i) Potential for malicious actors to seek to create an accident, and hence increase the probability of a release of radioactive material

ii) Potential for malicious actors to seek to damage the demonstrator and thereby setback the UK's development of commercial fusion power

15 What in your view should cyber security regulations for fusion cover?

No response.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Don't know

No response.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

We agree – engagement between developers and regulators as early as possible is essential to enable rapid development of any new technology.

18 What are your views on how such engagement should work?

No response.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Don't know

No response.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Don't know

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

There are opportunities for the development of technical capability in this area through secondments and recruiting from the sector by the regulator.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

UKAEA has world-leading experience in fusion research and development. Taking this to larger scale and ultimately to commercialisation UKAEA may benefit from the wealth of UK experience of planning, constructing, operating, maintaining and decommissioning a fleet of civil nuclear reactors.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

Should be managed in the same responsible manner that radioactive wastes from the existing UK nuclear industry are already managed. Management of waste should be waste-led rather than technology-led. For example, neutron-activated components from STEP decommissioning are no different to neutron activated components from AGR or Magnox decommissioning, and hence should be managed in the same way.

The Geological Disposal Facility’s ‘Wastes for Disposal’ which supplements the GDF safety case should include any ILW that will ultimately be destined for the GDF.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

No

This is not appropriate. Policy on waste should be waste-led rather than doctrine-led. If it is appropriate for a particular waste-stream to be disposed of in near-surface facilities, or in a deep geological repository then it should be so. Where the waste arises is irrelevant.

25 What are your views on how a fusion facility should be decommissioned?

The UK's civil power and research sectors have extensive experience in the decommissioning of facilities where components have become activated by neutrons, or contaminated by radionuclides (including tritium). This experience should be built on by the UK fusion sector to allow it to become a world leader in the decommissioning of fusion facilities.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

No response

27 Do you agree with the Government's proposals on safeguards for fusion?

Don't know

We believe that the international regime on non-proliferation needs to rapidly embrace fusion technology and manage any proliferation risks that are associated with the technology.

A commercial entity will be procuring/ building a breeder blanket which is considered a dual-use WMD item. It is important therefore to consider if this technology to not be covered by the remit of the UK safeguards regulator.

28 What should the Government consider when developing guidance for export controls and technology licensing?

Thinking in this area needs to consider the potential future commercialisation of this technology and how any proliferation risks can be mitigated in exporting the technology in future years.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

Yes – the regulatory framework for any technology should be kept under review as it develops.

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

Environment Agency

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

All critical regulatory areas to address radiological hazards and risks associated with fusion energy and their impacts on the public and the environment have been addressed.

The risks are comparable to existing industrial activities regulated under the Environmental Permitting (England and Wales) Regulations 2016 (as amended, EPR16), including those associated with the use of radiological materials Fusion energy sites will have a key role in delivering the UK’s Net Zero ambitions; therefore we query whether wider sustainability issues should be considered to make fusion more readily comparable to other energy sources? Due to the specific vires of radioactive substances activities (RSA) within EPR16 this is a topic we can only influence rather than impose specific requirements to regulate energy and resource efficiencies, such as water usage. Other non-radiological hazards may also need regulating by the Environment Agency under EPR16, for example the use of materials like lithium and beryllium.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

We agree with the Government’s conclusions regarding the expected hazards of future fusion power plants. Tritium is the radioactive material that will be used in the fusion reaction; in comparison with other radionuclides tritium has a low radiotoxicity with regards to the harm it can do to the public and the environment.

The inventories of tritium that will be kept and used on a fusion power plant will be much larger than tritium inventories on other permitted sites but the same standards will apply under EPR16. Tritium is a highly mobile ‘substance’ and will result in contaminated components that will need to be safely and securely stored, managed and ultimately disposed of.

When combining deuterium and tritium, high energy neutrons are produced which bombard the reactor and result in neutron activation of the components and the reactor structure itself. A confinement vessel should shield essential equipment from neutron bombardment, but the confinement vessel itself and other equipment will degrade over time due to bombardment. The reactor’s structural material will become activated by the intense neutron fluxes, the extent of this activation will depend upon the choices made for the design and build of the reactor, however this will generate activated structural components and materials that will need to be safely and securely stored, managed and ultimately disposed of. It is expected that the activated material will be a mixture of low level radioactive waste (LLW) and intermediate level radioactive waste (ILW), but no heat-generating, high level radioactive waste (HLW) associated with fission reactors.

Similar hazards and wastes are generated through the operation of cyclotrons which are routinely regulated effectively by the Environment Agency through EPR16, including the decommissioning of redundant cyclotrons.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

We support the proposal. The Environment Agency and Health and Safety Executive (HSE) have a long-standing relationship, working together to regulate sites of mutual interest. Both regulators carry out risk-based, proportionate, goal-setting regulation according to the hazards of the site and the activities carried out there, across a number of regulatory regimes such as EPR16, the Ionising Radiations Regulations 2017 (IRR17), the Radiation (Emergency Preparedness and Public Information) Regulations 2019(REPPIR19) and the Control of Major Accident Hazards Regulations 2015 (COMAH).

This approach aligns with the proposals for fusion energy plants that will use large amounts of a low radiotoxic material (tritium), will generate lower activity radioactive wastes than those on a nuclear fission energy plant, but will operate alongside more traditional hazards such as lasers and magnets.

For existing non-nuclear facilities (i.e. not on a nuclear licensed site) there are regular discussions and interactions between the two regulators to ensure sharing of knowledge and any issues identified, including potential enforcement action. Joint inspection visits between the Environment Agency and HSE occur when there is a clear purpose for doing so and where there are demonstrable benefits to all parties, both regulators and the operator, in having a coordinated approach. A memorandum of understanding exists between the Environment Agency and HSE which covers working together practices.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

Yes. EPR16 already provides the permitting regime for radioactive substances activities across England. They provide requirements through the demonstration of management understanding and control and the application of best available techniques (BAT) to ensure impacts to the public are as low as reasonably achievable (ALARA) and that the environment is protected. These mechanisms all rely on a risk-based, proportionate approach by the Environment Agency to assess the compliance of an operator. As well as being an environmental regulator, for radioactive substances the Environment Agency is also the security regulator, as specified within EPR16, with specific conditions included within environmental permits to take this into account.

For unsealed radioactive material, such as the tritium used in a fusion energy plant, the requirements in the EPR16 permit are to minimise the likelihood of loss of control by requiring the operator to use good practice, BAT and management controls to prevent unauthorised access and minimise the potential for radioactive discharges having an impact on people or the environment.

EPR16 and our regulatory expectations are non-prescriptive, goal-setting and are technology neutral.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Not Answered

We note that the consequences of licensing would mean we would not regulate the keeping and use of radioactive material or the accumulation of radioactive waste. However, we believe that we have the capability to regulate these matters on a fusion power plant, as we do for existing non-nuclear radioactive substances activities.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

We are supportive of the proposals. In particular the proposal to treat fusion technology designs collectively and to define the scope as covering the generation of net energy regardless of energy form. It should be made clear that the scope should include the radiation exposure of workers as well as the public and that any application should be wide ranging in its assessment of detriments and benefits, and not confined to those associated with radiation.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Not Answered

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

We support the production of a topic specific Fusion National Policy Statement (NPS) under the Overarching Energy NPS to support the decision-making process and provide continuity in decision making for major energy infrastructure (facilitated by the Overarching NPS). It is important to have a sector-specific Fusion NPS because they are a new technology that poses potentially significant environmental risks and hazards for which specific policy guidance is likely to be needed. This should seek to ensure there is a framework in place to assess and mitigate this range of risks for fusion plant proposals so people and the environment are protected, and that energy infrastructure is resilient to environmental hazards and there is no loss of energy supply. The Fusion NPS needs to be responsive to future changes in understanding of the risks and hazards posed by fusion plants and in environmental conditions (e.g. due to the effects of climate change).

A Fusion NPS should provide the opportunity to focus on key planning matters likely to be encountered, and provide clarity and long-term strategic direction regarding the way in which the new technology will be delivered.

We support the principle of fusion plants being a nationally significant infrastructure projects (NSIP) because they involve new technology with potentially significant environmental risks, and the development consent order (DCO) process provides a comprehensive and structured procedure to allow full consideration of the issues likely to be encountered. Using the existing trigger in England of a ‘generating station over 50MW’ is likely to cover most proposals for fusion plants, but we cannot be certain about this given the technology is in its infancy, and therefore consideration should be given to introducing specific criteria in the Planning Act to require all fusion plants (even if they generate less than 50MW) to be an NSIP requiring a DCO, if the risks posed justify this.

For instance, the programme of work seeking a site for a ‘Spherical Tokamak for Energy Production’ (STEP) by UK Atomic Energy Authority (UKAEA) indicates that STEP is likely to be a NSIP but also says it will not be a commercial site in the first instance.

There are a number of potential environmental issues that could be considered an exclusionary or discretionary siting criteria in a fusion NPS. These include flooding and coastal change, land contamination, water quality (groundwater, surface water and inland, estuaries and coastal waters), water resources and fisheries and biodiversity.

9 What other issues should a Fusion NPS address?

The Fusion NPS itself does not need to be a site-specific policy but should ensure alternative sites are considered, and that the lowest risk sites are chosen. The most effective and cost-efficient way to manage environmental risks and protect the environment is to avoid sensitive and high risk locations in the first instance.

10 Do you believe that a third party liability regime is required for fusion?

Don't know

We note that the Contracting Parties to the Paris Convention have yet to come to a decision about the inclusion of fusion. The inclusion of fusion in such a special liability regime would potentially send the wrong message about this developing technology. This would seem to be at odds with the general approach to enable this technology to fulfil its potential to be part of a low carbon energy mix in the long term, and be regulated in an innovative manner proportionate to the risks. However, there are benefits from applying such a regime (such as the protection, and facilitation, of the supply chain) which need to be weighed in the balance.

If fusion were to be covered under a special regime such as the Paris Convention, then efforts should be made to classify it as a ‘low risk installation’. We note that the consultation paper does not set out the alternative to a special regime namely resorting to tort law which would remain available for claims for damages to be brought against anyone shown to be at fault if necessary.

11 What are your views on the principles and issues around third party liability as set out in this paper?

The important principles and issues are covered. The principles which underpin the international regimes are sound and well established and tested. A key question is the risk level as addressed in question 10.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

The key issues are described in the paper. The responses to questions 10 and 11 provide comments on those issues.

13 How can the Government promote the development of suitable commercial fusion insurance?

Not Answered

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Not Answered

15 What in your view should cyber security regulations for fusion cover?

We agree with this proposal where it relates to cyber security of systems including those that control the facility. However, there is no proposal relating to the security of the radioactive materials in the consultation and it is not clear if this is intended to be covered by this section. We (Environment Agency), not HSE, have expertise in the security of radioactive materials. At present we regulate the site security of sealed sources in International Atomic Energy Agency (IAEA) Categories 1-4, under Part 5 of Schedule 23 of EPR16. We take advice from the police and other organisations on those security matters. If this was required for fusion, it would require changes to EPR16 to extend our security regulation beyond the scope of sealed sources.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

Yes. We support Government conclusions that at this time there is no need to introduce any compulsory pre-commissioning engagement and/or regulatory ‘hold points.’ The Environment Agency’s current regulatory framework under the Environment Act 1995 (EA95) and the EPR16 remain appropriate. The majority of our guidance is technology neutral, but we aim to review for relevance to fusion and will prepare new guidance where gaps are identified or developers require further clarification of our regulatory expectations.

We also agree that our existing arrangements enable sufficient engagement opportunities for the public to interact with fusion developers and the Environment Agency. Our Public Participation Statement (Environmental permits: when and how we consult) sets out when and how we would undertake enhanced consultation for “High public interest applications.” We decide whether an application is of high public interest on a case-by-case basis, but a fusion power plant is likely to be in this category.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

We agree there can be advantages for both the Environment Agency and the fusion developers to engage early. For example, it allows us to get involved with developers at an early stage, where we can have maximum influence. Design changes required to address regulatory concerns are more easily implemented while designs are still on paper, rather than when construction has begun, or expensive plant items have been manufactured. It enables us to identify issues early in the process so progressively reducing financial and regulatory risks for potential operators. As the Green Paper notes, engagement also enables us to understand better future technologies and identify potential challenges which could require staff up-skilling and guidance updates /development.

18 What are your views on how such engagement should work?

We suggest the Environment Agency should not impose any additional engagement on a developer – it has to be for the developer to request enhanced engagement, and any engagement would need to be fully funded in accordance with the polluter pays principle.

We consider current arrangements, whether through EPR16 pre-application engagement, or advice under section 37 of EA95, provide sufficient flexibility for the Environment Agency to offer pre-engagement where requested by fusion developers.

The Green Paper cites the example of the Government’s Advanced Nuclear Technologies (ANT) programme and the BEIS Advanced Modular Reactor Feasibility and Development (AMR F&D) competition. In terms of pre-engagement for fission reactors, the Environment Agency and the ONR also developed the GDA process in 2007 and this has now been successfully applied to a number of large, gigawatt fission reactors. Whilst it may not be proportionate to fully replicate the GDA process for fusion power reactors, we are reviewing the processes used in both AMR F&D and GDA to determine what aspects may be suitable for fusion developers. We strongly support close working with the other regulators, consistent with the Regulators’ Code, and already have established, long-standing arrangements with both the HSE and the ONR.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Not Answered

As noted in our response to question 16, the majority of our guidance is technology neutral, but we aim to review for relevance to fusion and will prepare new guidance where gaps are identified or developers require further clarification of our regulatory expectations.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

If yes, what are your suggestions for how this could be achieved:

Yes. A greater opportunity for the public to engage in the regulatory process for fusion will strengthen trust and confidence in us as regulators. While it will always remain the responsibility of the regulators to make decisions about the assessment of a fusion power plant design, we want our decisions to be better informed through good engagement. It is important to us that we involve people in decisions that affect their community. We want to understand peoples' comments and views. Where relevant we can use these to help inform our assessments.

A greater opportunity for the public to engage in the regulatory process for fusion could be achieved by a pre-permitting assessment process that includes public consultation. A pre-permitting assessment process is an established precedent to de-risk fission nuclear new build. The GDA process is run jointly by the Environment Agency and ONR and has recently been updated to ensure it is fit for purpose for less developed and innovative advanced fission designs. The GDA process includes a public consultation when we consult widely on our preliminary view following detailed assessment. We provide a consultation document explaining the reasons for our preliminary view. Following the public consultation, we carefully consider all relevant responses to the consultation and complete our assessments. A pre-permitting assessment process would be an opportunity for the public to engage in the regulatory process for fusion.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

The Environment Agency has been building its capability to assess and regulate ANT since 2017. These efforts have been funded by BEIS and have led to the creation of an internal reference and knowledge management library, creation of new bespoke training courses and targeted site visits. The Environment Agency will continue to build technical capability by developing the fusion specific knowledge management library, participating in relevant site visits and industrial engagement opportunities to upskill staff.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

We recognise the technical expertise established in UKAEA through their work at the Culham Centre for Fusion Energy. The Fusion Safety Authority has an important role for internal governance of UKAEA’s operations at both the CCFE and the proposed STEP plant. This knowledge and experience can also be used to support other global initiatives for fusion safety.

However, independence of regulators from developers and government is essential. We note IAEA Safety Standards General Safety Requirements (GSR) Part 1 Rev 1 “Governmental Legal and Regulatory Framework for Safety” states:

- Requirement 4: Independence of the regulatory body: The government shall ensure that the regulatory body is effectively independent in its safety related decision making and that it has functional separation from entities having responsibilities or interests that could unduly influence its decision making.

Therefore, we suggest it would be inappropriate for the Fusion Safety Authority to act as a ‘Technical Support Organisation’ providing technical advice to regulators on safety and environmental matters throughout the regulatory process

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

Minimising the impact to people and protecting the environment from waste management is one the main objectives of our regulatory remit, including regulation of discharges and solid disposals to land. Radioactive waste from fusion should be safely and sustainably managed following our guidance including the principles of optimisation of the management of the generation and disposal of radioactive waste such that “all exposures to ionising radiation of any member of the public and the population as a whole resulting from the disposal of radioactive waste are kept as low as reasonably achievable (ALARA), taking into account economic and social factors”.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Not Answered

We consider that Government policy should refer to general principles (waste management hierarchy, risk informed approach, etc.) rather than set out expectations for specific waste streams which could become constraints and prevent the best management options. If principles are clear at policy level, radioactive waste from fusion will be minimised as far as possible with plants designed, built and operated with this as a fundamental aim. Where waste cannot be avoided it should be managed in accordance with the waste hierarchy. As regulators, we expect a strategy and plan for radioactive waste management which demonstrates the chosen approach is the BAT and ensures that radiological risks to members of the public are ALARA, taking into account economic, environmental and societal factors

25 What are your views on how a fusion facility should be decommissioned?

The approach to decommissioning should follow the principles in UK decommissioning policy. Hence, decommissioning should be carried out as soon as reasonably practicable and a strategy and plan should be in place which explains how the decommissioning process will be carried out safely with due regard to security and protection of the environment. Facilities should be designed, built and operated in a way that enables prompt, sustainable decommissioning and minimises the generation of waste. Similar to nuclear fission power plants, suitable arrangements should be in place for adequate regulatory scrutiny of decommissioning arrangements (including funding) prior to the approval to construct a fusion plant and throughout its entire lifetime.

We note the Government legislated in the Energy Act 2008 to ensure that Operators of new nuclear power stations will have secure financing arrangements in place to meet the full costs of decommissioning and their full share of waste management and disposal costs. Government may wish to consider whether similar arrangements should apply to fusion power plants.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

Our radioactive substances regulation objective and principles apply equally to fusion as to any other permitted activity involving radioactive substances.

However, we will review our suite of regulatory guidance as it applies to both nuclear and non-nuclear sectors to ensure it remains appropriate. For example, for nuclear sites, we expect a Waste Management Plan (WMP) to set out how the radioactive substances will be dealt with, and a Site Wide Environmental Safety Case (SWESC) which demonstrates that people and the environment will be protected from the radiological hazard and any non-radiological hazards associated with the radioactive substances remaining on, or adjacent to, the site. These requirements are detailed in our management of radioactive waste from decommissioning of nuclear sites: guidance on requirements for release from radioactive substances regulation (GRR). We may wish to extend the scope of this guidance to apply to fusion, albeit this will need to be proportionate to the hazard.

27 Do you agree with the Government's proposals on safeguards for fusion?

Not Answered

28 What should the Government consider when developing guidance for export controls and technology licensing?

The Environment Agency recognises the need for export controls to be in place so as to help enable the use of dual use technologies for peaceful purposes and prevent proliferation of nuclear weapons. In considering its approach government should be mindful of the need to exchange information as well as the actual export of specific technology. This includes enabling appropriate engagement between regulators internationally in those countries to which exports are proposed to be made. This would enable better informed and consistent regulation and ensure that there is learning from operational experience internationally. It would also help enable exporting of UK technology because overseas regulators would be able to carry out their assessments of the technology more effectively and efficiently through engagement with the UK regulators.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

Yes. Fusion is a rapidly developing area of technology in the UK and overseas. Similarly other countries are also considering their regulatory frameworks, and there may be opportunities to compare regulatory approaches and learn from experience.

The Environment Agency actively supports ongoing initiatives to consider regulatory collaboration and harmonisation and how this could be achieved. We aim for continuous improvement in our regulation of radioactive substances activities and through our engagement with IAEA and other regulators to consider a common approach for assessment

Frazer-Nash Consultancy Ltd

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

As a Tier 1 supplier to the ONR, we are very familiar with their wide remit across the nuclear sector but one area of commonality would be regulation of transport of materials (new/spent fuel or activated materials) which could encompass the management of tritium (including all lifecycle aspects from breeding to atomic accountancy). Tritium management must be considered a critical area and a key consideration for any commercial fusion device, akin to the handling volatile materials in other sectors such as the process or industrial sectors.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

We consider the primary risks associated with a commercial fusion device will include the safe discharge of stored electrical energy and the controls required to manage gas systems. critical safety requirements.

We concur with the failsafe mechanism of a fusion device should a catastrophic event occur.

3 Do you agree with the proposal to maintain the existing regulatory approach?

We note that the RHC proposed that the EA & HSE regulate fusion development programmes, and we consider this to be a pragmatic approach for the short term.

Longer term, we see the potential need for a dedicated department (possibly within the ONR or HSE/EA) which would provide dedicated focus for commercial fusion regulation, and we would also expect to see some level of collaboration between fission (ONR) and fusion regulatory bodies.

We do have experience (from other sectors) that when two regulators try to cover the same issue, there are gaps. Usually (and understandably) safety takes upmost priority – so any collaboration in this case would see the ONR taking responsibility.

On the environment front we have EPR2016. That does cover Rad waste BUT there is also another section in there which covers “Installations” and the environmental implications of industrial activity at these Installations.. ONR sites frequently miss the installations issue and we have supported in these instances. There is energy-producing installation requirements and the fitness for purpose of this current section for Fusion will need consideration in our opinion.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes - no further comment.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

At the moment, we do not see any benefit in bringing the fusion developers under NIA65. Existing fusion/high energy physics facilities such as ISIS are regulated by HSE.

We should be cognisant of the differing fusion approaches - it's not just magnetic confinement and Tokamaks. For example FLFusion use a high velocity projectile approach. Would a single fusion regulatory approach fit all fusion devices? (Consider the MoD who self-regulate through DNSR and look at their high velocity weapons programmes).

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

We suggest that fusion regulation is broad or at a high level to foster innovation and allow the developers to continue undetered or hindered. We propose that over-restriction would inevitably stiffle innovation and hence the development of fusion technology which could lead to delay and reluctance for further investment.

We also propose that fusion regulation maintains a distinct divide with fission, with a pragmatic and proportionate approach adopted to support fusion development.

Regulation should apply to all fusion developers, including those who will not have fission or nuclear experience.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes - no further comment.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

NPS - National Policy Statement - England & Wales planning approach;
We see this as an evolving/iterative approach but conside it a sensible, consistent approach, provides a statement of intent for future fusion plants.
It ensures that there is control in who can actually build fusion plants.

9 What other issues should a Fusion NPS address?

No comments at this stage

10 Do you believe that a third party liability regime is required for fusion?

Potentially a sound idea but needs to be a bespoke solution for a fusion application;

11 What are your views on the principles and issues around third party liability as set out in this paper?

We consider the principles and issues as sensible & pragmatic.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

No comments at this stage

13 How can the Government promote the development of suitable commercial fusion insurance?

HMG could subsidence the insurance industry to share the risk. Any in-service downtime due to component failure is a concern and liability of downtime needs to be considered. We propose looking to other areas within the energy sector to see what approach they adopt, i.e. tidal turbines, renewables.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

We do indeed consider that all development plants should be subject to cyber security regulation, and STEP should follow the principles of NIS 2018.
We note that investors (private funded ventures) will want to see cyber security measures in-place, with demonstrable internal controls and with assurances that no external connectivity can be made to the facility or device.

15 What in your view should cyber security regulations for fusion cover?

We consider that cyber security should address - at least - the control of the device/plant, measures to restrict/counter any external attack, management of all data, the retention of IP (avoiding theft by external agents), internal physical measures to prevent tampering and/or unauthorised use, measures to prevent accident or deliberate failure.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

We broadly agree with the proposal.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes - we see this as a critical aspect for the developers to secure confidence in their design and de-risk future maturity programmes.

18 What are your views on how such engagement should work?

By any means which would promote free and transparent dialogue: Direct F2F contact, by invitation to relevant stage gates in the design process, through involvement in development of innovative techniques &/or materials.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes. Guidance will ensure clarity and provide transparency to fusion developers, the supply chain, the general public, regulatory bodies, etc.

As a point of note, regulation by the ONR is backed up by guidance (TAG's)

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

It would be a good opportunity to educate the public around fusion and the benefits of fusion compared to fission; There are many myths and errors associated with nuclear energy in the public domain, magnified by significant events such as Chernobyl, Fukushima and television dramatisations such as BBC's "Chernobyl".

Conversely there could be many issues arising as a result of engaging with the general public, so there is a fine balance to strike between engagement and no engagement.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Engaging with the technology developers, the wider supply chain; recruiting people in to the regulatory body with specialisms to support an informed fusion regulatory approach.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

UKAEA/CCFE seen as a fusion centre of excellence - it would seem sensible to make use of the technical expertise in the Culham/Harwell region to support the development and should include TEL & FLF.

Consideration should be made to making use of ITER experience/people and developoments in North America.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

Adopt current practices and categorise as LLW/ILW/HLW and store as current conditions dictate; long term storage solutions to be finalised.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

It is anticipated that the waste from the fusion device will be categorised as ILW or LLW. The volume & category of waste would determine the where and how we manage the waste. There are also site specific aspects and the local population consultation piece to consider.

25 What are your views on how a fusion facility should be decommissioned?

Adopting a DFX approach at the fusion device concpet phase must include end of life considerations to ensure we maximise the efficiencies of decommissioning.
This will be broadly similar to fission decommissioning but without the management of spent UO2 fuel.
Question for consideration: Would the Environmental Impact Assessment for Decommissioning regulations (EIADR) be equally applicable to fusion?

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

Open transparent - ensuring that all aspects are considered in the regulatory framework

27 Do you agree with the Government's proposals on safeguards for fusion?

We concur with the proposals on safeguards for fusion.
We note that ONR is currently responsible for regulation of safeguards relating to fusion in the UK.
Tritium does not currently fall under safeguards regulations but falls under the NCA since the UK supply comes from Canada.

28 What should the Government consider when developing guidance for export controls and technology licensing?

Tritium - dual use technology
Exporting of fusion - no specific guidance.
We suggest open and broad dialogue with the fusion developers and supply chain in helping to develop guidance.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes - it's a dynamic and evolving sector, currently, "no less frequently than every 10 years". We suggest this should be 5 years or less, based on the increasing development of technologies and move to 10 years at a later stage.

30 Do you believe there is anything else the Government should consider in regard to fusion energy regulation?

Regulation needs to be engaged with developers, be agile and responsive to the developers, and must not stiffle or restrict progress, if we want to see the UK maintaining a leading position in fusion development (US investment is significant and we could see them overtaking UK very soon)

Lithium availability and regulation of the provision of sufficient supply?
What about environmental considerations?

Deuterium operations require a license from the EA - this is a very slow process limiting fusion developer progress. A bespoke fusion regulator would help.

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

International Fusion Systems Ltd.

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

Not regulatory areas, but the area of appropriate standards to be followed in the design and construction of fusion power plants needs to be strongly considered by regulators. I don't believe that existing nuclear standards are fit for purpose for fusion plants, they are too onerous. Of course, the UK's goal-setting regulatory approach that ensures risk is ALARP should drive the use of the most appropriate standards. However, there may some unconscious expectations from regulators and other stakeholders that existing nuclear standards be followed. For example, nuclear pressure vessel codes, nuclear equipment qualification. These are the things which make the nuclear industry so costly and time-consuming to develop for at present, and should be avoided if appropriate for fusion. The government should consider encouraging the fusion industry to collaborate with regulators now to identify which existing standards (from any industry) are appropriate for the level of risk expected from fusion plants.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

Yes. Having worked on the UK fission power station fleet, ITER project and now for a private fusion project I agree that the accident analyses indicate that the potential hazard from a fusion power plant is orders of magnitude less severe than from a fission power plant.

I question whether the probability of such an accident happening is actually "very low" because this depends on the design of the facility, however I agree that the probability of severe harm to the public and environment is very low due to the nature of the released material (tritium) in the environment.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

There is no fundamentally different hazard beyond what is already catered for in the existing regulations. There is also no reason to attempt to follow prescriptive regulatory approach as the goal-setting approach already taken by the regulators will ensure risk is reduced to ALARP through innovation and following appropriate best practice for the hazards involved.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Don't know

I am not familiar with the most recent regulations, I am more familiar with their predecessors. However I believe that the previous regulations already provided a proportionate and appropriate way to consent and permit a fusion power plant.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit

of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

Whilst the NIA 1965 approach, site licences etc could be applied to fusion power plants, in practice the ONR is primarily concerns with the hazards that arise from the fission power industry and are not well-calibrated to the levels of hazard that a fusion power plant presents. It is therefore not the regulatory approach but rather the experience of the regulators involved which makes me conclude that teh EA+HSE approach is more appropriate for fusion.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

The governments proposals are fine in principle, in line with existing practices and not trying to cut any corners for fusion, which is good and important for public acceptability. I am slightly concerned about the need to try and avoid being technologically specific - there has to be some technological basis for the justification in order to determine and bound the negative impacts. On the other hand, being too technology specific could limit innovation and reduce the attractiveness of the UK as a location for developing fusion energy. I would recommend encouraging the global fusion industry to contribute their impact analyses to UKAEA as justifications for their preferred technologies, this way there is some confidence that the only technologies being excluded are the ones which are not realistically being considered anyway.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Don't know

I am not familiar with the detail of the NIA 1965 but if the government believes that it contains ambiguities which could be used as the basis of a legal challenge that fusion power plants should be regulated under the NIA 1965 and therefore by the ONR, then I agree that the legislation needs to be changed to provide clarification. The government must take care to do this thoroughly and not just justify on the basis that "fusion isn't fission" because that would undermine public confidence in fusion.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

It would be consistent with other energy sources and would allow fusion to be evaluated on a level playing field in respect of planning application. It would also prevent national policy issues being debated by local authorities for every fusion energy project.

9 What other issues should a Fusion NPS address?

A fusion NPS should address the other potential use of fusion such as high-grade process heat and hydrogen production. The proposal in respect of NPS only addresses the 50MW and 350MW limits in respect of electricity generating stations and perhaps the use of fusion for other purposes could inadvertently slip through the net. If the government needs to legislate to ensure that fusion power for heat or hydrogen production can be justified by an NPS then it should do so.

10 Do you believe that a third party liability regime is required for fusion?

Yes

Yes because it provides certainty to developer, operators and the supply chain.

11 What are your views on the principles and issues around third party liability as set out in this paper?

It appears that the Paris Convention approach is largely fit for purpose if applied to fusion. The tritium limits for fusion sites to be considered low hazard could be a concern, but the immediate classification as high hazard if these limits are exceeded acts as a strong incentive to plant designers and operators to stay below these limits, which is a benefit to the public living in the vicinity of these sites. If, in future, fusion power plant designs are produced which demonstrate risk to be ALARP but exceed these limits of tritium them the government should review the liability approach at that time.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

I am not aware of any.

13 How can the Government promote the development of suitable commercial fusion insurance?

Provide the insurance industry with access to the experts at UKAEA for assessing the risks which fusion facilities present.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Don't know

The question is not clear if it the government is proposing that all fusion power plants be 1) classified as CNI regardless of generating capacity, 2) they all be regulated under the NISR 2003, 3) they all be regulated similar to COMAH or 4) if they all be regulated in a new regime primarily for intellectual property and national interest reasons. I don't believe that the first two options are appropriate or justifiable under the existing regulations. The third option is justifiable but should be determined based on the level of hazards which could arise. The fourth option is justifiable but if implemented should not just apply to fusion but to all facilities which contain a large amount of intellectual property in the national interest.

15 What in your view should cyber security regulations for fusion cover?

Security of computer-based systems important to safety.

Protection of intellectual property in the national interest.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

50Mw is already in relevant legislation and 7x10^16 Bq is at the low end of the amount of tritium that a power plant will probably need. However there are designs being considered which aim to have <100g on-site, so perhaps the limit should be reduced to be broadly equivalent with the licence which the UKAEA Culham site has which I believe is 100g tritium.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

Most current developers of fusion technologies and power plant designs are not familiar with the UK regulatory regime and even if they are this will be a learning experience for all as, at this stage, there is no prior experience of regulating a fusion power plant. It will also increase public confidence that developers are in formal discussions with the regulator early in the development process.

18 What are your views on how such engagement should work?

I believe an approach similar to that taken with AMT programme, or even the ONR's GDA process, would be suitable - although the latter could be too formal and heavy for the level of hazards expected from fusion power plants.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

As regulations are not always about a specific industry or technology, specific guidance on the applicable regulations for any particular industry is always welcome.

Given that most current developers of fusion technologies and power plant designs are not familiar with UK regulations a one-stop-shop approach which explains the overall regulatory approach and the relevant legislation would be highly beneficial.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

This consultation is a good start. Public consultation on any national policy statement should also be done as well as any new regulations or changes to existing legislation which intend to enable the fusion industry.

The current approach by the nuclear industry to engage with local communities during the planning process and for the ONR to publish their assessments of power plant designs and licence applications on their website and inviting comment, are both things which should be replicated for the fusion industry.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Recruiting from the fusion industry - although it is small, it is growing rapidly and the few people needed by regulators could be taken from the fusion development organisations without much significant impact.

Attendance at the fusion industry main events.

Recruitment from parallel industries which use tritium, e.g. AWE.

Encouraging the fusion industry to collaborate to produce a standard training programme as an introduction for new entrants to the industry. Perhaps

UKAEA can open its training programme to outsiders.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

The government's proposal is fine. However, private fusion industry will be hoping to make use of the UKAEA's expertise as well and care should be taken not to make the role of the Fusion Safety Authority either too blurred across vendor/regulator lines, or to make it extremely one-sided towards regulation. The role of "internal regulator" in the nuclear industry is different from the proposed role of the FSA because internal regulators act on behalf of the nuclear operator, but independent from both the rest of the operator's organisation and from the ONR/EA. The government is proposing that the FSA actively support the regulator and not the operator/vendor, which is a very different role. The UKAEA's role is to enable the fusion industry, so it would seem more appropriate that the FSA be available " to hire" to private fusion industry as an internal regulator, and not to support the regulator.

However, such an approach could somewhat prevent the FSA being able to take a global lead in developing international regulation and standards.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

I agree with the government's view that the existing arrangements are largely appropriate although there will be some differences in the technical means used, particularly because of the different chemicals used, e.g. significant amounts of tritium, potentially more activated corrosion products, but no fission decay products which have leaked from fission fuel rods. Since some fusion plants may use beryllium this will also need to be considered for decommissioning, even though it is not radioactive.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

The government policy should encourage decommissioning and rad-waste management in the most cost effective manner, commensurate with the risk.

If near-surface disposal is considered technically acceptable for fusion rad-waste, and it is cost effective, then it should be encouraged.

25 What are your views on how a fusion facility should be decommissioned?

The current approach for decommissioning fission plants, to remove spent fuel, clean up the fuel handling plant and then put the reactor core into safe storage for ~100 years until the activated materials have decayed to sufficiently low radiation levels, is a good way to consider decommissioning for fusion plants at present. For a fusion plant, tritium should be removed as far as reasonable achievable from the reactor core and the fuel cycle, then that plant decommissioned and as much equipment as possible removed before leaving the reactor core to decay over ~100 years.

There is also the matter of cleanup of equipment removed from the core during maintenance, which may be highly activated. This should have tritium removed and then be left to decay in the same way as the core, however this could be done off-site at a central UK facility rather than build these capabilities at each fusion site. This should provide a more cost-effective means to for operators to dispose of this waste, as well as provide more cost-certainty to operators/vendors. However, it may limit innovation in the technologies needed for this, so it is not clear to me if this is a preferable approach.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

It is not clear to me how the current regulatory framework for fission plants addresses decommissioning either, but the need for operators to have a decommissioning fund, and be liable for decommissioning costs, is essential and must be covered in regulation to provide certainty to vendors, operators, owners and the public. Clarity must be provided to the vendors, operators and owners as to whether the NDA will take over their sites for decommissioning, or whether it is expected that operators/owners will continue to own the sites and the decommissioning funds, responsible for decommissioning the sites to a schedule and targets set by the NDA. My understanding is that there was confusion until a few years ago about the status of the AGR sites with respect to the NDA's role during decommissioning and the result was not necessarily satisfactory for the site owners and would have affected investment decisions if known earlier. This is why clarity is needed.

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

It is surprising that tritium isn't governed by safeguards regulations but the fact that accountancy is addressed under IRR should be sufficient. However given that fusion plants with tritium breeding ability will be able to create substantial quantities of tritium there could reasonably be public pressure to ensure that this tritium is not diverted to non-civilian usage, even inside the UK. I agree that the ONR should remain the competent authority for any safeguards regulation for fusion.

Would the potential use of fusion plant for transmutation of transuranic elements be covered under safeguards? As the government said earlier in the proposal, any fusion-fission hybrid would be regulated by the ONR, but how will the government ensure that fusion plants are not being covertly used for transmutation/breeding purposes?

28 What should the Government consider when developing guidance for export controls and technology licensing?

The government needs to ensure that export controls do not unreasonably constrain the nascent fusion industry from expanding from a UK base, or prevent international collaboration on designs. The UK in general has a habit of gold-plating international regulations, whereas other countries seem to take a more pragmatic approach. For example, a tritium plant system designed in the UK for an international project was marked export control, but it actually has no potential dual use in respect of gathering/refining a concentrated source of tritium. In comparison, another tritium plant system designed in the USA for the same project was not marked export control, even though this system was intended for refining/concentrating the tritium. The government should provide very clear guidance on which systems, which particular equipment functions and which technologies it considers to be subject to export control, rather than the currently vague wording which is open to interpretation. For example, perhaps only designs of components which can separate tritium from other hydrogen isotopes would be under export control.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

I agree that the framework should be kept under review and that every 10 years is a suitable maximum interval. The government should also consider whether to review the review period itself every 5 years, as some private fusion companies expect to develop commercial fusion much more quickly than anticipated by this consultation.

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

35 What is your country's / organisation's planned approach to regulating fusion energy?

Whilst based in the UK I have previously worked on the ITER project and currently work for a private fusion project in the USA. France does not appear to have a strategy for commercial fusion, as far as I can tell. The USA is developing one but it is not yet coherent and is still focussed on science rather than on technology demonstration and commercial application.

Kinectrics Inc.

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

Please explain what these are and why they are important.:

The Government has identified the following critical regulatory areas:

- health and safety regulations for workers and the public
- environmental and public protection regulations
- land use planning
- third party liabilities and insurance obligations
- security and safeguards for nuclear material

Based on Kinectrics review of regulatory frameworks in Canada and elsewhere, regulatory frameworks for fusion generally address national security, health and safety of persons and the environment, and international obligations. The five identified broad areas of regulatory concern address these issues.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

Kinectrics has developed hypothetical preliminary descriptions of fusion facilities covering a range of approaches to fusion and identified the following broad categories of related hazards:

- Radiological
- Primary neutrons
- Secondary emissions including X-rays
- Tritium
- Activated components
- Activation products in erosion dust, gases and liquids
- Chemical
- Beryllium
- SF6
- Liquid metals
- Thermal
- Plasma
- Pressurized Water
- Steam
- Cryogenics
- Liquid metals
- Physical
- Rotating equipment
- Magnetic/electrical Forces
- Automated equipment/Remote Handling
- High Velocity projectiles
- Regenerating high power pistons
- Electrical
- High voltages
- High Currents
- Other
- Radio Frequencies

- Neutral beams
- Flammable materials
- Hydrogen as a possible source for fires or explosions

These align with the hazards identified in Chapter 2 of the consultation report.

The Government concludes that the hazards of fusion power plants will remain of a similar magnitude to those associated with other industrial activities that are currently regulated by the EA and HSE. Radiological, chemical, thermal, physical, electrical, and other hazards are already in use on large scale in a wide range of industries globally in a safe and well-regulated manner. An example is the Darlington Tritium Removal Facility in Canada which processes large quantities of tritiated heavy water to extract, isotopically separate and store tritium. It should also be noted that the scale of hazards developed in Chapter 2 are based on current design studies, and as mentioned in several US Nuclear Regulatory Commission public workshops, developers recognize the need to innovate and come up with designs that reduce or eliminate the quantities of tritium that need to be handled on a fusion site and reduce the activation of structural materials. This supports the Governments conclusion on the hazards of fusion power plants.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

The current goal-setting regulatory process of the EA and HSE regulates fusion as a “radioactive substance activity” and is considered to be proportionate to the overall risk and hazard associated with future fusion power plants and to be fit for purpose.

As noted, the current regulatory approach in the UK has been proven in its regulation of the JET fusion facility which currently holds the record for DT fusion plasmas. The Kinectrics review of regulatory frameworks for fusion found that France is using a similar goal-setting approach for regulating the ITER facility currently under construction: high-level objectives are set and the proponent demonstrates compliance with these. As noted elsewhere in the report, goal setting (as opposed to a more prescriptive approach) can facilitate innovation.

However, it does put an onus on the regulator to be knowledgeable about the technologies being regulated and to have criteria set in advance for judging when the proponent has adequately demonstrated meeting the goals.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes:

As noted in the response to Question #3, the EA and HSE already have demonstrated the current regulatory approach works for fusion R&D facilities and large-scale hazardous industrial facilities.

As noted in our response to Question #5, Kinectrics has found that regulatory frameworks it has reviewed may contain explicit or implicit assumptions about the nature of the hazards associated with the processes used by the applicant. In this case, a systematic and independent review of the EA and HSE regulatory framework documents as written is recommended to identify potential gaps or issues associated with applying these to a fusion power plant.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

When Kinectrics reviewed regulatory frameworks for fusion power plants, in most jurisdictions the same regulator dealt with all applications of nuclear substances and ionizing radiation including fusion and fission. However, we found in many cases ‘technology neutral’ formulations for ‘reactors’ had explicit references to fission-specific hazards (e.g., criticality) and/or implicit expectation of these. This could create regulatory uncertainty for an applicant in terms of how to interpret requirements or guidance for application to a fusion facility, require additional needs to justify why irrelevant requirements are not needed, and/or impose unnecessary design or operational burdens. Continuing the existing regulatory approach would avoid this complication.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

The Government proposes having the UKAEA STEP programme prototype fusion power plant as the mechanism to develop and submit an application to the Justifying Authority regardless of technological approach to enable the rapid commercialisation and safe deployment of fusion in the UK. Given the broad range of approaches being developed for fusion and the resulting range of potential hazards this may not be achievable if the Justifying Authority expects justification specific to the reactor design in question. An approach used in other jurisdictions for siting nuclear power plants may be useful in this regard. For example, Kinectrics was involved in supporting Ontario Power Generation in obtaining a license for siting new nuclear power stations on the Darlington site using an enveloping approach as the specific large fission reactor design had not been selected. OPG is using this site preparation license for a much less hazardous SMR on the site.

As noted, it will be important that the regulatory justification of fusion cover the broad range of potential application of fusion power so as not to hamper its development and deployment. The Government proposes a justification application for the ‘generation of net energy by fusion power stations’ to accomplish this. It must be noted that there has been confusion around the term “net energy” in relation to fusion which will need to be addressed: does this refer to more energy released by the fusion reaction compared to the energy input to the fusion fuel, or a net energy production from the fusion facility relative to the electrical inputs to it.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

Amending legislation to state that fusion power plants should not be regulated under the same regulatory regime as fission will provide long-term clarity and confidence to industry. Further it will provide opportunities for public input to obtain the widest range of opinions in a transparent manner. Doing so will also avoid potential future challenges during the consent and planning processes.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Refer to our response to Question #9

9 What other issues should a Fusion NPS address?

A Fusion National Policy Statement to provide a development consent framework would give confidence to developers who wish to bring forwards fusion projects. In conjunction with legislative amendments and regulatory justification it would clear a number of planning and regulatory uncertainties by focussing on specific planning issues, not on broader policy questions. Linking the Fusion NPS to the Overarching Energy NPS ensures a broad consensus is established.

As per regulatory justification of fusion, the Fusion NPS should address not just generating stations using any fusion technology. but the broad range of potential application of fusion power so as not to hamper its development and deployment as noted in Question #6.

10 Do you believe that a third party liability regime is required for fusion?

Yes

This is not straight forward. The Government assumes in setting the regulatory approach for fusion power plants that:

- fusion hazards and risks comparable to other industries currently regulated by EA and HSE
- consequences of events at fusion power plants would be limited in time and space compared to fission hazards
- events at fusion power plants would be unlikely to affect other nations

Other industries with large potential liabilities are not subject to comparable legislative requirements (refer to https://www.oliverwyman.com/content/dam/marsh/Documents/PDF/UK-en/100%20Largest%20Losses%2023rd%20Edition-03-2014.pdf However, as deployment of fusion power plants in the near term will not have established a record of safe operation comparable to other industries currently regulated by EA and HSE, the government may wish to consider some sort of third part liability regime for prototypes until such a track record has been demonstrated such that commercial insurers have confidence to provide competitive insurance for fusion power plants.

11 What are your views on the principles and issues around third party liability as set out in this paper?

The Government has identified the following principles and issues with respect to third party liability:

- Capping fusion liabilities
- Setting the liability cap at an appropriate level
- Strict liability
- Financial security
- Channelling liability
- Liabilities across borders
- Timeframe for compensation
- Regulatory harmonisation
- Established rules
- Ease of developing a fusion insurance market

As noted in our response to Question #10, an established fusion power industry should present a hazard to the public comparable to other large-scale (non-nuclear) industries and as such should expect comparable treatment for capping liabilities, financial security, etc. To do otherwise is likely to undermine public trust. The public, developers/operators, their suppliers, and potential insurers need confidence that hazards are limited and that in the unlikely event of an accident affecting others, that the third-party liability framework will be in place.

In the near term until a reasonable operating history is established this is likely to require some sort of Government involvement to protect early developers of fusion power plants, provide confidence to the public and allow insurers to adequately assess the risks they are expected to insure.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

We believe that the key issues have been identified regarding any fusion third party liability regime.

13 How can the Government promote the development of suitable commercial fusion insurance?

Promoting a suitable commercial fusion insurance capability will require time. Insurers will need information on the risks involved, confidence in the developers/operators, confidence in the regulatory regime, and a reasonable operating history. Early and continuing involvement of potential insurers will be essential to understand the technology and its hazards and risks. And as noted in our response to Question #11, some sort of Government involvement should be established to protect early developers of fusion power plants until a safety track record has been established and insurers are willing to be involved.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

Regulatory requirements for fusion power should be limited to that required to ensure protection of the public and environment regardless of their energy generating capacity.

15 What in your view should cyber security regulations for fusion cover?

Cyber risks are well established, and the owner/operator of a fusion power plant should be prepared to protect their assets and be responsible for self-protection against economic damages and their Intellectual Property.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Don't know

Kinectrics has experience with supporting developers in early engagement with regulators to assist both parties in understanding relevant hazards and applicable regulatory requirements. Based on this, we clearly support that there should be formalised opportunities for engagement for fusion power plants early in the regulatory process. However, it is not clear that a formal definition to determine the facilities that it believes should be in scope are required. This should be a decision by the proponent to engage the regulator to minimize their regulatory risk in proceeding.

The proposed formalised engagement at the design stage and associated guidance (i.e., designed with a net generating capacity over 50 MW of energy and/or handle over 7x10^16 Bq of tritium) are appropriate. As noted in our response to Question #6, more clarity is required in defining “a net generating capacity” and allowance is required to encompass fusion approaches with reduced tritium inventories.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

Based on Kinectrics experience with supporting developers in early engagement with regulators, we clearly support that there should be formalised opportunities for engagement for fusion power plants early in the regulatory process

18 What are your views on how such engagement should work?

The Canadian Nuclear Safety Commission has developed a Vender Design Review (VDR) process which could be adapted for fusion power plants. A VDR is a feedback mechanism that enables CNSC staff to provide feedback early in the design process based on a vendor's technology. The assessment is completed by the CNSC at the request of the vendor. The objective of the review is to verify, at a high level, the acceptability of a nuclear power plant design with respect to Canadian nuclear regulatory requirements and expectations, as well as Canadian codes and standards. These reviews also identify fundamental barriers to licensing a new design in Canada and assures that a resolution path exists for any design issues identified in the review. A similar approach could be established for fusion in alignment with the established regulators and regulatory requirements.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

Guidance on how to proceed through regulatory processes is normally useful. Kinectrics' experience in reviewing regulatory frameworks and supporting novel reactor technologies suggests that guidance should not address specific hazards or design issues, but focus on information to help the proponent understand the goals, objectives and the criteria that need to be met to demonstrate compliance with these. A focus on hazards and design issues presupposes an understanding by the regulator on the specifics of a technology and could unintentionally inhibit innovation.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

The Government wants the public to have greater opportunity to engage with the regulatory process to provide views to the developer and regulators on proposed designs and regulatory decisions but does not propose to make such engagement mandatory for fusion power plants.

Particularly during the early deployment stages of fusion power plants, it is likely that a significant portion of the public will be interested in local developments. If the processes are seen by them as lacking transparency, there could be ill-will generated regarding a fusion power plant development.

While it is obviously in the best interest of the proponent to engage with the public through local liaison committees and public forums, during the initial deployment stages of fusion power the Government may facilitate transparency and public engagement by mandating some level of proponent-public engagement.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

This is an on-going issue for regulators as new technologies come into focus. It can be difficult to maintain independence between regulators and developers when the bulk of the knowledge regarding the technology to be regulated is in the hands of the developer. Regulators should be encouraged to share best practices in this regard if they are not already doing so. From our experience, apart from training, conference attendance and selective hiring can be helpful, as well as the use of universities and independent consultancies to supplement internal capabilities.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

The UKAEA is as both a source of technical knowledge on fusion energy and an instrument of government. As such they are in unique position to act as a technical expert for supporting regulatory agencies while continuing to be involved in the development of fusion technologies.

L'Institut de Radioprotection et de Sûreté Nucléaire (IRSN) in France and TÜV provide examples of similar entities that support regulators. For example, IRSN is a public expert with industrial and commercial activities under the joint authority of the Ministries of Defense, the Environment, Industry, Research, and Health as the nation’s public service expert in nuclear and radiation risks, and its activities cover all the related scientific and technical issues. IRSN interacts with public authorities, local authorities, companies, research organizations, stakeholders’ associations, etc.to contribute to public policy issues relating to nuclear safety, human and environmental protection against ionizing radiation, and the protection of nuclear materials, facilities, and transport against the risk of malicious acts.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

Based on Kinectrics development of hypothetical models of a broad range of fusion technologies and experience with radioactive waste handling issues, we agree that radioactive waste from fusion can be expected to be safely managed within the type of facilities that are already used for storage and disposal of radioactive waste. As such, radioactive wastes produced by fusion can be subject to existing policy and strategy on radioactive waste.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

No

As noted in the response to Question #23, radioactive waste from fusion will be no different from any other radioactive waste produced by other technologies and as such there should be no need for further statements that waste from fusion can be disposed in near-surface disposal facilities. To do so would imply that fusion waste is somehow to be differentiated from other radioactive wastes that are already safely managed and regulated.

25 What are your views on how a fusion facility should be decommissioned?

Based on Kinectrics experience in decommissioning nuclear facilities, we agree that the same general principles would apply to the decommissioning of fusion power plants as currently applies to the decommissioning of nuclear facilities.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

As described in our responses to Questions #23, #24, and #25, we do not believe that there is a need for fusion-specific guidance to be developed for addressing radioactive waste or decommissioning within the regulatory framework.

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

As noted in the Report, tritium does not currently come under safeguards regulations and accounting for tritium in the UK is specific supplier agreements.

In addition, the IRR 2017 requires duty holders to account for radioactive material and to prevent any reasonably foreseeable loss or theft. As such, we agree that any additional regulatory provisions would not be needed on safeguards

28 What should the Government consider when developing guidance for export controls and technology licensing?

In Kinectrics review of regulatory frameworks for fusion, it was noted that the descriptions of dual use items is in general, and probably necessarily, 'loose'. Many components in a fusion power plant could be considered as requiring import/export controls such as bellows-sealed scroll-type compressors and bellows-sealed scroll-type vacuum pumps, microwave power sources and antennae, magnet power supplies, etc.

Developers would benefit from clarity and specificity around components which require export controls.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

The Government proposes to review the fusion regulatory framework no less frequently than every ten years. Given the pace of development in fusion technology, a period of 10 years may not be sufficient once actual fusion power plant prototypes have gone through the consent and permitting processes. The government may wish to consider a milestone based on actual developments as an initial point for review.

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

35 What is your country's / organisation's planned approach to regulating fusion energy?

Kinectrics is committed to supporting the development and deployment of fusion power and has, and will continue, to support developers and regulators in ensuring that this technology is made available in a safe and economic manner.

Our evaluation of the CNSC regulatory framework's readiness to regulate fusion was very well received by the CNSC and it is our belief that there would be significant benefit to collaboration and sharing of this information

National Nuclear Laboratory (NNL)

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Not Answered

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

Our response is focussed around questions 3, 4 and 5 of the consultation. NNL agrees that the proposal to maintain the current regulatory approach, and the framework provided by IRR 2017 and EPR 2016, can be effectively used for the consenting and permitting of fusion power plants, as has been shown by many years of successful operation of the JET facility.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

NNL's view is that fusion plants should not necessarily be considered as nuclear installations in line with NIA 1965 and they could be regulated under the framework provided by IRR 2017 and EPR 2016 on the proviso that the approach to fusion provides similar levels of protection against risks to workers and the public as fission. NNL recommends government explores the opportunity to benefit from the experience and approach of many decades of nuclear fission operations providing high levels of radiological protection to both public and workers.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

As the fusion programme develops further NNL recommends government ensures technical capability and capacity within the regulatory bodies to maintain public confidence in a competent, independent regulatory body.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

9 What other issues should a Fusion NPS address?

10 Do you believe that a third party liability regime is required for fusion?

11 What are your views on the principles and issues around third party liability as set out in this paper?

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

13 How can the Government promote the development of suitable commercial fusion insurance?

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

15 What in your view should cyber security regulations for fusion cover?

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

18 What are your views on how such engagement should work?

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Not Answered

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Not Answered

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

25 What are your views on how a fusion facility should be decommissioned?

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

27 Do you agree with the Government's proposals on safeguards for fusion?

28 What should the Government consider when developing guidance for export controls and technology licensing?

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

Nuclear Advanced Manufacturing research centre

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

The fusion sector will not be regulated by the Nuclear regulators, ONR or DNSR. However the quality of the engineering must still be of the highest standard. Hence regulation on the design and safety methodologies used will be needed, for example ASME 111 for mechanical systems, as a failure of the balance of plant systems, Ie those connected to the Fusion reactor in order to raise steam and produce electricity, would still be undesirable. It may be that the guidance of existing standards such as DEF STAN 08-107 and 59-411 are appropriate , as it provides good engineering practice, even if the product is not of a military nature. BS EN 615108 and other standards will should also apply to the design process.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

Fusion is inherently safe as it is extremely difficult to attain and sustain a fusion reaction and any failure results in a safe cessation of the reaction in a safe manner.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

The Nuclear Regulators are rightly conservative in their approach to control of fission power plants and other products. However, that is overly onerous

for Fusion as the fuel for fusion is much more benign than that for fission. The consequences of a release of fusion fuel to the atmosphere and the general public is significantly lower than for fission as it is mostly naturally occurring water. Tritium less so, but with a half life of 12 years, and the fact that it would mix with natural water, including atmospheric, so as to be present in minute quantities, the long term environmental impact of such a release is not likely to be significant. Current regulatory framework for Fusion R&D plant is appropriate for fully operational fusion power plant.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Don't know

The IRR 2017 is primarily aimed at Fission and the control of Uranium or radionuclides. The controls within will be unnecessary for Fusion power. EPR 2016 is appropriate for the control of planning for fusion plant.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

The Fusion reactor is inherently safe due to the extreme conditions that are required to produce a fusion reaction. That is, there is no possibility of an avalanche or prompt criticality event , such as is possible with fission plant. Any failure of a control system or input parameter will cause a fusion reaction to stop and the plant to shut down in a safe state. The balance of plant systems, are likely to be the same or similar to those of conventional fossil fuelled power plants and therefore that element does not require nuclear regulation. So regulation to Nuclear standards is not necessary for a Fusion power plant.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

I think they are correct, Fusion does not require Nuclear regulation. Amendment to the legislation to clarify that nuclear site licencing is not required for Fusion power plants, will prevent confusion on the applicability of NIA1965 or NIR 1971

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

The site of a fusion power plant, will not store, handle or use Radioactive materials, other than tritium, and therefore a nuclear site licence is not appropriate. The most dangerous item used is Tritium, which is of low toxicity and has a very low potential to induce harm to humans or other fauna or flora, if accidentally released to the environment.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

A Fusion NPS will encourage a rapid deployment of fusion plant once the technological challenges have been conquered. This will help to support the UK s 2050 Net Zero objectives by encouraging private investors as well as existing power producers to plan the installation of fusion power plants.

The NPS will set a guiding standard approach for the other devolved nations, who may wish to adopt it, or create a facsimile of it.

9 What other issues should a Fusion NPS address?

Education, prior to any public consultation I would suggest a series of educational adverts be presented on national TV and social media, to make the general public aware that fusion is not only inherently safe, but that it will not produce high level radioactive waste, or use highly radioactive fuels. This will do much to dispel the myths associated with and general fear of Nuclear power. This will also allow you to demonstrate your commitment to decarbonising the UK.

10 Do you believe that a third party liability regime is required for fusion?

Don't know

On the one hand , third party liability would calm many people down and be seen as business as usual . The risk of an accident is extremely low and so it would be unlikely to be needed. On the other hand , if it is not needed , it introduces an unnecessary burden to fusion plant developers

11 What are your views on the principles and issues around third party liability as set out in this paper?

I agree with the concept of capping liabilities. These could be set at a different level for Fusion than fission, meaning that while protections are in place, they are less onerous than for fission systems.

I agree with the principle of channelling liabilities

I disagree with the principle of Financial security on the basis that it will present an insurmountable barrier to entry for all but the largest energy suppliers. This will weaken the take up of fusion power.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

The list is comprehensive.

13 How can the Government promote the development of suitable commercial fusion insurance?

Offer time limited incentives to insurance companies, such as tax relief on revenue in proportion to the value of the fusion liability insurances that they provide.

Consult with the major insurers, the Lloyds register, for example, to explore what products they could offer.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

There is an international race to fusion power. The first country to successfully achieve a working plant will be afforded a huge opportunity for financial reward, licence fees from patents and other IP and a business advantage in getting to market first. We must protect the UKs position from Industrial espionage, sabotage by rival nations, and criminal exploitation by sophisticated bodies, who may seek to ransom our design and technical information, eg by locking down all IT systems at UKAEA or Tokamak energy. Cyber security has never been more important or necessary than it is now.

15 What in your view should cyber security regulations for fusion cover?

Fusion power plants like all power plants will contribute to the UK s domestic and industrial power needs. They will be assets of national importance in guaranteeing the security of supply of this power. Internal and external agents may seek to ransom this supply for criminal financial gain, access design, operational and maintenance information for industrial espionage, or seek to destabilise the UK economy by interrupting supply. Regulation should ensure that standards are kept up to date, and incorporate the latest research from academia, plus feedback from national and friendly international security agencies.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

This is a sensible approach

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

This will ensure that each party has a clear understanding of expected outcomes and that a developer can clearly demonstrate compliance , knowing that this will lead to the necessary approvals for operation.

18 What are your views on how such engagement should work?

Design and project progress stage gates are common in the design of large and complex systems. The regulator can be present at the gate reviews, or can approve the minuted records of those reviews.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

Fusion power plants will not be the same as research reactors. The former will have balance of plant systems and grid connections that a research reactor will not have. The regulations must ensure that the balance of plant systems are designed, built and operated to suitable standards, and a whole plant safety justification is developed and maintained for each fusion power plant.

As stated above the design of balance of plant systems, e.g. Electrical Controls and Instrumentation, including operator interfaces, fluid systems, material choices, operational regimes for normal and faulted conditions.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Don't know

Transparency is always a good policy, however, for projects of high importance and high benefit to the country, it may be necessary to mandate their deployment and accept that public objections will occur.

The public who are in favour of fusion will typically remain silent, while those who are opposed will be very vocal and will be likely to gain high levels of media coverage, that could damage public perception and acceptance of fusion as a future power solution. Uneducated, NIMBYs , ie those who object to any change due to a lack of willingness to change, have equal say to those who understand the technology and its impact on the world.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Strategic recruitment, is a powerful method of increasing technical capability in the regulatory bodies. By employing regulators with a strong background and experience in the fusion community or related technical disciplines , they will increase their ability to effectively regulate the industry. Perhaps the regulatory role could be conducted on a rotational basis, with suitably qualified and experienced individuals , e.g. from Nuclear Defence programmes, or civil nuclear power companies, or the UKAEA, performing the role of regulator for a period of time, say 2 years , before returning to their main line of work and employer.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

If an Independent body were created to oversee the development of the regulatory framework , led by key individuals from UKAEA, but also made up of other associated parties , such as Nuclear plant operators, e.g. Westinghouse, EDF Energy etc, the Nuclear AMRC, (who will teach manufacturers how to manufacture Fusion plants) and individuals from the current regulatory bodies, EA and HSE, then that body is likely to produce, fair , clear and effective regulations.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

Fusion will produce low level radioactive waste. The existing infrastructure for handling the wastes of fission plant could be expanded or developed to cover the needs of fusion wastes.

Alternatively , as the wastes may well be tritiated, with a half life of approximately 12 years, bunds could be formed, that could be emptied on a 12 year rotation and refilled with fresh waste, these could be local to , or on the same site as the Fusion power plant.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

No

There may be many options for the disposal of the wastes from Fusion plants, I don't believe the government should limit possibilities by providing such an expectation.

25 What are your views on how a fusion facility should be decommissioned?

The balance of plant, can be simply dismantled and recycled as appropriate for fossil fuelled, steam raising plant. The Fusion reactor may well contain tritiated dust caused by spallation. Unless a solution to spallation, such as effective barrier coatings can be developed. This dust will have to be carefully controlled to avoid release to atmosphere. The magnets and other rare earth metals can be recycled once they have been decontaminated, as necessary.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

The regulatory framework should include a requirement for fusion plant designs to include a decommissioning phase and for that to be costed as part of the overall plant cost breakdown. Modularisation methods applied to the manufacture and assembly of fusion plant will in turn make decommissioning and dismantling activities simpler and easier to plan, manage and execute.

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

The presence of depleted Uranium leads to the need for stricter control of material holdings. As it could be used in the manufacture of "dirty bombs" or as is current practice, in the tips of armour piercing munitions. The suggested approach of regulation by the ONR and use of IRR 2017, is appropriate.

28 What should the Government consider when developing guidance for export controls and technology licensing?

One Key consideration is ITAR. Currently this states that if 1% of a product is deemed to be a development of a US derived technology, then the US Government have the rights to the whole product to control where and when and to whom it is sold. As the stated aspiration of UK government is for UK industry to export fusion technology, export controls should be clear on the applicability or exemptions from the ITAR. This will be particularly important if the UK is first to achieve sustainable fusion reactions. In the past the US government have attempted to claim ITAR applicability to a project because one component in a system was made on a machine tool, manufactured by a US supplier. The attempt was unsuccessful, but regulation must ensure that this risk is mitigated.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

The nature of a whole fusion plant may be different than expected and experience from operation and maintenance of STEP and ITER, may yield unforeseen issues that require regulatory control , so it is appropriate to keep regulations live and revisit them periodically.

31 Before today, how much did you know about fusion energy?

Knew a little

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a little

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

35 What is your country's / organisation's planned approach to regulating fusion energy?

The Nuclear AMRC is working in collaboration with the University of Sheffield, on research projects for the UKAEA, aimed at helping them to solve some of the key challenges to Nuclear Fusion. The Nuclear AMRC will be developing a "Fit for Fusion" programme to mirror their highly successful "Fit for Nuclear" and "Fit for Offshore wind" programmes. If the suggestion of an independent peer group to create the regulatory framework and regulations for fusions is accepted, then the Nuclear AMRC would be happy to provide suitably qualified and experienced panel members to that body.

The Nuclear AMRC also have staff members who sit on international standards committees such as ASME and EPRI. These could be used to inform those bodies of the work done by their UK counterparts in the regulatory bodies and to cross fertilise, best practice from other nations .

Nuclear Industry Association

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Not Answered

3 Do you agree with the proposal to maintain the existing regulatory approach?

Don't know

The following answer covers questions 3, 5, and 22:

The NIA does not hold a strong opinion on who becomes the regulator of nuclear fusion technologies. However, in making this decision, there are several factors we feel the Government should consider.

The ONR will already have scaled significantly by the time that fusion reactors are a reality, with mass deployment of SMRs and SMRs throughout the 2030s as stated in Government ambitions of the nuclear industry. By the time nuclear fusion requires operational regulation, it could be that it is a natural addition to the ONR’s responsibilities.

While there are obvious differences between fission and fusion technologies, the similarities cannot be ignored. The ONR is a world-leader in nuclear regulation and to not use their expertise and talent could be time-consuming and costly. Adapting the role of the ONR must be weighed up against creating a new body, or expanding the roles of existing bodies such as the EA and HSE.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Not Answered

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit

of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Don't know

The following answer covers questions 3, 5, and 22:

The NIA does not hold a strong opinion on who becomes the regulator of nuclear fusion technologies. However, in making this decision, there are several factors we feel the Government should consider.

The ONR will already have scaled significantly by the time that fusion reactors are a reality, with mass deployment of SMRs and SMRs throughout the 2030s as stated in Government ambitions of the nuclear industry. By the time nuclear fusion requires operational regulation, it could be that it is a natural addition to the ONR’s responsibilities.

While there are obvious differences between fission and fusion technologies, the similarities cannot be ignored. The ONR is a world-leader in nuclear regulation and to not use their expertise and talent could be time-consuming and costly. Adapting the role of the ONR must be weighed up against creating a new body, or expanding the roles of existing bodies such as the EA and HSE.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

The NIA notes some concern about the Government’s plans for fusion regulatory justification. While the current process for building a new nuclear reactor is strict, we do believe that it is right for each reactor type to go through justification.

Not only would justifying fusion technologies more broadly lead to potential legal problems for industry and more worryingly, the Government, relaxing the process so significantly may undermine the current regulatory justification process for fission reactors. This may cause issues for developers in building these reactors, which is not in alignment with current Government policy.

As the Government well knows, the role of Justifying Authority (JA) for new nuclear projects was recently moved from BEIS to EA due to a conflict of interest. If the EA is to remain the JA for fusion technologies, we would question whether they should be acting as the regulator. The Government needs to look closely whether this would be another conflict of interest. This would not be an issue if ONR was the regulator.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

The NIA agrees that requiring a nuclear site license could be limiting for fusion technologies, especially given the scale of nuclear fission reactor construction expected before the former comes online. We believe the Government already needs to significantly extend the list of licensed nuclear sites without consideration of the placement of fusion reactors.

If the Government believes that fusion power plants should not require a nuclear site licence, then it must assess whether Clause 3 of the Nuclear Installations Act 1965 should be amended.

Given the number of decades that nuclear reactors occupy sites for, the Government needs to seriously consider their ambitions for fusion and fission technologies in parallel, especially if fusion reactors are required to be on a licensed nuclear site.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Not Answered

9 What other issues should a Fusion NPS address?

10 Do you believe that a third party liability regime is required for fusion?

Not Answered

11 What are your views on the principles and issues around third party liability as set out in this paper?

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

13 How can the Government promote the development of suitable commercial fusion insurance?

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Not Answered

15 What in your view should cyber security regulations for fusion cover?

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Not Answered

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

Yes, as we believe this has worked well with developers as part of the Government's AMR programme. The process should be considered as a template to build on for fusion technologies. However, this is an evolving process so will need monitoring and updating.

We suggest that fusion developers not only consider regularly communicating with Government on such a matter, but also reach out to AMR developers, particularly if the process is going to be managed by the same Government body.

18 What are your views on how such engagement should work?

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Not Answered

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

As with any big infrastructure – nuclear or not – there should be local engagement. Positive interactions and investment in public education of a project within local communities will improve the approval of any new reactor, as seen at Sellafield and Hinkley Point C.

In the consultation, BEIS highlighted a public opinion poll that found that 46% of participants had 'never heard of' fusion. The fear of the unknown and a lack of understanding will be the toughest hurdles of new fusion projects, and therefore we recommend that the Government mandates a minimum level of public engagement from developers.

Not educating the public – both locally and nationally – on fusion technologies will be of a detriment to the industry and developers may struggle to deploy at scale if communities are not on their side.

The document notes HSE currently does not need to consult the public on regulatory decisions, which is of concern. The current nuclear industry has found that transparency is key, with higher rates of public acceptance in communities with nuclear projects. This is backed up by annual NIA polling that shows that the more an individual knows about nuclear power, the more likely they are to support it. We believe this general principle will also apply to fusion technologies.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

The following answer covers questions 3, 5, and 22:

The NIA does not hold a strong opinion on who becomes the regulator of nuclear fusion technologies. However, in making this decision, there are several factors we feel the Government should consider.

The ONR will already have scaled significantly by the time that fusion reactors are a reality, with mass deployment of SMRs and SMRs throughout the 2030s as stated in Government ambitions of the nuclear industry. By the time nuclear fusion requires operational regulation, it could be that it is a natural addition to the ONR's responsibilities.

While there are obvious differences between fission and fusion technologies, the similarities cannot be ignored. The ONR is a world-leader in nuclear regulation and to not use their expertise and talent could be time-consuming and costly. Adapting the role of the ONR must be weighed up against creating a new body, or expanding the roles of existing bodies such as the EA and HSE.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

The NIA recommends that the responsibility for nuclear fusion waste falls under the NDA. In a similar tact to previous answers on safeguards and regulation, it could be wasteful to create a new authority instead of expanding the role of an existing body.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Not Answered

25 What are your views on how a fusion facility should be decommissioned?

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

Yes, we are happy with the Government view for this to be kept under review and for the ONR to be the competent authority.

28 What should the Government consider when developing guidance for export controls and technology licensing?

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Not Answered

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

Nuclear Risk Insurers Ltd

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

No - we consider that the government has considered all the relevant regulatory issues within the Green Paper.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

Specficially we agree that the involvement of ONR is not required in regulating Fusion.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

So we consider yes to the principals of the NIA and "channelling" of liability but this does not need to be as part of a ONR licensing framework. So either a new Act with the benefits of NIA or an 'endorsement' to the NIA covering Fusion separately.

Of course - consideration as to an appropriate level of Liability amount would need to be considered. Clearly a Fusion Operator would not need to hold Eur1.2bn of Insurance and/or Alternative Financial Protection. Perhaps the OECD's NEA and the IAEA would be entities worth referring to in deciding upon an appropriate amount?

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

NRI considers that the government has approached their consideration appropriately given the fundamential differences between Fusion and Fission.

ONR regulation would be overkill in our opinion.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

But for the fact that we beleive, as stated above that a strict liability and 'channelling' would assist in giving the general public "peace of mind" and would also be helpful for inwards foreign investment and the involvement of foreign contractors. The governments recent intentions iro the CSC would also facilitate this in our opinion.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

9 What other issues should a Fusion NPS address?

10 Do you believe that a third party liability regime is required for fusion?

Yes

NRI believes that a third party liability regime is required for Fusion.

A liability regime would allow the development of commercial insurance products, which importantly would remove the risk from government indemnification. This would also enhance public confidence in this new technology, demonstrating that the risk of harm to the public and the environment are fully understood and quantifiable.

A factor that we consider should also be considered is given the small no of Fusion projects and the likely insurance premiums it is unlikely, in our opinion, that Commercial Insurers will apply the resources and will lack the expertise to consider these technical risks. "Incubating" Fusion within the Nuclear Insurance market would seem appropriate to us until such times as the risks and the volume of premium became better understood and commercially viable to a wider Insurance market.

11 What are your views on the principles and issues around third party liability as set out in this paper?

NRI agrees with the principles and issues set out in this paper.

- Classification of a fusion plant as high hazard (with maximum liabilities of 1.2b€) is disproportionate on the basis of the likely radioactive inventory and the nature of the potential accident scenarios.
- Working within a Liability regime would also allow fusion to set a maximum liability rather than this be unlimited.
- Strict liability is appropriate for fusion for the reasons outlined in the paper (accountability of the operator, public can seek damages, simplification of claims procedure).
- Channelling of liability also supports the 3rd stated objective of the regulatory framework regarding innovation and providing certainty to developers and their supply chain. Suppliers to fusion projects would not be exposed to nuclear liability.
- Regulatory harmonisation promotes the international collaboration needed to develop commercial fusion technology.

The paper proposes that the government will look at best practice in other industries to inform its thinking on the appropriate timeframe for compensation in a liability framework. Any timeframe for compensation should be date-stamped from a trigger event which has led to significant radiation exposure or contamination, and not from diagnosis of illness or death.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

The known radiological risks associated with fusion, which stem from tritium and neutron-activated materials, do not correspond with the significant risks associated with a transboundary fission accident that the current civil nuclear liability regime is designed to protect against.

The paper is light on transboundary effects and liabilities across borders, and states only that international conventions channelling the liabilities to the operator and country of the accident would only be relevant for a fusion plant that happened to be built on an international border. It should demonstrate why transboundary effects and liabilities is not a concern if that is the view.

13 How can the Government promote the development of suitable commercial fusion insurance?

The government can promote the development of suitable commercial fusion insurance by setting out clearly the liability regime. It should then allow the market to respond, based on its longstanding knowledge and experience of fission sites.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

Assuming that Fusion would be regarded as critical national infrastructure then it is difficult to see why Cyber security would not be a key concern.

Building this into the prototype stages will mean that by FOAK and Commercial Operation that Cyber security would be ingrained within the concept rather than as an afterthought.

15 What in your view should cyber security regulations for fusion cover?

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

18 What are your views on how such engagement should work?

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Don't know

For the public to be involved there would need to be a detailed education process.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

Given UKAEA's expertise in Fusion it would seem sensible for them to be consulted together with wider consultation.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Not Answered

25 What are your views on how a fusion facility should be decommissioned?

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

27 Do you agree with the Government's proposals on safeguards for fusion?

Not Answered

28 What should the Government consider when developing guidance for export controls and technology licensing?

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

The regulatory framework needs to be capable of adapting to this developing technology.

31 Before today, how much did you know about fusion energy?

Knew a little

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a little

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

Nuleaf

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants? Please provide as much evidence as possible to support your view.

The explanation of hazards provided is concise, relatively clear and accessible to those with more limited technical knowledge. It is helpful to have the likelihood and potential individual impact of a range of worst-case scenarios quantified and set out in a table.

3 Do you agree with the proposal to maintain the existing regulatory approach? Please explain your response.

Fusion is a technology that is not mature and which is anticipated to evolve significantly in the future.

We do not have a view as to whether the proposed regulatory approach, or an alternative approach that delivers regulation through NIA65, is preferrable. The focus should be on ensuring that the regulatory regime at any given time delivers the optimal outcomes in terms of worker and community safety, security and environmental protection.

Regulation of fusion should therefore be subject to regular and rigorous re-assessment. We support the proposal that regulation should be reviewed at least every 10 years but believe that intervals between reviews should be pegged to progress with and learning from design and deployment. The view of host communities and stakeholders should be used to help guide the review process.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

We agree with these proposals. The STEP reactor will generate a modest amount of net energy which might not be in the form of electricity but could be, for example, hydrogen production. We agree with the proposal that waste arisings should also be part of the consideration as to whether the development is justified.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined above?

Yes. We support the establishment of a Fusion NPS given the complexity of the development.

9 What other issues should a Fusion NPS address?

We believe it should also address the socio-economic impacts of a fusion development and set out criteria for community benefits to be provided to the host community. It should also explain how engagement between the site and the local community should be supported. For operational fission plants this is through a Local Liaison Committee.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

We support the engagement with the Committee on Radioactive Waste Management (CoRWM) that is being undertaken and have read with interest their recent Preliminary Position Paper: Radioactive Wastes from Fusion Energy1. We support the three recommendations contained in that paper:

BEIS and CoRWM should engage to amend the CoRWM Framework Document to formalise consideration of decommissioning, radioactive waste management, radioactive waste disposal associated with fusion power.

Following consultation with BEIS, CoRWM should provide appropriate scrutiny and advice of radioactive wastes from fusion power, through its annual work plan.

Following conclusion of the current Green Paper consultation, CoRWM should produce a consolidated position paper on decommissioning, radioactive waste management, radioactive waste disposal associated with fusion power.

In terms of waste arisings, CoRWM's recent Preliminary Position Paper states that 'There is a need to ascertain the extent to which radioactive wastes arising from future fusion systems can be confidently expected to meet LLW criteria at 100 y after End of Life (EOL), and to understand whether any ILW can be plausibly managed in near surface disposal facilities. There is also a need for consideration of the other hazardous or non-radiological properties of the radioactive wastes from nuclear fusion, which may be the determining factor for acceptance as LLW and near surface disposal.'

More information on the waste arisings from fusion, and their management, should therefore be provided by Government. The information on waste in this consultation document is limited and poorly presented:

The consultation refers to UKAEA's Technology Report as providing more information on waste arisings for a TOKAMAK. However, the link provided (p.35) simply take you to the UKAEA website and not to the report, which is difficult to locate.

The paper refers to Annex D, but this simply provides some general information about the waste hierarchy and the types of waste that have to be managed. It would be useful to have information on the likely volumes of waste arising for (a) the proposed STEP reactor and (b) and large scale (e.g. 2GW) plant and also some quantification of what 'shorter lived' means.

The consultation also notes that, while most ILW will become LLW after 100 years of decay storage, some ILW may be classed as such for thousands of years. Even if the overall amount of ILW generated will be relatively small in terms of the total ILW inventory, it still equates to thousands of tonnes that will have to be stored for at least a century. This has implications for the community hosting the site or waste store if that is located elsewhere.

LLW arisings can also have an impact, with this material likely to be diverted along a range of routes for management and disposal. This has a community and environmental impact.

We believe that these impacts should be recognised and a clear commitment made to the preparation of a waste management strategy for each fusion development, with a particular focus on ILW and on minimising waste arisings. We also believe that community benefits should be enshrined within any siting process for a fusion development.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

The disposal route for fusion wastes should be informed by a risk-based assessment and by the views of host communities. The disposal of some wastes in a Near Surface Disposal (NSD) facility may be appropriate, but that should be decided by the disposal authority, in discussion with regulators, as is the case with the decommissioning of former fission power stations by the NDA.

As this paper explains, a fusion plant will also generate a range of low-level waste (LLW). Such waste should again be managed through the most appropriate route. This is likely to be disposal to a surface repository, landfill or through recovery, recycling or other treatment processes. The management of these wastes is not explained clearly in this document.

Finally, we would expect more to be said on the storage of wastes. We note that CoRWM's recent Preliminary Position Paper states that in terms of tritiated wastes, there could be the need for 'very significant decay-storage capacity with a lifetime of at least 100 years.'

25 What are your views on how a fusion facility should be decommissioned?

We agree with the basic approach proposed. However, the section indicates that a funded plan for decommissioning will be required, as is the case with new fission plans. There is no explanation of who would be responsible for decommissioning or how this would be decided. It is not clear if the developer, another organisation or the NDA would be the lead organisation.

The decommissioning plan should ensure that the design and operation of any fusion facility is optimal in terms of minimising waste arisings and easing decommissioning.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

We would expect more information and more clarity on decommissioning and waste management within any fusion regulatory framework.

This paper does not address the storage of waste and this should be covered within guidance.

29 Do you agree with this proposed approach for keeping the fusion regulatory framework under review?

Yes. We believe it is essential that regular reviews are undertaken. As the paper acknowledges, this is a fast-moving field and a technology that is not close to reaching maturity. The commitment to reviewing the regulatory approach every 10 years as a minimum, and more frequently if developments in the design and generation of fusion facilities requires, is appropriate.

Opal Flame Consultancy

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

A fusion plant needs to be considered with the same safety casing, security, procurement, 'intelligent customering' and everything else associated with a fission plant. This is a no brainer. A fusion plant (tokamak) needs tritium which is highly hazardous and needs to be secure, and the spent lithium in the casing is radioactive and dangerous for some years and needs to be dealt with accordingly.

I think the current document is weak on procurement and value-based decisions as I will outline later in my response.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

No

Chapter is deficient. Not covered:

- Risk of tritium or any radioactive waste getting into the wrong hands - dirty bombs etc.
- Hazards associated with lithium casing in tokamaks not covered at all which is a significant omission

3 Do you agree with the proposal to maintain the existing regulatory approach?

No

Big mistake - fusion needs to be regulated by the ONR. You've totally missed the point about spent lithium casings in chapter 2. They're more dangerous per se and targets for terrorists than you have indicated in the document.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Don't know

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Yes

per q3 above

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

Short sighted and has not considered all the current facts about the operation and waste produced by tokamaks, let alone other methods.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

No

Per above answers

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

No

An NPS approach is good, but not for the reasons cited. 3rd bullet "fusion NPS would not be site-specific... confirm that a nuclear site-based license ... not required..." is fundamentally flawed for all reasons given in earlier questions.

9 What other issues should a Fusion NPS address?

use the template for fission plants

10 Do you believe that a third party liability regime is required for fusion?

Don't know

No opinion

11 What are your views on the principles and issues around third party liability as set out in this paper?

No opinion

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

No opinion

13 How can the Government promote the development of suitable commercial fusion insurance?

No opinion

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

Because of the materials handled and waste generated and processes and engineering - this needs to be at SC or DV security clearance, commensurate with fission.

15 What in your view should cyber security regulations for fusion cover?

Per Q14

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Don't know

No opinion

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

18 What are your views on how such engagement should work?

use existing approaches

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

There are many methods of achieving fusion energy at the moment, competing for achieving the goal of sustainable energy output.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

If yes, what are your suggestions for how this could be achieved:

Do things as are done in your typical DCO application, or education programmes that e.g. the defunct Horizon nuclear power would have done, to educate the public in all matters relating to fusion - the benefits, costs, hazards and everything.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Keep Harwell running! Keep a stake in ITER! Retain the last few engineers and other disciplines with nuclear experience at all costs, before they leave the country or move to other sectors like oil & gas.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

Throw money at projects to retain that expertise which is still present in major consultants in this country, per Q22.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

First acknowledge the waste - you've down-played tokamak lithium casings big time here.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

Probably OK given the nature of the waste.

25 What are your views on how a fusion facility should be decommissioned?

Firmly advocate design-for-decommission, an approach woefully lacking in all the built environment - even the DCO application for Horizon Nuclear Power a couple of years ago. Use the best of BIM in your design, in all its dimensions and in accordance with ISO 19650.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

VERY CLEARLY. make it easy for consultants to follow.

27 Do you agree with the Government's proposals on safeguards for fusion?

No

Need to upgrade the level of safeguarding for tritium.

28 What should the Government consider when developing guidance for export controls and technology licensing?

Do as you do for fission materials!

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

For all reasons I have said here

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

Oxfordshire Local Enterprise Partnership

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

No, based on the information in the consultation document, there do not appear to be any other critical regulatory areas that have been overlooked.

However, members of the Oxfordshire fusion cluster who have greater knowledge of the fusion R&D environment may be able to identify other areas.

A fusion risk register infographic would be a clear way to demonstrate that the proposed regulatory framework covers all the risks that may require regulation.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

Yes agree, the analysis that leads to the conclusions, appears to consider all the expected hazards of future fusion power plants, including worst case scenarios involving hazardous materials.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

Yes agree. To the best of our knowledge there have been no accidents at Culham, since fusion R&D started on site, that have resulted in concern that the existing regulatory approach is inadequate.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

Yes agree, fusion power plants will use low and intermediate level radioactive materials, as do many other facilities in other sectors such as health.

However, fusion power plants will not be breeding high level waste.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

No, fusion power plants should not be considered as nuclear installations. Hopefully placing fusion power plants within the remit of the nuclear licensing framework will not be necessary. One of the major benefits of fusion in comparison to fission is that it does not create such a high degree of radiological hazard. The government should ensure this benefit is maintained by encouraging public and private sector fusion design choices that do not involve a considerably higher degree of radiological hazard than is currently expected.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

As described in the consultation paper, the justification proposal does not appear to sufficiently differentiate between the justification of fission and fusion. The potential health detriment of fusion is considerably less. Therefore, the assessment of the justification of fusion should be proportionate and not use the fission justification assessment framework.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

Yes agree, legislation will provide clarity and certainty about what is a fusion power plant and how it is regulated. Clarity will reduce the risk of legal challenges that could delay a project. Clarity of regulation will also encourage international inward investment into UK fusion energy research and deployment.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

Yes agree, it is important that the development of fusion power plants is linked to the Overarching Energy NPS to reinforce that fusion energy is a key element of the net zero strategy. It’s noted that the energy National Policy Statements are currently being reviewed.

The General Fusion demonstration plant at Culham is expected to be operational in 2025. If the NPS or at least a draft, is available in the near future, it may expediate the General Fusion plant.

9 What other issues should a Fusion NPS address?

It appears that revised and new NPS documents will include more detail on environmental and design considerations, this is welcome as it will reduce the number of objections to power plants on environmental or design grounds. However, as an NPS is about principles rather than detail it should not override the local planning policies covering a site location.

10 Do you believe that a third party liability regime is required for fusion?

Yes

A third party liability regime introduces clarity, certainty and reassurance. However is the comparison with the fission liability regime wholly appropriate?

The fusion third party liability regime should be appropriate to the level of risk involved in the operation of a fusion, as opposed to a fission plant.

11 What are your views on the principles and issues around third party liability as set out in this paper?

Is the comparison with the fission liability regime wholly appropriate? The fusion third party liability regime should be appropriate to the level of risk involved in the operation of a fusion, as opposed to a fission plant.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

The nature and extent of strict liability needs to be clearly defined. The principle of strict liability should not be allowed to facilitate legal action that is designed to hinder the operation of a fusion power plant.

13 How can the Government promote the development of suitable commercial fusion insurance?

i) A clear and comprehensive third party liability regime will help the insurance market assess the risk.

ii) Consideration should be given to Government underwriting reinsurance for the first demonstration plants to encourage insurers to enter the market.

Once insurers have gained a detailed knowledge of the risks, Government could withdraw from the market.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

Yes agree, for safety and protection of intellectual property. Fusion power plants should not create a weak link within UK energy infrastructure cyberspace.

15 What in your view should cyber security regulations for fusion cover?

The regulations should be appropriate to fusion, following the principles of NIS 2018 but recognising the differences in the safety and security risks between fusion and fission.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Don't know

It is not clear in the consultation document if this definition will exclude smaller demonstration (less than 50MW) projects and as a result will smaller projects find it more difficult to engage and progress through the regulatory process?

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

Yes agree, formal engagement will ensure any regulatory issues are resolved at an early stage and potentially at a lower cost.

18 What are your views on how such engagement should work?

It is recognised the engagement process for fusion reactor design described in the consultation paper was implemented because no existing process existed, but the process for fusion power plants should not be ad hoc and should be properly resourced to ensure it can deal effectively with what may be a heavy and time critical workload.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

Yes agree, it is important that private sector fusion developers as well as UKAEA work with the regulators on the joint guidance document. Areas could also include cybersecurity, health and safety and environmental impact. It is important that the guidance document demonstrates that there is a regulatory golden thread. If a golden thread is not clear the document may not achieve the Government's aim of giving the industry and public constructive information, clarity, and transparency.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

Yes agree. The local liaison groups organised by UKAEA have proved successful in keeping local communities, businesses and government informed about research operations and plans. Regular site visits for the public have also proved successful. It is anticipated that private sector fusion energy developers will adopt a similar approach to public engagement as they scale up and deliver a demonstration plant project.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

EA and HSE staff could be embedded for a period within public and private sector fusion research organisations 22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

The UKAEA Fusion Safety Authority provides good foundations for a Technical Support Organisation. The TSO would need to demonstrate its independence from UKAEA and have the capability to support regulatory development for the many different general and specific technical approaches (other than a spherical tokamak) to the generation of fusion energy. For example, in Oxfordshire we already have a different approach (shock-driven inertial confinement) as well as the spherical tokamak approach and we will soon have a third approach (magnetized target fusion).

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

It is agreed that existing regulations are appropriate for the management of radioactive waste from fusion. However regular reviews should be carried out to check if the existing regulations remain fit for purpose.

The decommissioning of JET will be the pilot for the safe decommissioning of fusion facilities and plants.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

Government policy should definitely reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities. The relative safety of fusion energy in comparison to fission energy is one of its key advantages. It may be possible to resolve fusion challenges by allowing materials to absorb more radioactivity but this would mean that a key advantage of fusion is diminished, public concerns about fusion are raised and plant maintenance and decommissioning costs increase.

25 What are your views on how a fusion facility should be decommissioned?

OxLEP does not have the technical knowledge to comment in detail, other than to support the view that decommissioning should be similar to that for a fission plant. This will help to reassure the public that decommissioning is comprehensive and rigourous.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

Management of waste and decommissioning requirements should be clearly set out in guidance. This will help to allay any public concerns about legacy safety and costs.

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

Yes agree, safeguards are already comprehensive

28 What should the Government consider when developing guidance for export controls and technology licensing?

The Government should ensure that controls will be suitably robust to ensure the civil use of fusion technology.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

Yes agree, no less frequently than every ten years would be appropriate given the rate of progress in developing demonstration and commercial fusion power plants.

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

Scottish Environment Protection Agency

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

We agree with the proposal to maintain the existing regulatory approach as it is proven to work effectively for existing fusion research sites in England and could work equally effectively in Scotland.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

We agree that the existing regulations, and equivalent in Scotland, provide for proportionate and appropriate permitting and consenting. The current regulations, and equivalent in Scotland, provide a flexible framework for the regulation of all radioactive substances activities that means that fusion research and power generation will be adequately regulated within an existing regulatory regime that is well-established and provides proportionate regulation.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

We do not think that fusion power plants should be considered to be nuclear installations under NIA65 because as explained in our response to question 4, we believe that the current regulations under which fusion is regulated, and equivalent regulations in Scotland, are appropriate and proportionate for the regulation of fusion power generation.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

Fusion should not be justified as a class or type of practice under the heading of ‘Generation of electricity by nuclear reactors’ for the reasons given in our response to question 5 relating to public perception of fusion in relation to fission. Therefore, we agree that the proposed application should be for the ‘generation of net energy by fusion power stations’ as this also captures all the potential types of energy that might be generated by a fusion reactor.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion powerplants?

Yes

We agree that clarifying that a nuclear site licence is not needed for fusion power plants in legislation is helpful as it will avoid any doubt in the future and clarity in legislation is always helpful.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Not Answered

9 What other issues should a Fusion NPS address?

10 Do you believe that a third party liability regime is required for fusion?

Don't know

We believe that any third party liability regime should be commensurate with what is required for any similar type of industrial or national infrastructure project and the potential hazards from fusion power generation; it should not be assumed to require the same third party liability regime that applies to fission power stations.

11 What are your views on the principles and issues around third party liability as set out in this paper?

The principles and issues seem reasonable.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

No issues to add.

13 How can the Government promote the development of suitable commercial fusion insurance?

No comment; this is outwith our area of expertise.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

We agree that fusion power plants should be subject to cyber security regulations as for any other type of critical national infrastructure.

15 What in your view should cyber security regulations for fusion cover?

No comment; this is outwith our area of expertise.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

We always encourage operators to engage at the earliest opportunity with us and agree that this should continue to be encouraged for potential fusion operators in Scotland.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

18 What are your views on how such engagement should work?

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

If the regulation of fusion energy is considered to be sufficiently different from how we regulate other radioactive substances activities then additional guidance should be developed. It may provide reassurance to potential fusion energy operators on the expectations of the regulators and the process for determining applications for fusion energy. It may also provide transparency of the process for the public and other stakeholders so they have confidence that it will be regulated appropriately.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

There is already an obligation on SEPA for public participation in the Environmental Authorisations (Scotland) Regulations that requires us to publish a public participation statement and have regard to this in exercising our public participation functions and we would consider if this needed any amendment for any potential new radioactive substances activities.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

SEPA has experienced staff involved in the regulation of a wide range of radioactive substances activities, and although we do not currently regulate any fusion operators, we are confident that we can build the technical capability within our staff through training and familiarisation with the technology and radioactive substances issues involved. This could be achieved through formal training and potentially supported by spending some time in a placement at an existing fusion facility.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

We believe that the formal regulation of fusion should be solely the responsibility of the existing environmental and health and safety regulators to ensure the clear and transparent separation of the operator and regulator functions. The technical expertise of UKAEA could be used to support the training and development of existing regulators' staff but the UK needs to be careful to avoid regulatory capture by involving the UKAEA's Fusion Safety Authority in any formal regulation or advice to government.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

Radioactive waste from fusion should be managed according to the same principles that we regulate radioactive waste from any other radioactive substances activity.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

The Scottish Government already has a policy that higher-activity waste is disposed of in near surface facilities so we would expect this for any radioactive waste arising from fusion activities as well.

25 What are your views on how a fusion facility should be decommissioned?

The Government already has a nuclear decommissioning policy that includes fusion; we propose that this policy is extended to include all the decommissioning of all radioactive substances activities, not just nuclear and fusion and then any considerations of how a fusion facility should be decommissioned can be addressed.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

If it is any different from decommissioning of other radioactive substances activities then separate guidance may be needed within the fusion guidance; if not then existing guidance may be appropriate.

27 Do you agree with the Government's proposals on safeguards for fusion?

Don't know

No comment; this is outwith our area of expertise.

28 What should the Government consider when developing guidance for export controls and technology licensing?

No comment; this is outwith our area of expertise.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

Yes, it is always good to keep the regulatory framework for all radioactive substances activities under review to ensure that it is appropriate and effective.

31 Before today, how much did you know about fusion energy?

Not Answered

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Neither support nor oppose

33 What is your level of knowledge about fusion after reading this paper?

Not Answered

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Neither support nor oppose

South Gloucestershire Council

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

This Council is not aware of any other regulatory areas, security or liability issues that should be addressed in relation to fusion energy, however the detail of fusion technology falls outside the expertise of this Council. The case presented by Government in the Green Paper in relation to maintaining the existing regulatory approach, cyber security and liabilities seems appropriate and proportionate to a lay reader.

The primary concern of this Council is to ensure that fusion technology is regulated appropriately and proportionately to ensure the safety, security and wellbeing of the communities, workforce and environment of South Gloucestershire and the wider area, and that there is openness and transparency with respect to the regulation of fusion during construction, operation and decommissioning.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Don't know

This Council does not have the technical expertise to be able to assess whether the Government’s conclusions in relation to the hazards and definition of future fusion power plants are correct.

The primary concern of this Council is to ensure that fusion technology is regulated appropriately and proportionately to ensure the safety, security and wellbeing of the communities, workforce and environment of South Gloucestershire and the wider area, and that there is openness and transparency with respect to the regulation of fusion during construction, operation and decommissioning.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Don't know

This Council does not have the technical expertise to be able to assess whether the Government’s conclusions in relation to the hazards and definition of future fusion power plants are correct.

The primary concern of this Council is to ensure that fusion technology is regulated appropriately and proportionately to ensure the safety and wellbeing of the communities, workforce and environment of South Gloucestershire and the wider area, and that there is openness and transparency with respect to the regulation of fusion during construction, operation and decommissioning.

In order to ensure safe and efficient decommissioning, it is vital that regulation actively requires consideration of this during the design of all fusion power plants.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Don't know

This Council does not have the technical expertise to be able to assess whether the Government's conclusions in relation to the hazards and definition of future fusion power plants are correct.

The primary concern of this Council is to ensure that fusion technology is regulated appropriately and proportionately to ensure the safety and wellbeing of the communities, workforce and environment of South Gloucestershire and the wider area, and that there is openness and transparency with respect to the regulation of fusion during construction, operation and decommissioning.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Don't know

This Council does not have the technical expertise to be able to assess whether the Government's conclusions in relation to the hazards and definition of future fusion power plants are correct.

The primary concern of this Council is to ensure that fusion technology is regulated appropriately and proportionately to ensure the safety and wellbeing of the communities, workforce and environment of South Gloucestershire and the wider area, and that there is openness and transparency with respect to the regulation of fusion during construction, operation and decommissioning.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

This Council does not have the technical expertise to be able to assess whether the Government's conclusions in relation to the hazards and definition of future fusion power plants are correct.

The primary concern of this Council is to ensure that fusion technology is regulated appropriately and proportionately to ensure the safety and wellbeing of the communities, workforce and environment of South Gloucestershire and the wider area, and that there is openness and transparency with respect to the regulation of fusion during construction, operation and decommissioning.

Given that fusion is an evolving technology, this Council agrees that the regulation should be regularly reviewed as the technology develops. The frequency of review should keep pace with the learning from the prototype and early plants. While no less than 10 years may be appropriate, it is suggested that intervals should be pegged to progress with and learning from design and deployment.

In order to ensure safe and efficient decommissioning, it is vital that regulation actively requires consideration of this during the design of all fusion power plants.

With respect to radioactive waste, it is recommended that consideration is given to a fusion regulation regime mandating that the volumes and levels of waste arising from fusion are safely minimised. It is suggested, given successes in recent years in achieving waste minimisation arising from fission plants and their decommissioning, there may be transferrable learning from the fission industry that might be applicable to the development of plans and strategies to deal with arisings from fusion technologies.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Don't know

This Council does not have the technical expertise to be able to assess whether the Government’s conclusions in relation to the hazards and definition of future fusion power plants are correct.

The primary concern of this Council is to ensure that fusion technology is regulated appropriately and proportionately to ensure the safety and wellbeing of the communities, workforce and environment of South Gloucestershire and the wider area, and that there is openness and transparency with respect to the regulation of fusion during construction, operation and decommissioning.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

From the public information available to date, and in particular from the STEP siting process, it seems that a fusion power plant is likely to be of a scale and complexity that is commensurate with other power plant technologies that come under the Planning Act 2008 (as amended) Nationally Significant Infrastructure Project regime. Given the timebound nature of this process, and the rigour with which projects are examined and determined, this seems an appropriate planning regulatory regime for fusion power plants.

9 What other issues should a Fusion NPS address?

10 Do you believe that a third party liability regime is required for fusion?

This Council is not aware of any other regulatory areas, security or liability issues that should be addressed in relation to fusion energy, however the detail of fusion technology falls outside the expertise of this Council. The case presented by Government in the Green Paper in relation to maintaining the existing regulatory approach, cyber security and liabilities seems appropriate and proportionate to a lay reader.

The primary concern of this Council is to ensure that fusion technology is regulated appropriately and proportionately to ensure the safety, security and wellbeing of the communities, workforce and environment of South Gloucestershire and the wider area, and that there is openness and transparency with respect to the regulation of fusion during construction, operation and decommissioning.

11 What are your views on the principles and issues around third party liability as set out in this paper?

This Council is not aware of any other regulatory areas, security or liability issues that should be addressed in relation to fusion energy, however the detail of fusion technology falls outside the expertise of this Council. The case presented by Government in the Green Paper in relation to maintaining the existing regulatory approach, cyber security and liabilities seems appropriate and proportionate to a lay reader.

The primary concern of this Council is to ensure that fusion technology is regulated appropriately and proportionately to ensure the safety, security and wellbeing of the communities, workforce and environment of South Gloucestershire and the wider area, and that there is openness and transparency with respect to the regulation of fusion during construction, operation and decommissioning.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

This Council is not aware of any other regulatory areas, security or liability issues that should be addressed in relation to fusion energy, however the detail of fusion technology falls outside the expertise of this Council. The case presented by Government in the Green Paper in relation to maintaining the existing regulatory approach, cyber security and liabilities seems appropriate and proportionate to a lay reader.

The primary concern of this Council is to ensure that fusion technology is regulated appropriately and proportionately to ensure the safety, security and wellbeing of the communities, workforce and environment of South Gloucestershire and the wider area, and that there is openness and transparency with respect to the regulation of fusion during construction, operation and decommissioning.

13 How can the Government promote the development of suitable commercial fusion insurance?

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

The primary concern of this Council is to ensure that fusion technology is regulated appropriately and proportionately to ensure the safety, security and wellbeing of the communities, workforce and environment of South Gloucestershire and the wider area, and that there is openness and transparency with respect to the regulation of fusion during construction, operation and decommissioning.

15 What in your view should cyber security regulations for fusion cover?

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Don't know

This Council does not have the technical expertise to be able to assess whether the Government's conclusions in relation to the hazards and definition of future fusion power plants are correct.

The primary concern of this Council is to ensure that fusion technology is regulated appropriately and proportionately to ensure the safety and wellbeing of the communities, workforce and environment of South Gloucestershire and the wider area, and that there is openness and transparency with respect to the regulation of fusion during construction, operation and decommissioning.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

Given that fusion is an emerging technology, it would seem appropriate that formal and fusion specific engagement between developers and regulators is put in place. This will help provide host communities with reassurance that any emerging issues in respect of safety, security and wellbeing are addressed at source. Separation and clear differentiation of responsibilities between developers and regulators will need to be made specific, open and transparent to ensure confidence that there are no conflicts of interest, and regulation is rigorous.

18 What are your views on how such engagement should work?

Given that fusion is an emerging technology, it would seem appropriate that formal and fusion specific engagement between developers and regulators is put in place. This will help provide host communities with reassurance that any emerging issues in respect of safety, security and wellbeing are

addressed at source. Separation and clear differentiation of responsibilities between developers and regulators will need to be made specific, open and

transparent to ensure confidence that there are no conflicts of interest, and regulation is rigorous.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

It is agreed that fusion energy guidance should be put in place in respect of fusion energy regulation, and it is requested that in order to maintain transparency for Councils, the public and communities, a plain English version of any guidance should be made available.

It is further suggested that this guidance requires the establishment of site-specific local community Site Stakeholder Groups for each site. These would provide a vehicle whereby progress, regulation and performance against standards and permits can be explained to the public and community representatives, and local people and organisations are able to ask questions of both the developer, operators and regulators of the facility throughout the planning, operational and decommissioning phases of the fusion power plant. The existing Nuclear Power Station Site Stakeholder Groups provide an appropriate model for this.

In terms of public engagement in the planning stages for an individual fusion project, as a Nationally Significant Infrastructure project, consultation requirements are set out in the Planning Inspectorates advice and guidance notes.

Public consultation along the lines of the Generic Design Process for fission might provide a useful starting point for designing consultation on fusion regulation and its review as the technology develops. This Council found it helpful to be able to ask relevant questions during the Generic Design Assessment for proposed fission technology, both via written responses and consultation workshops. These enabled non-expert questioners to receive plain English responses to questions about safety and environmental concerns from the community.

It is agreed that fusion energy guidance should be put in place in respect of fusion energy regulation, and it is requested that in order to maintain transparency for Councils, the public and communities, a plain English version of any guidance should be made available.

It is further suggested that this guidance requires the establishment of site-specific local community Site Stakeholder Groups for each site. These would provide a vehicle whereby progress, regulation and performance against standards and permits can be explained to the public and community representatives, and local people and organisations are able to ask questions of both the developer, operators and regulators of the facility throughout the planning, operational and decommissioning phases of the fusion power plant. The existing Nuclear Power Station Site Stakeholder Groups provide an appropriate model for this.

In terms of public engagement in the planning stages for an individual fusion project, as a Nationally Significant Infrastructure project, consultation requirements are set out in the Planning Inspectorates advice and guidance notes.

Public consultation along the lines of the Generic Design Process for fission might provide a useful starting point for designing consultation on fusion regulation and its review as the technology develops. This Council found it helpful to be able to ask relevant questions during the Generic Design Assessment for proposed fission technology, both via written responses and consultation workshops. These enabled non-expert questioners to receive plain English responses to questions about safety and environmental concerns from the community.

In order to ensure safety throughout the lifetime of a fusion facility, guidance should cover all phases of fusion development – construction, operation and decommissioning. Given that this is an emerging technology, guidance should be the subject of regular review in the light of experience and learning from the prototype plant and any follow-on operational plants.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

Public consultation along the lines of the Generic Design Process for fission might provide a useful starting point for designing consultation on fusion regulation and its review as the technology develops. This Council found it helpful to be able to ask relevant questions during the Generic Design Assessment for proposed fission technology, both via written responses and consultation workshops. These enabled non-expert questioners to receive plain English responses to questions about safety and environmental concerns from the community.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

The primary concern of this Council on behalf of its communities is the safety of its communities and environment and that of the wider area. While it is recognised that the particular skills and knowledge of UKAEA is world leading, in order for there to be confidence in the process, it is considered vital that the development of a regulatory framework must be subject to external and independent scrutiny.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

The primary concern of this Council on behalf of its communities is the safety of its communities and environment and that of the wider area. While it is recognised that the particular skills and knowledge of UKAEA is world leading, in order for there to be confidence in the process, it is considered vital that the development of a regulatory framework must be subject to external and independent scrutiny.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

With respect to radioactive waste, it is recommended that consideration is given to a fusion regulation regime mandating that the volumes and levels of waste arising from fusion are safely minimised. It is suggested, given successes in recent years in achieving waste minimisation arising from fission plants and their decommissioning, there may be transferrable learning from the fission industry that might be applicable to the development of plans and strategies to deal with arisings from fusion technologies.

In order to ensure safe and efficient decommissioning, it is vital that regulation actively requires consideration of this, including wastes arising, during the design of all fusion power plants.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Don't know

With respect to radioactive waste, it is recommended that consideration is given to a fusion regulation regime mandating that the volumes and levels of waste arising from fusion are safely minimised. It is suggested, given successes in recent years in achieving waste minimisation arising from fission plants and their decommissioning, there may be transferrable learning from the fission industry that might be applicable to the development of plans and strategies to deal with arisings from fusion technologies.

25 What are your views on how a fusion facility should be decommissioned?

In order to ensure safe and efficient decommissioning, it is vital that regulation actively requires consideration of this during the design of all fusion power plants.

The primary concern of this Council is to ensure that fusion technology is regulated appropriately and proportionately to ensure the safety and wellbeing of the communities, workforce and environment of South Gloucestershire and the wider area, and that there is openness and transparency with respect to the regulation of fusion during construction, operation and decommissioning.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

It is agreed that fusion energy guidance should be put in place in respect of fusion energy regulation, and it is requested that in order to maintain transparency for Councils, the public and communities, a plain English version of any guidance should be made available.

Guidance should cover all phases of fusion development – construction, operation and decommissioning. Given that this is an emerging technology, guidance should be the subject of regular review in the light of experience and learning from the prototype plant and any follow-on operational plants.

27 Do you agree with the Government's proposals on safeguards for fusion?

Not Answered

This Council does not have the technical expertise to be able to assess whether the Government’s conclusions in relation to the safeguards for fusion are correct.

The primary concern of this Council is to ensure that fusion technology is regulated appropriately and proportionately to ensure the safety and wellbeing of the communities, workforce and environment of South Gloucestershire and the wider area, and that there is openness and transparency with respect to the regulation of fusion during construction, operation and decommissioning

28 What should the Government consider when developing guidance for export controls and technology licensing?

The primary concern of this Council is to ensure that fusion technology is regulated appropriately and proportionately to ensure the safety and wellbeing of the communities, workforce and environment of South Gloucestershire and the wider area, and that there is openness and transparency with respect to the regulation of fusion during construction, operation and decommissioning

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

Given that fusion is an evolving technology, this Council agrees that the regulation should be regularly reviewed as the technology develops. The frequency of review should keep pace with the learning from the prototype and early plants. While no less than 10 years may be appropriate, it is suggested that intervals should be pegged to progress with and learning from design and deployment.

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

sw-Artha Ltd

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

Sharing the technology with developing countries … as I understand there is minimal risk to nuclear Hazards and falling the dangerous material in wrong hands…

If we keep this in the hands of limited countries, then it will become counter productive to climate change.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

It’s inline with current regulations and getting it up to date from time to time is a mandatory…. Based on technological advances …

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

No

Licensing is must.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

9 What other issues should a Fusion NPS address?

What to do with byproducts and it’s disposal…

10 Do you believe that a third party liability regime is required for fusion?

Yes

11 What are your views on the principles and issues around third party liability as set out in this paper?

-

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

-

13 How can the Government promote the development of suitable commercial fusion insurance?

-

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

15 What in your view should cyber security regulations for fusion cover?

Cyber attacks to sabotage or take down the IT systems of the power plant

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

18 What are your views on how such engagement should work?

-

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

No

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

Thru consulatation

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Thru close collaboration and paying well to physicist in this domain… this will propel the capabilities

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

Attract best talent and pay them well

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

It seems fusion energy will not produce hazardous waste….

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

25 What are your views on how a fusion facility should be decommissioned?

They can be recycled since it's pretty safe

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

-

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

28 What should the Government consider when developing guidance for export controls and technology licensing?

-

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

31 Before today, how much did you know about fusion energy?

Knew a little

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

Tokamak Energy

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

This answer and all answers in this response by Tokamak Energy only covers the regulatory context, associated hazards and our understanding magnetic confinement in spherical tokamaks and tokamaks. It does not consider the regulatory context and hazards of other technological approaches to fusion such as inertial confinement fusion, pulsed laser fusion or magneto-inertial fusion.

The proposal outlines most of the key hazards associated with the operation of a magnetic confinement fusion power plant such as a spherical tokamak. Hazards that were not referenced in the proposal include the use of pressure systems as well as the control of work equipment and machinery. The pressure system safety regulations as well as the provision and use of work equipment regulations already cover the risks associated with these activities and are suitable for the expected level of risk. Remote handling requirements of large / heavy elements of the tokamak and surrounding structures will fall under the lifting operations and lifting equipment regulations which are also suitable for dealing with the expected risks associated with these activities.

One of the elements not covered in a significant level of detail in the regulatory framework proposal is the possibility for fusion power to provide heat for industrial processes. This, along with other potential applications of fusion plants should be considered.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

Having reviewed the government proposals, the analysis contained is for power plants of the DEMO scale (very large single tokamaks operating at 3 GW fusion power). It follows that our emphasis on compact, modular devices significantly reduces the hazard associated with an accident scenario, because it would only mobilise the dust and tritium inventory from a single smaller device (except in the incredible case of complete destruction of the facility). We therefore believe that our system could be orders of magnitude safer than the design parameters than the parameters the consultation document is based on.

Nevertheless, the overall conclusions around expected hazards of future fusion power plants such as (spherical) tokamaks are well considered. Table 1 shows the limited hazard potential of even a large-scale fusion plant and effectively demonstrates the relative societal safety of future power plants. The third hypothetical scenario is only credible in the event of an extreme natural disaster or the attack of a foreign nation on a country's infrastructure. The impact of these events would dwarf, by many orders of magnitude, the potential radiological impact. As the UK is a (relatively) seismically inactive the consideration for such scenarios do not require significant substantiation. Other occupational health and safety and environment risks present a far more likely impact scenarios.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

The approach recognises that there a fundamentally different levels of radiological and environmental risk between nuclear fission and nuclear fusion plants: namely that due to the nature of the fuel, the former has the potential for uncontrolled criticality/accidents and the accidental dispersion of very long-lived alpha-decaying radioisotopes into the environment – the nature of nuclear fusion is such that similar accidents are not credible. The different regulatory regimes reflect the very considerable difference in risk between nuclear fission and nuclear fusion, and therefore ensures that the degree of regulatory oversight is proportionate. As noted in Table 1 of the Proposal Document, the radiological consequences of a worst-case scenario accident in a fusion plant is substantially (orders of magnitude) lower than corresponding accidents from fission plants.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

The three hierarchical tiers of Registration, Notification, and Consent embodied in IRR17 ensures that the HSE regulator is fully engaged prior to any operation involving deuterium/tritium requiring consent, and through the consent process and additional engagement can be satisfied that all necessary risk assessments and procedures/measures are in place to reduce the risk to ALARP. Likewise, the EPR16 permitting process ensures that the EA regulator is able to fully consider radioactivation and waste disposal routes, can be satisfied that all necessary discharge and keeping permits are in place for prior to activities and the quantities of radioactive material present are within radio-isotope specific limits set by legislation, and that all practices to limit the impact on the environment – balanced against other risks – is compliant with the BPEO/BPM philosophy. The risks associated with nuclear fusion are more comparable with the chemical industry and facilities holding large source for industrial radiography than nuclear fission (where run-away chain reaction accident scenarios are credible) - therefore regulation through IRR17/EPR16 as for the chemical and radiography industries is both proportionate and consistent.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

Power plants that do not contain fissile materials should not be regulated under NIA65. The NIA65 presents a proportionate approach to the regulation of the fission industry due to the high severity of incidents (as evidenced by high-profile catastrophic plant failures around the world). This hazard is not present in fusion plants and therefore there is no requirement for the stringent safety requirements placed upon the fission industry to be placed on the fusion industry.

As we have highlighted in our other responses the proposed regulatory framework must be proportionate to the level of risk presented by the technology.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

A national policy statement for fusion power plants is sensible. Existing justified practices allow the use of ionising radiation for fission power stations.

Fission plants produce significant amounts of high-level long-lived radioactive waste. Additionally, the catastrophic hazard of a nuclear meltdown exists.

Fusion power plants by comparison produce comparatively small amounts of radioactive waste that is not as long lived. There is no risk of a runaway nuclear reaction, and an improbable worst-case off-site release of radioactive materials presents only a comparatively minimal hazard to the public.

The timing of the justification process needs to consider the requirements of both private and public fusion organisations, taking into account that private fusion developers are seeking to deliver fusion plants earlier than public organisations.

If the government is seeking to put in place this national policy statement, then feedback and input should be sought from the private fusion operators in the UK to ensure their expertise and input is embedded into the policy statement.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

Currently under the NIA(1965) the appropriate Secretary of State has the power to prescribe certain installations as falling under the auspices of the NII (now ONR) by declaring the installation a “prescribed kind” 1(1)(b). “Prescribed kind” meaning ‘An installation which produces or uses atomic energy’ 1(3)(a) and ‘atomic energy’ is defined as “the energy released from atomic nuclei as the result of any process” by the Atomic Energy Act (1946) – therefore the possibility exists for fusion plants (particularly where energy released during the fusion process is recirculated for auxiliary heating, hotel power or converted to electrical energy to the grid or heat energy for industrial applications) to be declared within scope of ONR regulation through a statutory instrument (regulation) along the same lines as the Nuclear Installations Regulations (1971) for other nuclear installations. This may have a chilling effect on the roll-out of nuclear fusion in the UK given the uncertainty/risk. Specifically clarifying through primary legislation that nuclear fusion is not in scope of the NIA(1965) as amended would greatly increase confidence in nuclear fusion from a commercial operation perspective.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

A fusion NPS will be very helpful as part of a process to accelerate development of commercially deployable fusion energy – and then to enable rapid deployment in the UK. This will help to achieve two objectives: i) assist the UK in achieving deep decarbonisation targets in the late 2030s and 2040s; ii) enable the UK to have a strong position as an exporter of fusion technology and hence to secure long term economic benefit based on the UK’s current world lead in fusion science.

Note that our expectation is that private investment in fusion energy will grow very rapidly in the next few years (in the US, UK and globally), to the point where it easily exceeds the present level of public funding – and the effect of this will be to accelerate the development timescale for fusion energy.

9 What other issues should a Fusion NPS address?

A fusion NPS should cover all elements of the technological benefits of fusion plants. This includes the potential for production of zero carbon high-quality industrial heat and fuels for a hydrogen economy.

It should also be emphasised that fusion power is the only technology that can deliver a low carbon base load supply of energy with a low environmental

footprint whilst generating comparatively small amounts of low level and intermediate level radioactive waste.

10 Do you believe that a third party liability regime is required for fusion?

The Paris Convention specifically excludes facilities with low-levels of radioactivity such as uranium mining and milling, and radioisotope production. We believe that a fusion facility consisting of modular compact spherical tokamaks falls within this category. We note that the accident scenarios outlined in the “Hazards associated with fusion” section are derived from studies on DEMO devices with major radius > 6 m, containing large mobilisable inventories of dust and tritium. Loss of containment for such a device could lead to the consequences outlined in Table 1, but the same accident scenario involving a compact tokamak would have potential consequences an order of magnitude smaller. The doses also assume that the plant has water in the primary coolant loop, which leads to the release of HTO; our design philosophy is based on water-free devices, to simplify design and improve safety. The inhalation dose coefficient for HT gas is 10,000 times lower than that of HTO [ICRP134 page 39], therefore the off-site consequence of tritium released during a foreseeable accident is negligible.

We concur that the total tritium inventory within a fusion-energy plant or facility is likely to be of the order of 1018 Bq or lower, well below the NIR18 limits. We also note that the worst-case release of the entire tritium inventory to the environment is unlikely to lead to any “nuclear damage” as defined in the Paris Convention: Widely dispersed, the tritium activity is unlikely to lead to any significant biological effects in a population or ecosystem, owing to the relatively low dose coefficient for tritium-containing compounds [ICRP134 page 39].

While a convention on third-party liability may be appropriate for fusion plants with large tokamaks that could foreseeably have moderate or significant off-site consequences in the event of an accident, it is disproportionate to have specific rules in place for modular fusion plants that have low or negligible consequences. We suggest, therefore, that any such convention should have a threshold for applicability, based on a HAZOP assessment. Fusion facilities below the threshold should be able to seek insurance within the competitive market for general industrial plant and avoid the complexity of international convention.

11 What are your views on the principles and issues around third party liability as set out in this paper?

As above.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

There should be no strict liability around the requirements for third-party liability as per the reasons outlined the answer to question 10.

13 How can the Government promote the development of suitable commercial fusion insurance?

It should be noted that the risks associated with the radioactive inventory in a fusion facility are similar to those of other large industrial plants. It would seem prudent for similar insurance requirements to exist for fusion plants as they do for these types of industries.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

We agree that if any cyber-security regulations are put in place, they should be appropriate and proportionate to the level of risk presented by the infrastructure. In the example used in the government consultation document COMAH sites are regulated via the HSE. This is an approach proportionate that reflect the level of risk presented by fusion power devices.

Furthermore, fusion technology providers need to protect their business interests from industrial espionage and attack. Therefore, it will be important for those building and operating fusion power plants to have appropriate cyber and physical security control in place that protect their intellectual property and assets.

15 What in your view should cyber security regulations for fusion cover?

There should be no sector specific requirements for fusion around cyber-security as there are no specific risks associated with the technology that require regulation above and beyond the regulations currently in place for other industrial facilities and (non-nuclear) power generation facilities.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

The proposed definition of fusion energy facilities as 1) producing >50MW of generating capacity; 2) handle >7E16 Bq of tritium, is sound based on the rationale provided (national strategic interests (1); and 100 times the limit set in REPPIR (2)). The proposal could be improved on three points:

A) by replacing "and/or" with simply "or" to remove ambiguity; reflecting that if either criterion is satisfied then the corresponding rationale would by itself justify enhanced regulatory engagement.

B) Furthermore, it should be clarified that for fusion energy facilities with modular design concepts, the generating capacity should be taken as the actual intended capacity of the facility as a whole – accounting for the fact that modules may not be generating power concurrently. For example, two tokamak modules each capable of generating 40MW but with a common fuel cycle, power supplies and power generation plant which cannot accommodate both tokamaks simultaneously (such that the facility power output is capped at 40MW at any one time) should not be within scope – assuming that the tritium criterion is not satisfied; whereas in contrast 2 off 40MW modules which are designed to operate simultaneously/ independently such that the facility power output is 80MW should be within scope.

C) More precise definition of "handle" as it pertains to tritium. This could mean the amount of tritium which is kept on-site and is wither within recoverable storage, or mobile within the fuel cycle – not including tritium which is immobile and irrecoverable (absorbed within structure) outside of a detritiation process.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

Tokamak Energy believe that a formal engagement between the HSE and EA would be beneficial to ensure that there is alignment between fusion plant operators and regulators. A framework proportionate to the risks presented by fusion will ensure that the legal requirements enforced by the regulator are efficiently and effectively addressed by industry. This will allow for a fast, safe and timely delivery of commercial fusion energy helping the world achieve its carbon reduction targets.

Tokamak Energy are an advocate of goal setting approach that is not overly prescriptive. As an example, current health and safety legislation in the UK is largely goal setting and in terms of safety outcomes and leaves the detailed implications up to the organisation to manage. In the same way regulatory engagement might set performance outcomes leaving the detail of how these safety goals are archives to the designer and operator.

Formal engagement will also support fusion organisations to fulfil their legal duties as they progress from research and development devices that demonstrate key technologies, to continuously operating fusion power plants. The shift from R&D to power plant operators will bring with it the requirement to adapt processes and organisational structures.

It is evident that where e.g. France has chosen to regulate fusion (ITER) under the traditional nuclear fission framework, this has introduced significant complexities that are disproportionate to the level of risk presented by fusion devices. Should the UK implement a proportionate level of regulation facilitated by effective formal engagement this will be a model that can be duplicated across the world thereby accelerating the global deployment of fusion energy and delivery of net zero.

We have also seen that the ONR generic design assessment process (GDA) which has designated legal hold points in it would significantly and unnecessarily slow the potential deployment of fusion in the UK / globally. Nuclear licence site operators also need to meet certain licence conditions.

These are overburdensome for the level of hazard presented by a fusion power plant and present a disproportionate level of time, effort and resource.

18 What are your views on how such engagement should work?

Early formal engagement sessions should involve the setting and review of high-level targets or safety goals. Subsequent engagement sessions would then allow the designer of a plant to demonstrate how these safety goals are being met in the design. As an example, in the design of the tritium fuel cycle a regulator might set a maximum level of inventory present on the whole site. How the inventory is safely managed would be incumbent on the designer to prove.

Where an organisation evolves from designer to operator formal engagement sessions would adapt to suit the needs of the changing requirements.

Formal engagement sessions between regulators could cover:

• An overview of the planned designs, associated hazards and the controls in place to ensure employee, public and environmental safety

• Sharing of information on organisational resources, structures and capabilities

• Providing an overview of processes around ionising radiation safety, dosimetry and environmental monitoring, hazardous and radioactive waste

management and other relevant areas of occupational health and safety

• Review of emergency planning arrangements

It is also important for regulators to ensure the transparency in the regulatory approvals process and ensure that the current status, timescales and decision points are clearly understood by all parties involved in the permitting process. Regulators should also ensure that a sufficient level of resource is allocated to ensure swift turnaround on any regulatory engagement sessions to give the UK fusion industry a competitive agile edge.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

The Health and Safety Executive and Environment Agency have a large range of helpful publications that detail how legal requirements related to certain environment and occupational health and safety topics can be met. These documents present useful guidance on how to achieve best practice whilst allowing organisations the latitude to find alternative controls that meet or exceed the requirements of the UK's goal setting legislation.

Additionally, the consultation document highlights a "joint guidance document" being "produced by BEIS, EA and HSE, working with UKAEA as necessary".

Any guidance documentation being produced should also be done in consultation with public and private fusion entities operating in the UK.

Guidance providing clear information on the responsibilities of designers, operators and ancillary industries within the proposed UK fusion framework from criteria for safety assessment principles, to operational expectations and the disposal of radioactive wastes would allow our sector to operate effectively.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

Public engagement in the regulatory process for fusion is likely to produce a groundswell of enthusiasm for the technology as the majority of the public start to understand the inherently safe nature of fusion and start to understand the environmental and economic benefits. This groundswell of enthusiasm will help to drive more private investment into development and deployment of fusion energy technology and will also encourage public investment in the underpinning research.

Over the next few years' it seems highly likely that global carbon emissions will continue to rise, despite reasonable efforts in many countries. This carries risks of social unrest. Many young people in particular feel that global warming is an insurmountable problem. Fusion offers one of very few possible and desirable solutions to the challenge of deep decarbonisation. The public will expect to be engaged in the regulatory process for fusion and are likely to embrace development and deployment of the technology.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Fusion energy has a wide variety of hazards associated with the design, operation and subsequent decommissioning. While the device looked at as one system presents a high level of complexity, many of the individual subsystems' hazards are found in far greater proportions in other industries that are already successfully regulated by the EA and HSE. Both agencies already employ experts in many of these areas.

There may be a requirement for both regulators to work closely together to ensure a level of consistency as well as a clear understanding of what elements of fusion are looked after by each body. It will also be important for regulators to ensure the proportionality of the interpretation / implementation of fusion regulations to the hazards presented by fusion energy devices.

Regulators may wish to understand the capabilities of their own organisations and form a suitable working group that are able to gain the specialist technical capabilities already present. Capability may also be built through the regulatory engagement referenced in earlier sections whilst having processes in place to ensure regulatory capture does not occur.

Where technical expertise may be lacking in specific areas the agencies may need to recruit directly from the fusion industry to gain necessary expertise.

Direct recruitment of fission expertise should be considered carefully as from our engagement with expertise from this sector has shown that there is a

tendency to apply fission principles which are disproportionate to the hazard presented by the operation of a fusion plant.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

It is reassuring that the potential for a conflict of interest has been identified regarding the UKAEA's own development programmes (i.e. STEP). The technical expertise of UKAEA is invaluable but the experience of UKAEA with respect to fusion regulation is largely derived from JET, which applies a safety infrastructure similar to that of a nuclear licensed site, and ITER, which is equivalent to a nuclear licensed site in the French regulatory system. Therefore, there is a risk that the UKAEA's advice will be biased towards disproportionate caution. The advice should therefore be transparent, so that it can be challenged. We suggest that the technical expertise could best be used within a framework of technical working groups involving the UKAEA, the regulator, industry and academia. Working groups would provide opportunities for the regulator to learn from experts and provide dissemination of best practice in the fusion sector.

Another area of caution is to ensure that regulatory approach for fusion and timescales for implementation are not determined by UKAEA's own programme requirements (i.e. STEP), but by the requirement of the sector as a whole which will undoubtedly move faster.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

As far as possible a fusion device should be self-shielding to minimise the total mass of activated materials and the fuel cycle should minimise tritium loss. The most sustainable waste management strategy is that which reduces disposal to a minimum, therefore recycling/reuse of device and fuel-cycle materials should be maximised. This will require safe decay storage and economically viable detritiation facilities, with clear routes for reuse of materials, e.g. in the nuclear industry. Recovery of tritium will be in the interest of operators, as it will reduce the likelihood of migration into the environment and will have high economic value as start-up inventory for new fusion devices. For a fusion facility with multiple devices, it may be economically viable to have the detritiation facility on the same site, with a mechanism for feeding recovered tritium back into the fuel system for other plants.

Typically, materials from fusion devices have a low proportion of long-lived radionuclides ($t1/2 > 30$ years), especially if carefully designed, therefore a strategy of detritiation and temporary decay storage could reduce the overall volume of radioactive waste requiring specialised disposal facilities. For materials that cannot be reused or recycled near-surface disposal facilities appear to be the most economic and sustainable disposal route, given the relatively low risk that is anticipated from detritiated waste.

If detritiation is not economically viable then temporary decay storage for ~50 years could be used to reduce both the activation and tritium activity. This is the approach taken with ITER waste and the INTERMED facility.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

Activated materials from fusion plants are typically metallic and ceramic components containing beta and gamma-emitting radionuclides. The waste should have relatively high self-shielding factor and low dose-rate to activity-concentration ratio. At-surface disposal facilities including concrete vaults should suffice to minimise the external dose rate, thus the effect on people and the environment. This is especially true if materials are detritiated prior to disposal to prevent uncontrolled migration of tritium into the environment. If no detritiation is conducted prior to disposal then dedicated facilities with strategies for minimising the effect of tritium off-gassing would be necessary, but these could still be near-surface facilities.

25 What are your views on how a fusion facility should be decommissioned?

It is likely that a fusion facility will contain one or more devices in sub-grade silos. When a device reaches end of life it would be left in situ for a period to allow the decay of short-lived radionuclides. Remote handling technologies, which will be required for maintenance, will then the used to dismantle the machine and separate the waste according to tritium contamination and activation. Tritium-contaminated components would be sent to a detritiation facility and then either to an accessible decay store pending re-use or recycling, or to a near-surface disposal site. Optimising the site end state could involve leaving sub-surface structures in situ and filling voids with the rubble from above ground, thus shielding the surface environment from the most activated structures. The decommissioning process would be directed towards creating a site suitable for publicly accessible heathland. This strategy is aligned to the assumptions on the end state for the Winfrith and Trawsfyndd sites as outlined by the NDA [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/973438/NDA_Strategy_2021_A.pdf]. With careful fusion plant design this should be achievable within 50 years of the end of life of the facility.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

Guidance could provide the regulators' view on the Best Available Techniques (BAT) for management of waste from the fusion-energy industry. Since fusion is in its infancy and there are differing regulatory approaches in different countries, it would be beneficial to have a benchmark of the BATs that developers could improve on over time.

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

As tritium is not a fissile material there should be no legislative requirement for safeguarding of the material. Strict tritium accountancy is going to be an important factor for any fusion power plant to ensure that the fuel does not escape into the environment or cause exposure to persons. Should safeguarding controls for tritium be implemented it is likely to place unreasonable burdens on operators.

There are also small amounts of radioactive materials contained in various diagnostic equipment. These are typically miniscule amounts and are currently governed by the requirements of the IRR.

28 What should the Government consider when developing guidance for export controls and technology licensing?

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

With any new regulatory regime, it is important to ensure that it is reviewed in consultation with those who are bound by the regime, provided that the foundations of the regulatory framework do not change significantly. Major policy changes and shift in regulation may have the unintended effect of raising uncertainty and reducing potential investment in the sector thereby slowing the national and global deployment of fusion.

That being said, there is a wide variety of technological approaches to achieving fusion energy. The best understood and most researched technology is magnetic confinement fusion in the form of a (spherical) tokamak. There are however still many challenges that need to be solved to achieve the delivery of power generation to the grid. Even though the hazards are generally well understood there is the possibility for some new, currently unforeseen, engineering or physics hurdles to appear. Additionally, it may be that an alternative approach that is not magnetic confinement fusion is more successful that however brings with it some hazards that have not previously been anticipated. Only in circumstances where substantial changes in the hazard profile arise should significant policy and regulatory changes be made.

Minor adjustments to the regime to clarify areas that were not appropriately considered, or were not operating as smoothly as they could, would benefit from a review framework. For these reasons, with the above caveats, it is prudent to keep the regulatory framework under review as appropriate when significant shifts occur or when further clarity is required.

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

35 What is your country's / organisation's planned approach to regulating fusion energy?

Tokamak Energy see the implementation of a risk-propionate and clear approach to the regulation of fusion energy as critical to the success of the commercialisation of the technology. Such regulations will give designers, operators and ancillary industries the confidence to operate within a clearly understood framework, whilst providing an assurance to the public that fusion is safe.

Internally we are developing transparent systems that will provide our people, regulators and the public the assurance that all hazards are well understood and appropriately managed to ensure environmental protection, safety and the wellbeing of all persons affected by our operations.

UK Atomic Energy Authority (UKAEA)

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

Not explicitly, although the coherent application of multiple sets of regulations will need to be kept under review.

The Green Paper makes clear that regulations relevant to non-fusion industrial facilities (e.g. COMAH) will also apply. However, until detailed safety analysis is completed there remains some potential that the response to one set of regulations may be in tension with the response to another set of regulations. For example, industry-standard responses to issues like discrimination within electrical systems may need adaptation to ensure any non-electrical faults in a complex tokamak are not exacerbated. Experience of operating JET provides a solid basis for assessing coherence across multiple regulations, but the challenges of energy-scale plant may alter the current understanding. Hence, as commented later, a close working relationship between STEP (and other early operators) and Fusion Regulators will be necessary.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

We agree broadly, though there are specific non-radiological hazards that UKAEA understands from its experience in operation of JET that must be considered in a proportionate way within the overall Regulatory framework.

Overall, we agree that the radiological hazards are well described in the Green Paper and the accompanying Fusion Safety Authority's (FSA) "Technology Report – Safety and Waste

Aspects for Fusion Power Plants". The accident scenarios that could affect the public are conservative/pessimistic (e.g. release of all mobilisable tritium and activated dust from a large device for the hypothetical worst-case accident), which provides reassurance that the conclusions will survive as device designs and site layouts are developed, especially given the scope to reduce the hazards and impacts by design, although it is very important not to prejudge the eventual situation. We agree that these single extreme events identified are likely to have the biggest potential impact on the public (e.g. releases during normal operation and maintenance are negligible). We note that the dose at a reference 1km from the release should not be taken as an indicator of the necessary site dimensions but is simply a reference.

The spirit of the Green Paper is to encourage and accommodate innovation ("Our proposals aim to enable the safe and rapid deployment of fusion energy power plants, promoting innovation while maintaining human and environmental protections at all times"), reflecting the early stage of development of fusion power plant concepts. We agree that the uncertainty in the concepts at this stage means that the accident scenarios and the nature of the hazard mitigation cannot be described in much detail. Furthermore, investors and other stakeholders may choose to adopt a higher risk appetite or an unconventional balance of risk and benefit as far as investments are concerned in order to enable early success and rapid progress without the traditional exhaustive experimental verification and prototyping – indeed such verification is impractical for some parts of any fusion device.

While the design process is likely to be rigorous in mitigating predictable events even for innovative concepts, the first fusion power plants may have unexpected failures, and there may be upgrades. However, this is expected primarily to affect the frequency or likelihood of internally generated events, not their severity in terms of radiological impact. In addition, it is possible that significant upgrades and improvements may be needed, which will modify the details of the hazards, but they are expected to remain within the categories already identified. For the worst-case events, the Green Paper and the FSA report focus on the containment barriers and do not give credit to the reliability of the internal components and systems or make assumptions about their failure modes – this seems an entirely appropriate approach at this stage and has the side benefit of making the accident assessment more resilient to, and accommodating of, innovations and internal changes inside the containment barriers. Clearly, the safety cases produced for fusion plant will address mitigations within these bounding assumptions.

For magnetic confinement fusion plant designs there is a range of non-radiological hazards in a variety of areas - while they have not been assessed in detail, they are expected to be no worse than in other large facilities and plant even if different due to different technologies. These other hazards are more numerous and varied than the radiological hazards, but their effects are expected to be localised within the plant. They may however, as with many large facilities and industrial plant, be the dominant issues for the protection of the short and long term workforce during the life of the plant and will need consideration throughout, starting from the concept selection and design (they are alluded to in the FSA report). Examples include (some are complicated by the presence of activated materials):

• Building and plant construction and operation: known hazards associated with very large structures. Handling of large components for maintenance;

• Equipment manufacture and supply: issues with material purity can affect the activation levels, untestable components may fail in unexpected ways (so these must not be safety critical);

• Operation and maintenance: high voltages, strong magnetic fields, high power microwaves and radio frequency waves; high pressure and high temperature fluids; cryogens and associated oxygen depletion; chemical hazards including explosion (hydrogen isotopes are used as fuel);

• Decommissioning: construction and demolition hazards; movement and size reduction (machining) of large items.

We also note that alternative (non- magnetic confinement) fusion concepts use high power lasers, high velocity projectiles, or high velocity and pressure pistons.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

We agree broadly, although the detail of best practice will need to evolve consistent with the different hazards and technologies that energy-scale plants will present.

As commented earlier, the existing approach to regulation of fusion has proved effective and proportionate. The evolution of energy-scale plant presents both increased and different hazards and so the approach taken to date will also need to evolve. Experience from fission safety work shows that the way in which detailed methodologies develop and become embedded in the form of “relevant good practice” can, in certain cultures, lead to excessive conservatism and complexity which add little if anything to delivered safety but increase cost and schedule. Fusion has the potential to be a lower risk technology than fission and hence, at the strategic level, could eventually be an ALARP choice. But that potential will only be realised if an appropriate approach is taken to the detail of justification and to the culture in this nascent industry, as well as to the overarching Regulatory Framework. Through the STEP Programme, UKAEA intends to develop appropriate methodologies for the justification of safety and will work collaboratively with Regulators on these.

UKAEA also notes that the proposals will result in at least 3 organisations (EA, HSE and ONR) having defined regulatory responsibilities for fusion. Given this, it is also advised that early cross-regulatory forums are established to ensure coherency across the Regulatory community. STEP intends to convene such a forum at the strategic level, along the lines of that established at Sellafield Ltd. and adopted subsequently by Defence Nuclear sites.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

These regulations have proved proportionate and successful at Culham. UKAEA has implemented a safety case approach where safety, environmental and security aspects are considered across all project phases from design and construction through to commissioning and operations and decommissioning, which has allowed us to demonstrate compliance, but the regulations themselves have proved appropriate. Although future power plants will be on a larger scale, there is confidence that the regulations can continue to be applied, allowing proportionate assessment of the relevant radiological and non-radiological hazards.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

Whilst there is much good in the arrangements that flow from the NIA65, the hazards presented by fusion plant are significantly different and should be regulated through a bespoke framework.

UKAEA agrees with the initial premise of UK Government, and recommendations of the Regulatory Horizons Council, that Fusion facilities should not in the foreseeable future be considered under the terms of the Nuclear Installations Act 1965 and as such should not be brought within the remit of the nuclear licensing framework led by ONR.

As the Green Paper notes, Fusion, especially at energy-generating power levels, will present significant radiological hazards, principally through high-energy neutron flux, the consequent activation of some materials within the plant and through the use and generation of tritium. However:

• There is no runaway criticality scenario, as exists for fission plant;

• The radiological toxicity of substances held on site are less significant than is the case for fission plan, specifically there will be no High Level Waste;

• There is not a spent fuel handling scenario as exists for fission plant;

• The timescale of any reasonably foreseeable accident sequence is very short which, combined with the nature of the radioactive substances on site,

would result in off-site hazards comparable with major industrial plant and far lower than fission plant in the unlikely event of any accident.

Due to these significant differences, the scale of risk arising from a fusion plant is fundamentally different to that for fission plant, and as such application of the same regime would be disproportionate. The problem is best characterised as “radiological” rather than “nuclear” (in the sense that nuclear is understood more widely by the public) and those radiological hazards can be adequately regulated through the IRR2017 and EPR2016 (see answer to Question 4).

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

UKAEA is supportive of the proposals but advises that the process must be proportionate to the early stage of fusion energy development and not seek to cover the same depth as later formal permissioning, and must recognise a wide variety of technology approaches.

UKAEA recognises the obligation to undertake a “Regulatory Justification” for any new class or type of activities involving ionising radiation, to demonstrate that the benefits of the activity outweigh the radiological risks. UKAEA agrees that STEP - as the major government backed programme to deliver an energy-scale plant in the UK - should make such an application.

The appropriate scope of any such application must be developed based on a review of the technical information and the requirement of the regulations.

This should include analysis of what range of technologies and concepts could be covered under a single application. UKAEA agrees that the STEP application should be shaped to enable other projects to be included within its remit, where it is possible to do so whilst providing a submission which is sufficiently specific to meet the requirements of the justifying authority. UKAEA will engage private sector parties – and the Justifying Authority – to address this question.

UKAEA agree that it is not beneficial to focus such an application solely on production of electricity, but on energy more generally.

Recognising that fusion plant could provide a number of different roles on the path to commercial operation, UKAEA propose that any such application should not be limited to net energy production but should be scoped to provide for energy generation in pursuit of the realisation and application of fusion energy.

The form and depth of a Regulatory Justification application is also a point for further consideration alongside the Justifying Authority. While there is a relatively established format for those submitted by the UK’s Nuclear Industry Association (NIA) for the EPR, AP1000 and UK ABWR, this form and depth is not common across all nations covered by the applicable ionising radiation regulations. As such, STEP will work with UK Government to agree the appropriate form and depth of the application, prior to submission.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

The development of fusion technology and its wide adoption will require total clarity for developers and investors.

UKAEA agrees that a legislative approach would offer certainty, clarity, and confidence to stakeholders (investors, industry, delivery organisations) that a nuclear site licence is not required for fusion plant. However, we also note that legislation can take time to put in place and significant delay could have the counter-productive effect of increasing stakeholder uncertainty. We suggest that significant preparation is done to ensure the speedy passage of such legislation and advise that this is one of a number of aspects of fusion where formal and enduring cross-Party support should be actively pursued.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

UKAEA agrees with the proposal but consideration should be given to widening the intended NPS scope beyond “generating stations”.

Establishment of a National Policy Statement (NPS) for Fusion plant would bring planning arrangements in line with those applicable for other energy technologies of a similar scale and significance. This would: ensure consistency across the planning regimes; offer all the benefits and efficiencies of the Planning Act 2008 to Fusion Plant; provide for the same levels of public consultation for Fusion Plant as those available to communities hosting other major technologies, as established under the Planning Act 2008; and would offer confidence in the delivery pathway for fusion plant to stakeholders (investors, industry, delivery organisations).

Given the early stage of fusion technology development, UKAEA do not believe this should be limited solely to ‘generating’ technology. UKAEA urge that the National Policy Statement is developed with sufficient breadth to provide confidence and clarity to a wider range of fusion plants. As we also note in response to Question 16, large-scale research plants may not generate net energy above 50MW but may have thermal power levels of many hundreds of MW and, therefore, similar hazards to energy generating plant. There is also potential for some plants to focus on Tritium production rather than net energy generation and these should absolutely be in the scope of any NPS, and of any safeguarding measures. Further, there may also be potential for other major fusion technology facilities with similar radiological hazards that are not generating energy.

9 What other issues should a Fusion NPS address?

A Fusion NPS must be able to recognise the inherent variability in technological approaches given the early state of the technology.

UKAEA anticipate that any Fusion National Policy Statement would be established on broadly the same basis as those developed under EN-6, addressing strategic siting and environmental considerations. This should realise the strategic planning benefits as outlined in the planning Act 2008. Given the need to deploy fusion plant in a range of site environments, UKAEA agrees that a Fusion NPS should not be site-specific, thereby differing from the approach taken for EN-6. We also advise caution on the establishment of time constraints within a new NPS. EN-6 set a relatively short time horizon but to give certainty to developers and to stimulate the fusion sector, and much longer window, if any at all, should be set.

10 Do you believe that a third party liability regime is required for fusion?

Yes

Without adequate cover for liabilities, there is a risk this critical emergent technology will not flourish.

Third party liability ordinarily arises from loss, damage, injury or death caused by the negligence of a party which breached its duty of care to the victim.

Relying on common law fault liability as a sole remedy for loss or liability for potential injury from fusion activities could impede progress in establishing a fusion power plants due to the difficulty of assessing risk in operating this new fusion technology. This applies not just to lead developer organisations but may be a particular challenge for the many suppliers keen to engage but dissuaded by the potential liabilities they may face.

11 What are your views on the principles and issues around third party liability as set out in this paper?

A 3rd party liability regime is necessary, but the Paris convention may not be the most appropriate approach.

Although UKAEA agrees with the assessment that fusion is safe with very low likelihood of any accident occurring causing significant harm or damage, fusion is a developing technology and there are still elements of uncertainty around the overall hazard of fusion power plants. This uncertainty represents a potential serious barrier to entry into the fusion energy generation market. Further, the understanding of the relative risks of fusion among the wider public and stakeholders is low, which in turn could affect the establishment of a viable market. UKAEA is particularly concerned, as identified in the Green Paper, that “firms supplying key systems and components to fusion power plants should not be precluded from doing so by the potential for third party legal action…”, as has been experienced in the fission sector.

The Government envisages that liability for fusion power plants, like fission plants today, and the supply chain sustaining them should be ‘channelled’ to the site operator i.e. the entity who owns the site and plant. Liability in respect of radiological material connected with a fusion power generating site does then not need separate insurance to cover liabilities, helping to provide confidence to the supply chain and to investors.

The Government judges a strict (i.e. no fault) liability regime to be appropriate for fusion. The operator would be the party bearing such strict liability and UKAEA agrees with this approach. The Government has also expressed the belief at this stage that regardless of whether an international general liability regime was established, a competitive insurance market for fusion would help to ensure that the development and operation of fusion power plants is not hindered by the burden of [nuclear] liability.

These point to a need for a third-party liability regime, and an appropriate cap. There are currently extremely limited options for this which also forms a barrier to entry - for example, UKAEA has obtained Government indemnity for its own fusion operations due to the limited availability of third partly liability cover in the insurance market at the moment. However, although some of the features of the Paris Convention are relevant and attractive for fusion, extending the scope of that convention to fusion may not be the best approach, not least as it starts to apply legislation appropriate for fission to fusion when the intent of this Green Paper is to make a clear distinction between these technologies. We advise that further work is undertaken on developing a bespoke liability regime that could better assist the global use of fusion technology without conflation with existing fission protocols.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

Effectiveness in stimulating an insurance market, and a clear distinction from fission regimes.

Third party (and strict) liability could be a serious barrier to entry in the fusion generation market, especially to investors and site operators that they may consider investing in. The insurance industry will be sceptical at best and may even refuse to insure due to the uncertainty of the liability risk. Either way, it will result effectively in uninsurable risk that could price fusion energy out of the market. Hence the requirement for Government to promote commercial fusion insurance as noted in Q13. In addition, as noted in our response to Question 11, a bespoke liability regime distinct from fission would be preferable to enable investor and insurer clarity and to support the global deployability of this technology.

13 How can the Government promote the development of suitable commercial fusion insurance?

The Government should conduct a consultation or other exercise with the insurance market to educate it and seek views on the risks of fusion energy. The Lloyd's insurance market is particularly geared to innovative insurance solutions. Perhaps the Government could negotiate a second-tier insurance policy and Lloyd's would underwrite to a substantial level (and it would have reinsurance arrangements to spread the risk). The Government could act as a third-tier reinsurer effectively to de-risk the insurance market for liability over an agreed threshold. Other commercial insurers in the market could take on risk for the first tier of liability up to an agreed amount, and then tap into the second tier of cover excess cover offered by Lloyd's underwriters and the third tier of excess liability offered by Government.

There may be other and better models that the insurance market may suggest. The Government should also look at other sectors where insurance can prove difficult. For example, the Space Sector; the Government announced the results of its consultation on insurance and liabilities requirements in March 2021, and it may be suitable to take some of the proposed solutions, for example the limit on liability, and apply to the fusion market.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

Provided the selected regulations are appropriate to the hazards presented by each plant.

The Green Paper notes, and UKAEA agrees, that neither NISR 2003 nor NIS 2018 should apply to early fusion power plants. However, as plants develop, their contribution to the UK's dependable baseload energy supply may merit their consideration under NIS2018 (at potentially less that a 2GW total depending on total energy system resilience at the time).

The technology of energy-generating fusion plant is likely to include the capability to breed Tritium, and this may also be a feature of larger experimental machines or indeed the primary function of a fusion device. Tritium breeding technology, and the arrangements for the secure storage and handling of significant volumes of Tritium may attract interest from rogue states or actors and so compliance with cyber security protocols is critical. STEP plans to follow the principles of NIS2018 and this will provide more information on whether and how to adapt regulations to best suit the fusion case as we better understand the landscape. We would also note that projects starting now have the ability to build cyber resilience in from the start in a way that legacy projects do not, and so new projects should be encouraged to deal effectively with cyber risks.

15 What in your view should cyber security regulations for fusion cover?

Regulations need to be proportionate to the risks.

For example, loss of information or disruption of systems on some aspects of design or operation may present a genuine threat to national security whereas other intrusions may be limited to a commercial impact. Regulations should focus on dealing with wider and larger risks, effectively setting a risk appetite to be complied with in those cases, leaving organisations to determine their own appetite for risk on other matters such as commercial advantage. Concerning the wider risks, cyber regulation should consider, inter alia, anything related to: handling, breeding and storage of tritium; the potential for generation of fissile material in fusion plant; the robustness of critical fusion plant controls to external intervention.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

No

The criteria are a sensible starting point but should be expanded to cover significant thermal power and should specifically exclude fission-fusion hybrid plant.

UKAEA agrees that the thresholds of net generation of 50MW of energy, and or handling over 7 x 10^16 Bq of tritium, are appropriate for classification as a Fusion Net Energy Plant. However, the use of a net generation criteria only would miss large scale research plant or Tritium production plants, which would have very large thermal power levels and hence present significant hazards, but do not generate net energy, or large scale high energy neutron sources . Work is needed to define an appropriate thermal (fusion) power level and is complicated by the way in which fusion devices can have pulsed operation, but any such limit should broadly exceed thermal power levels achievable in the Joint European Torus. A different criterion would need to be developed for very short pulse concepts such as inertial fusion and magnetised target fusion and some other pulsed approaches.

We also believe that a formal definition of a Fusion Energy Facility should explicitly exclude fission-fusion hybrid devices, i.e. those devices where fissile material is deliberately introduced to produce tritium, energy gain or for materials processing. Exclusion would make clear that those devices would be regulated as fission plant, and this would create a clear distinction in the minds of stakeholders, investors and the public which would positively support fusion development.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

Early engagement between designers and regulators is critical to ensuring a shared understanding of the challenge, and hence a safe and proportionate response to that.

Such engagement is right for any complex technology where a principles-based regulatory system operates but is especially necessary for emerging technology where regulators need to build understanding and capability. Fusion is a relatively new context with both the design and supporting regulatory processes emerging. Differentiating between collaborative engagement and formal regulatory engagement is important to ensure the appropriate cultures and behaviours are developed. It is beneficial in the former to focus on developing the skills and relationships to partner well across the system, whatever the organisational context. Under collaborative arrangements both parties must learn from one another and mutually agree the necessary formal arrangements and processes. Once that has been completed, it is possible to conduct the more formal stage of engagement with guidance mutually agreed and adapted as necessary during first implementation.

Some of the key benefits of STEP, indeed a service that STEP intends to perform to benefit future privately run commercial plant, is to help develop regulatory SQEP by being a primary vehicle through which all stakeholders cut their teeth and learn lessons, and through which methodologies are developed jointly with regulators.

18 What are your views on how such engagement should work?

Engagement must respect the clear differences in responsibilities, but foster collaborative working. It must also have a strategic component. Where possible, engagement should be common across all regulatory bodies.

Early, regular engagement with regulators will help to secure a unity of purpose through active discussion, understanding expectations and challenges therein. Different levels of interaction may be appropriate, e.g. depending on whether the matters relate to policy, strategy or operational / technical issues. Experience from fission shows that strategic level engagement helps provide context for and guidance to those engaged in the more day-to-day detail of assessments. For regulators, such engagement provides understanding of the rationale for and strategic aspects of the project such as:

• Overview of the project programme, timeline for permissioning and consents, safety, environmental and security case strategy;

• Overview of plant design and key hazards and hazard management strategies;

• Focus on specific technical design and safety topics / issues (specific areas will be identified during higher level discussions);

• Keeping pace with developments in key fusion technologies so as to enable their safe but rapid adoption in plant within the scope of these new regulations.

Such higher-level engagements are also best conducted with all regulators present together with both the safety specialists and programme management team of the relevant programme. This way, there is consistency in the message and less chance of disconnects internal and external to the programme.

Detailed technical or site-specific engagements can then sit within the higher-level engagements as described. This should be a formal process, analogous to the Regulatory Interface Meetings / Forums used in the fission sector, with minutes and actions recorded to ensure transparency / auditability.

Any formal submissions to the regulator should be proportionate and focused. Further details can then be provided as requested or discussed via specific interactions.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

Additional guidance is necessary, but following the agreement on Regulators and with the support of STEP as a lead “developer”.

Firstly, the appointment of lead Regulators is necessary to ensure accountability for guidance. Issuing guidance in advance of that risks constraining the responsible regulators, undermining ownership. Secondly, and in this unique case owing to the novelty of the technology at power plant scale and the relative unfamiliarity of regulators, we would advise that guidance is co-developed / piloted so it can be assessed in terms of whether it can be followed.

STEP provides an ideal opportunity for this.

Additional guidance would be of benefit to clarify regulatory expectations, particularly in relation to the requirements of the safety, security and environment justifications, e.g. the need for a 'safety case' which is developed as the project evolves.

Guidance on relevant good practice relating to engineering and technical matters, the application of relevant legislation and risk assessment methodologies would also be of benefit. Examples include guidance similar to that provided by the HSE on offshore health and safety and COMAH sites, fusion specific guidance on Best Available Techniques and guidance on proportionate Security Assessment Principles for fusion.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

Public engagement in regulation should be on a voluntary basis and should be done in a structured and careful way.

UKAEA agrees with the thrust of the Green Paper that public support for fusion is essential, and that a clear and effective Regulatory Framework is a necessary part of generating that confidence. Hence, finding ways of engaging the public will be beneficial. The way in which this is done needs to recognise the variable level of understanding of fusion that will exist in the public at large. We see part of the Regulator’s role as being to help address that whilst maintaining an objective distance on any particular proposal. The current voluntary basis has proved effective in building trust and is able to be tailored appropriately to local circumstances.

A particular risk with public engagement, especially if on a statutory rather than non-voluntary basis, is that of introducing significant delay, potentially grossly disproportionate to the concern. Finding a way to weave Regulatory engagement with the public into the existing consenting mechanisms is likely to be the effective and efficient approach.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Through engagement in credible existing and planned programmes.

Both JET and ITER offer credible and significant opportunities for building regulatory SQEP and offer different approaches which could be helpful in stimulating thing. Engagement with STEP offers the opportunity to learn about the challenging design trades needed at power plant scale (which differ from experimental machines) and to work with a programme on the development of appropriate safety methodologies.

In addition, we would encourage engagement with the: medical sector given their experience in radiotherapy; the pharmaceutical sector given expertise in broader enabling innovation at pace for wider benefit; and perhaps the space sector which deals with rapidly evolving technology.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

UKAEA’s expertise across the fusion lifecycle, in particular in D-T operations, make it uniquely placed to support fusion regulation.

UKAEA is a world leader in fusion technology, safety, security, operation and environmental matters across the plant life cycle and has much to offer in supporting the development of a new regulatory framework for fusion energy. UKAEA, through the Fusion Safety Authority (FSA), have the expertise to assist development of a regulatory function in a number of ways including acting as a Technical and Scientific Support Organisation (TSO) to a regulator.

In such a role, there is a need to balance the benefits of accessing the unique technological expertise that exists within UKAEA with the need to be demonstrably independent in thought and operation from the wider UKAEA. Models exist to achieve this and, whilst specific proposals will be needed, we believe that a TSO could be established within UKAEA, defined clearly and with appropriate independence. That TSO could then be contracted by Regulators as a discrete unit of UKAEA, but with the crucial ability to reach back for additional expert input from colleagues across UKAEA. This is analogous to the arrangements in place for current UK regulator TSOs (ONR/DNSR and Jacobs (ex-Wood/Foster-Wheeler) RSD), where the TSO also has commercial interests.

Such a model could also enable UKAEA's expertise to support the development of pragmatic regulations internationally, for example in support of the IAEA.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

The overriding approach needs to be one of proportionality to the risk. The establishment of a fusion framework presents the opportunity to move to a risk-based classification of fusion waste rather than the current three-level approach.

Fusion waste is likely to be dominated by radioactive structural materials, such as steel. The risk of this relatively benign (compared with fissile waste) type of radwaste should be factored in when considering how it should be managed, particularly in comparison to other forms of waste with similar radioactivity, such as fission waste contaminated with spent fuel and other fission products. There needs to be a risk-based approach to waste that would likely allow fusion waste to be handled more straightforwardly, at a lower cost, without compromising on safety. The current 3 tier classification system (HLW, ILW, LLW) is an overly blunt tool given the significant variations in risk radiological waste presents.

Noting that fusion is in the early stages of development and that optimal materials still need to be developed, the first action in managing waste is to produce as little of it as reasonably practicable, and this requires innovation from industry and academia, working together, to develop better materials and manufacturing techniques that minimise impurities and activation levels and, ideally, maximise lifespan. Thereafter, alongside facilitating economically sustainable disposal through risk-based criteria, UK industry (nuclear or otherwise) should consider the merits of recycling certain nuclear materials more strongly than it has so far. The development of recycling capabilities and proving their scalability to power plant scale could significantly reduce the waste burden from fusion (and indeed other nuclear installations). This development of nuclear-recycling could be motivated by messaging and government policy that provides dose-rate recommended limits to categorise material that could be (re)used in future nuclear and non-nuclear industrial applications. Development of viable recycling routes for the major materials from fusion, mainly steel and concrete, but also valuable functional materials such as beryllium (if used) and tungsten, will create a more sustainable fusion economy. Sustainability through recycling needs to be driven by incentives to industry to accept the challenge of using recycled activated material.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

This is a valid expectation to set, but its realisation will need NDA plans to be aligned.

Some of the waste generated from fusion will, by current classification, be ILW. The hazard can be safely mitigated through the application of distance, shielding and time. Whilst underground storage may provide a shielding benefit, it carries the detriment of access for inspection and also the potential broader detriment of land disruption as it is unlikely that anything would be built above a repository. So, the approach should be that fusion does not need to be stored below ground, but in a particular location that may be, on balance, be the best solution.

However, near-surface disposal cannot be a given as a definitive expectation for fusion waste until there is confirmation from NDA that this will be possible. Factors such as the magnitude and half-life of activity that can be accepted in a repository will be critical in determining viability for fusion, as well as whether the repository will be built with capacity to accommodate the volumes of fusion waste. In the near-term, the focus should be on recommendations to NDA, RWM, etc., that fusion wastes need to be considered in the future development of repositories for intermediate and low-level waste. CoRWM have already engaged with the UK fusion community and would be the natural choice to provide guidance to government and regulators that fusion wastes should be included in the plans of future disposal facilities.

25 What are your views on how a fusion facility should be decommissioned?

Decommissioning should minimise environmental hazard and cost, which will require flexibility in approach as new technologies become available.

A fusion facility should be decommissioned in as cost-effective and environmentally sustainable manner as possible, following best-available technologies (BATs) and via ALARP principles. Waste strategies should allow flexibility, deferring decisions about unrecoverable consolidation (e.g. vitrification) or final permanent disposal until absolutely necessary (e.g. for environmental or cost reasons). This deferral will allow time for the development of advanced waste treatment approaches that could eventually reduce the overall disposal requirements, e.g. by separating severe radwaste from milder forms leading to increased recycling or more cost-effective landfill disposal. The UK via UKAEA will learn a great deal on this from the JET Decommissioning Programme and more detailed guidance should build on this experience.

In addition, the Government will need to consider the financial liabilities associated with decommissioning. Whilst the principle of “polluter pays” is reasonable, getting this critical but embryonic industry off the ground may need more overt assistance from Government on decommissioning liabilities.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

By driving proactive management of waste, and by moving to a risk-based classification system for radiological waste.

The regulation around fusion waste should focus on guidance that allows proactive management of waste – i.e. so that approaches can be developed that allow for the maximum possible usage of waste mitigation, minimisation, and treatment. For example, if waste disposal deferral is advantageous because it offers the possibility of developing treatment technologies that will minimise intermediate levels of waste requiring disposal, then this (deferral) should be prioritised over rapid (prompt) disposal and decommissioning, which would otherwise lead to higher volumes of more severe wastes.

Fusion specific waste regulation should also be developed to distinguish/classify wastes based on relative risk/hazard to people and the environment, which will differ from the primary classification currently applied based on total radioactivation. Risk-based waste classification is needed, combined with clear regulatory guidance around recycling of nuclear material (also based on risk/hazard).

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

Given the early stage of development of the technology this aspect will need to be kept under review.

There are two potential safeguarding risks in relation to fusion: (1) the use of tritium which is a material used in nuclear weapons; (2) the use of a fusion device as a neutron generator to produce fissile material (e.g. from natural uranium or thorium). Hence, we recognise that robust assurances regarding nuclear safeguards and security are required. We also believe that fusion technology needs flexibility to be built into the regulatory regime to allow agility in its development. The regime under IRR 2017 (i.e.to monitor, control and account for irradiated material and their transport for safety and security purposes) offers a proportionate solution to providing such assurance for UK fusion power plants.

Export Control regulations, both in the UK and internationally, also provide a further level of protection (e.g. regarding dual use items). The strict regime applied to fission materials by ONR (and for some sources by the EA) would be disproportionate to the risk that it would aim to mitigate in the case of fusion. We also agree with the Government's view that this issue should be kept under review to ensure that UK's safeguarding regime meets any developments in international safeguarding standards and in the uses to which fusion technology may be applied on a fusion site apart from exclusively the generation of fusion energy for the commercial market. The UK should continue to take a lead role in influencing any such developments. This response is based on UKAEA's expertise in magnetic confinement fusion.

28 What should the Government consider when developing guidance for export controls and technology licensing?

A balanced approach is necessary, enabling the fusion to develop rapidly through technology exchange whilst ensuring robust controls to minimise risk and increase public confidence.

The key consideration is to minimise the barriers to fusion research, innovation and development due to excessive export control restrictions – such restrictions need to be evaluated to balance the benefits against any adverse effect on innovation and development. In determining that balance, a suitable weighting should be applied to the benefit of achieving the goals of COP26 and of the Fusion Strategy, given the potential economic benefit for the UK as a leading player in fusion.

Key factors in achieving effective fusion research, innovation and development (and which could be adversely affected by export control barriers) include:

• International R&D collaboration will continue to be fundamental to fusion development;

• Engagement with industry partners will be increasingly vital to taking fusion development though the TRL stages to prototype and commercial production of fusion energy;

• Advancement in materials, robotic and computing science and technologies.

Some of the advancements are increasingly likely to overlap with potential military and armaments applications and there is a risk that well-meaning controls in that arena become too broad and have an unintended and detrimental effect on fusion development. Equally, controls are needed to minimise risk and to underpin public confidence in fusion as a peaceful technology. International co-operation is key here as effective innovation will require both exports and imports, so we advise early Government-to-Government engagement with key international partners on the scope of any fusion controls and on the potential for other controls to affect fusion.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

Fusion is a developing technology, and the devil will be in the detail as the technology moves into commercial production. Regulation is required to set the key safety and security requirements of any fusion energy plant, but it would be a considerable mistake to over-regulate the means by which those requirements are to be met. Developers need flexibility in regulation to enable innovative solutions to the many problems that will be encountered in designing and building commercial fusion energy plant.

The Government's proposal to review the fusion regulatory framework at least every 10 years is a sensible balance at this stage. Some certainty is needed to stimulate the sector but if understanding of fusion and its risks demands an earlier review of the framework then Government should be open to that.

As detailed design work progresses, options for development should narrow down, and risk assessments of developments and mitigation measures will better informed. In time, this should lead to a well-developed regulatory framework which should always maintain sufficient flexibility to allow for agility in seeking innovative solutions. The Government should remain open to earlier review if substantial new developments in fusion technology are made.

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

35 What is your country's / organisation's planned approach to regulating fusion energy?

N/A given UKAEA's position.

However, we would observe that, ideally, fusion regulation should be harmonised internationally so far as is reasonably practicable, to support the most rapid and broad spread of the technology to address climate change. Harmonisation is also necessary if the ambition to sell UK fusion power plants to other countries is to be achieved; the UK would gain a market leadership position if it were first of a kind. The UK should take a leading role in influencing the IAEA and individual nations towards a pragmatic approach to regulation and away from one based on existing fission approaches.

UK Health Security Agency

Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

Given that the responsible regulators are the Health and Safety Executive (HSE) and the Environment Agency the Government should take account of recommendations from the International Atomic Energy Agency's (IAEA) Integrated Regulatory Review Service (IRRS) to the UK. Recommendation R4 of the mission was that "the HSE should increase the number of both Specialist Inspectors (Radiation) and Ionising Radiations Regulatory Inspectors." The IRRS team stated that it was "is of the opinion that the HSE is not able to perform adequate regulatory oversight, especially of the high-risk activities and facilities." If the HSE are required to regulate fusion energy prototype power plants it would be essential that there are sufficient staff with adequate expertise in this area. In Table 6 a RAG rating of green is given to the Regulatory Capacity and Capability. It would be useful if the Government or the Regulators could develop a competence framework and training plan to demonstrate how this risk would be met.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

UKHSA agrees with the overall conclusions but some of the wording should be reviewed such as the description of a potential worst-case individual impact of < 1 Sievert being mild/moderate and the statement that tritiated water is more likely in such an event to enter biological systems, while tritium gas would instead be readily dispersed in the wind. In the event of any plant going through a consenting or permitting process, UKHSA would expect to see a more detailed approach to the modelling of tritium both in the environment and within the human body.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Not Answered

The requirements of REPPIR 2019 should be highlighted. REPPIR 2019 is referred to in the consultation and fusion energy prototype power plants must step through the REPPIR 2019 process. This includes checks to identify if the site holds in excess of the levels in Schedule 1 of the REPPIR regulations, and thereafter (if such requirements apply) the identification of source terms (and the associated likelihoods) reflecting the full range of hazardous events which may occur at the site, and the derivation of a consequence assessment detailing the assessed potential public health impacts on the basis of such source terms. From the scoping calculations performed and detailed, it looks likely that all such stages of the REPPIR process will be relevant. The regulator(s) and regulatory framework must hold the required knowledge and experience to ensure that each phase of the REPPIR 2019 process is suitably followed and addressed. For REPPIR 2019 the regulator is the Office for Nuclear Regulation (ONR) for nuclear licensed sites, authorised defence sites, nuclear new build sites and nuclear warship sites and the HSE for all other sites. The IAEA's IRRS review commented that "since the introduction of REPPIR 2001, no HSE sites have been identified as meeting the criteria requiring the development of an off-site plan." Therefore, the Government would need to ensure that the regulator has the suitable knowledge and experience.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

UKHSA believes that IRR 2017 and EPR 2016 are the appropriate legislation of the consenting and permitting of fusion power plants but as discussed previously REPPIR 2019 should be adequately considered and the Government should ensure that there is sufficient regulatory resourcing and expertise.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Not Answered

UKHSA does not have a view on this.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

UKHSA does not have a view on this.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Not Answered

UKHSA does not have a view on this.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

UKHSA agrees that this is an approach consistent with other energy generating stations.

9 What other issues should a Fusion NPS address?

10 Do you believe that a third party liability regime is required for fusion?

Not Answered

UKHSA does not have a view on this.

11 What are your views on the principles and issues around third party liability as set out in this paper?

UKHSA does not have a view on this.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

UKHSA does not have a view on this.

13 How can the Government promote the development of suitable commercial fusion insurance?

UKHSA does not have a view on this.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Not Answered

UKHSA does not have a view on this.

15 What in your view should cyber security regulations for fusion cover?

UKHSA does not have a view on this.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

The consultation states that "Secondly, Schedule 1 of REPPIR 2019 specifies a set quantity of radionuclides derived by Public Health England 7 x 1016 Bq of tritium is 100 times the threshold for considering application of REPPIR 2019, so can be considered a significant amount of tritium. This reflects the fact that an increased amount of tritium is the key differentiator in the increased radiological hazard of a fusion power plant: not only because of the increased radioactive inventory that this represents but also the much higher rates of activation resulting from the increased use of tritium in the fusion fuel." The basis and reasoning for use ofa scaling factor of a 100 should be clearly explained. It might be more appropriate that all fusion energy prototype power plants should be defined as being in scope whereas for example experimental facilities are not included.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

UKHSA notes that this engagement process has been successfully used for new nuclear build.

18 What are your views on how such engagement should work?

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Don't know

UKHSA does not have a view on this.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Don't know

UKHSA does not have a view on this.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

See ressponse to Q1

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

Whilst it is recognised that the UKAEA Fusion Safety Authority is organisationally separate from the operational and research parts of UKAEA (FSA), it is not independent. Although FSA will be able to provide the regulators with advice it is important that the regulators have sufficient technical expertise that they are not overly reliant on UKAEA's FSA and that the risk of regulatory capture is avoided.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

The radioactive waste should be treated in the same manner as radioactive waste from other industries

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Not Answered

UKHSA does not have a view on this.

25 What are your views on how a fusion facility should be decommissioned?

UKHSA believes that decommissioning should be planned during the design stage as done for nuclear fission plants in the Generic Design Assessment.

Relevant lessons from both the Generic Design Assessment and the Guidance on Requirements for Release from Radioactive Substances Regulations should be drawn across to the decommissioning of fusion facilities.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

The regulators should review both the Generic Design Assessment and the Guidance on Requirements for Release from Radioactive Substances Regulationse and see if additional guidance needs to be developed for fusion facilities.

27 Do you agree with the Government's proposals on safeguards for fusion?

Not Answered

UKHSA does not have a view on this.

28 What should the Government consider when developing guidance for export controls and technology licensing?

UKHSA does not have a view on this.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Not Answered

UKHSA does not have a view on this.

31 Before today, how much did you know about fusion energy?

Knew a little

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Neither support nor oppose

33 What is your level of knowledge about fusion after reading this paper?

Knew a little

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Neither support nor oppose

2.2 Responses received from individuals

Individual A

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

I find it surprising and concerning that a nuclear fusion plant would not be classed, considered or defined as a nuclear installation – it will (hopefully) be producing power from nuclear reactions, as well as producing small quantities of short/medium-term radioactive nuclear waste. The 'fusion regularly framework' therefore needs to include regulation of nuclear fusion technological functions.

I hence find it unsatisfactory that ONR are currently only involved in the transport and safeguards side of the fusion lifecycle (Annex C, p88), also given that ONR published Ref 87 only last year. Also, the level of radioactive hazards will be increased with scale-ups to commercial plant, as well as the end disposal (albeit on a shorter timescale than for fission plant). I would expect ONR to still be involved in some way, even if with a more limited role. ONR would be better placed to lead approvals, with relevant input from others. It is unlikely that HSE/HID have sufficient technical expertise in this technical discipline (nor should be expected to).

Otherwise, H&S and environmental regulations are as applicable here as elsewhere with any other major infrastructure project or operating power station.

Cyber-security and AI are topics of increasing concern that also need to be considered when approving current designs and systems for use in an operational plant. With current rapid advances in technology, there could easily be other technologies that appear that could impact approvals by the time a commercial fusion power plant is built.

Indeed, fusion itself is currently a rapidly advancing technology (as identified by RHC). A flexible, less definitive, 'Agile', approach is thus advisable in the short to medium term, and as proposed by BEIS in Annex B.

Environmental risk and sustainability also require more consideration nowadays.

Resilience is another 'hot topic' of concern, especially in the power sector.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

No

No. The current assessment is focused on nuclear hazards, and by the use of a worst-case approach is largely consequence-based rather than risk-based.

(This is not to say that worst-case isn't appropriate to look at, it is when considering deterministic safety margins within a design, but worst-case scenario usually only comprise a small fraction of the overall safety risk of an industrial facility).

Additionally, the worst cases mentioned appear centred on only one part of the system (vacuum vessel/cryostat) or the whole system (earthquake scenario). However, there may be other scenario that have lesser consequence but happen more frequently, presenting a higher risk overall; handling, structural integrity failure of breeder blankets, high intensity magnets, and the exhaust/divertor require further consideration, for example.

There are a range of conventional hazards associated with a fusion plant: high voltages and magnetic fields, cryogenics, structural integrity of the blankets, and the superheated exhaust/divertor(s), and also potentially large quantities of lead (for blankets and/or cooling). These (or similar) are also seen in other regulated industries. In practice, these can carry a higher safety risk to humans (workers, and possibly people nearby) than the radioactive hazards; the latter also tend to be more rigorously managed.

Domino or chain effects also need to be considered; a collapsed or breached exhaust could lead to other structural/containment failure(s) - the design of the exhaust systems is still one of the biggest challenges in fusion plant design.

It is not prudent to speculate on what hazards may or may not exist at this stage, but safety risk assessment of various options can help to inform the designs.

The radiation hazard may or may not be 'the worst' nor the most likely hazard on a fusion plant, but the suite of MAHs (major accident hazards) and MATTEs (major accidents to the environment) needs to be identified - but simply knowing what they are does not fully inform the risk profile, nor inform the taking of risk-proportionate decisions. Further risk analysis will be required as designs progress to enable this activity.

Looking at the risk profile for the whole suite of expected and potential hazards is advocated, in line with new and novel developments of other highly regulated infrastructure, from COMAH sites to transportation systems. This is also in line with a goal-setting approach rather than a prescriptive approach.

3 Do you agree with the proposal to maintain the existing regulatory approach?

No

No. Going forwards, it would be better to start with ONR involvement and then subsequently - if need be - reduce or minimise their input/involvement, rather than the other way around. Without them (or a similar nuclear SQEP body), it cannot be guaranteed that all potential hazards or accident scenario will be identified, or adequately assessed or reviewed, resulting in an incomplete or inaccurate Safety Case.

Conversely, also, relying on the EA and/or HSE/HID to identify gaps in fusion risk assessments is not a reasonable request as the technology becomes more advanced and the projects scale up to full plant size, with associated increasing complexity. The knowledge required to deal with this already sits with people with nuclear engineering background, so to use people who don't have this type of engineering background would be both inefficient and potentially also ineffective and unsafe.

In summary, there are SQEP, efficiency and effectivity, and safety, issues with maintaining the existing approach as these proto-plant develop towards larger scale commercial variants.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

No

No. As indicated above, regulating a test rig/experiment is one thing but a power plant involves a whole different level of engineering, complexity and knowledge.

Especially when taking into consideration, for example, more 'modern' hazards such as from cybersecurity vulnerabilities and indeed more unusual ones that come with the fusion process such as cryogenics and superheated exhausts. The current regulations do not cover such hazards in a suitable manner, as they haven't needed to.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Yes

As per response to 1, to not call them a nuclear installation is an oxymoron.

Yes, they should be brought under ONR's remit, at least initially. It is better to be safe than sorry. However, the big caveat on this is that although ONR should (probably) be in the lead, they should not take such a prescriptive (fission-type) approach with a fusion plant. This is a problem that happened on ITER with the French nuclear regulator, resulting in unnecessary overwork/overdesign and expense.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

I do not see why the approach to justification of fusion, from a societal benefit and 'net energy' perspective, should be any different to any other power sources. There is no need to single it out in this basis; it is simply another source of power.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

No

Other. As per responses elsewhere, my view is that a fusion plant is a nuclear installation 'by default'. I am of the view that a nuclear site license is needed, but not however in its current form i.e. not in a manner that is (for historic reasons, not current ones) reflective of fission plant sites.

In theory, I don't see a problem with altering legislation to include an 'addendum' for fusion plant and there are precedents to this type of situation in other sectors. For example, certain rail schemes would have never been approved if certain safety legislation had not been updated to include for high-speed lines or modern signalling technology.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

No

Other. The Fusion NPS should be linked to an Overarching Energy NPS (which if it doesn't already have mention of fusion, needs to include it ASAP), and should be applicable for any fusion technology.

As per previous comments, it will be a nuclear site, but in a different form, to account for the 'new technology'. The Fusion NPS therefore needs to account for this.

The Fusion NPS should be neither site-specific nor country-specific. This is particularly important for early permitting (there could be several FOAK plant installed across the UK). The planning policy may be devolved by regions, but the approach to Fusion NPS should be consistent across the regions.

Regular reviews will be needed, as per adoption of any new technology into critical infrastructure projects.

9 What other issues should a Fusion NPS address?

The Fusion NPS should cover planning with respect to PCZs and EPZs (similar to existing nuclear and COMAH sites).

10 Do you believe that a third party liability regime is required for fusion?

Yes

Developers and operators need to retain liability for accidents, as with any other hazardous industry.

Current best practice in other (UK) highly-regulated/hazardous industries with regards third party liability could or should form the basis for any approach.

11 What are your views on the principles and issues around third party liability as set out in this paper?

Insurance regimes already exist for a wide range of highly-regulated industries.

It is envisaged that these can be used as a basis for consideration for applicability to fusion.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

It is envisaged that these can be used as a basis for consideration for applicability to fusion.

13 How can the Government promote the development of suitable commercial fusion insurance?

This is possibly more a question of educating the insurers, for recognition that a fusion plant represents a low risk.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

Yes, there already exist a suite of OT (operational technology) and IT cybersecurity standards that apply to safety-critical systems such as control and instrumentation, which a fusion plant, as per other power/industrial plant, will have within its design.

As part of prototyping, engineers will need to assess cyber vulnerability for future scale ups.

The IET has recently published guidance on this topic, and the SCSC (safety-critical systems club) is also currently developing guidance.

15 What in your view should cyber security regulations for fusion cover?

Similar to other sectors, control and instrumentation that involves electronic/ computer-based systems should compulsorily undergo threat, vulnerability and risk assessment (TVRA) for cyber hazards. For power plant, these systems are predominantly OT systems rather than IT systems, but as a matter of course it is also advisable to assess the IT systems for vulnerabilities.

Refer to best practice on the subject in other highly regulated sectors.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

No

Definitions/limits are (or tend to be) too prescriptive for new technology developments. Lower levels of power/tritium handling should be considered, and any design that could be deemed an energy producing plant. New guidance is appropriate.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

In other highly-regulated sectors, many regulators are engaged from early design (or even concept) stage. The energy sector should be no different. With new/novel technologies it is recommended that regulators have semi-regular involvement right from concept/feasibility stage, rather than becoming involved near the end of design phase.

18 What are your views on how such engagement should work?

It is helpful to provide expectations to developers/design teams regarding the level or extent of reviews by the regulator, and the frequency of their engagement.

Guidance on audits and addressing corrective actions is also useful.

Much of this is already covered under existing best practice in highly-regulated sectors.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

Fusion should be no different to other new energy sectors and other engineering systems, in this respect. Additional guidance is needed.

However, ONR should be involved in the development of the guidance i.e. not only BEIS, EA, HSE, UKAEA.

Such guidance needs to be prepared by engineers with understanding of fusion technology, but should be written in an accessible manner as far as possible.

As per other highly-regulated sectors, the full lifecycle, from concept, through design, operations and maintenance, through to decommissioning.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

If yes, what are your suggestions for how this could be achieved:

Similar to COMAH sites, a PCZ and EPZ should be implemented.

In this way, the process and development become more transparent to the public from the start.

This is especially important when introducing new/novel technologies into the public domain.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Specialist staff are required. The technical capability is very likely already there within some individuals within ONR. Real sufficient technical experience/background (over a significant number of years) is expected for people in regulatory roles. Such people are most likely to come from other parts of the nuclear sector, including the existing fusion sector, with other energy sectors in second place for sourcing relevant experts.

Training people up in fusion capability within HSE or EA is not expected to be an efficient nor adequate way to go about gaining expertise in fusion nor for succession planning.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

UKAEA holds a mine of information on fusion technology and trials, and this can be well-utilised by the industry. It can provide good technical input and ideas into the new fusion framework but, at the same time, UKAEA should not be responsible for or involved in approvals. It should be remembered that, here, UKAEA is essentially in a designer/supplier/manufacturer role, who has a project (STEP).

The project is expected to have a designated safety manager/safety authority and supporting team. UKAEA is not doing anything unusual in this regard compared to other industries by creating a Fusion Safety Authority (or similarly titled team) within their organisation, however the role of the FSA needs to be questioned. “Separation” is not feasible, as described here (p.60). They are basing their structure on being ‘organisationally separate’, sometimes called “Chinese Walls”, which in today’s regulated industries is not regarded as best practice nor an up-to-date approach due to being subject to Conflicts of Interest (COIs), and is hence not to be recommended.

What the FSA shouldn’t be doing (nor requested to do) is to assume an ISA (independent safety assessor) role - which seems to be what is being proposed here. They are ‘too close’ to the project and to UKAEA itself as a business, which creates a technical COI not acceptable under current best practice safety engineering (ref SaRS, IET codes of practice). They need to create the safety case for their project, not be an ISA to it; a truly independent ISA/INSA organisation is required for such a role, outside of UKAEA. This is separate to the role played by the Regulator, and usually carried out by an accredited SQEP body, who are generally more connected with the project than with the regulator.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

In line with existing best practice on ILW/LLW, as relevant.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

Fusion should not be treated any differently to existing best practice for ILW/LLW, as relevant.

25 What are your views on how a fusion facility should be decommissioned?

A Decommissioning Management Plan should be developed by the operator during design stage, and regularly reviewed and updated through life. The contents may vary depending on plant design and selected materials.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

With support from existing decommissioning experts in the nuclear sector and ONR.

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

Other / Yes, broadly. However, safeguards expected to be in place may be different to prior expectations as different sites/regions not currently used for nuclear facilities may be used for fusion plant, which could affect the way that safeguards are managed and/or overseen. A case-by-case approach is usually needed for FOAKs.

The reducing reliance on Canada, and increasing internal UK production, and that different materials are involved, should also form part of a safeguards review.

28 What should the Government consider when developing guidance for export controls and technology licensing?

Any guidance should be developed with support from existing experts and regulators in the sector.

Copyright/trademarking of designs developed by UK organisations will also be important going forwards, for UK plc to benefit.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

No

Other / Yes and No. The framework should be kept under regular review. However, at the rate that fusion technology is increasing (and others e.g. digital technology), a review every ten years is viewed as inadequate. A review every 2 or 3 years would seem more appropriate given current paces of change in fusion and other technologies.

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

35 What is your country's / organisation's planned approach to regulating fusion energy?

Points already covered above, in particular in terms of definition of ‘nuclear installation’, expected hazards and risk profile, ONR involvement, restrictive/prescriptive definitions, consistency across different UK regions, approach to PCZs, changes to safeguards, impact of digital technologies.

Environmental (other than radiological) risk, sustainability and resilience have not had significant mention in the document but need to be considered. I currently work in the Regulation research group in the Nuclear Futures Institute at Bangor University, on a project creating design safety guidelines for future commercial fusion plant. I have three decades of experience in developing and peer reviewing safety cases in a wide range of highly-regulated sectors, and have previously worked on ITER. I am aware of research projects within UK academia dealing with the regulatory side of fusion. These should be accounted for within any reviews on legislation.

Individual B

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

Good to see the detailed balance between fusion and fission that seems to be a good strategy to ensure safety and supporting regulatory regime to accelerate deployment.

Nuclear fission should be considered, however, it must be stressed the fundamental differences between fusion and fission and that the regulatory regime for fusion does not stifle innovation. A supportive outcome orientated regulatory regime will be critical to keep the UK at the forefront of fusion research and commercialisation, and to continue to attract international fusion players to the UK.

Space/aerospace may offer interesting comparison regulatory regimes. In particular, a useful case study would be that of Space-X's Starship programme where close coordination and adaptability is needed between the operator and regulator in a fast-changing environment to deploy a new game-changing technology.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

Yes. Tritium and activation of the reactor structure are the key hazards for fusion.

The calculation assumptions of a complete inventory release seem very extreme (and unlikely/impossible), but puts a limit case.

Tritium handling experience from JET put the UK at a forefront for safe control and safety expertise.

It should be noted that in the development of fusion it may be necessary to utilise materials that contain activating materials in order to demonstrate

reactor designs whilst non-activating materials are demonstrated (e.g. Ni in current stainless steels). Also noting that not all materials within the reactor

will be exposed to potential activation, e.g. substructure. The LLW target should remain for fusion.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

It is good to see fusion considered distinctly from fission. The hazards involved are different and so it is sensible to assess it separately. As fusion progresses from experiment to demonstration to commercial the regulatory approach can be reviewed and adjusted to include real use experience. It is vital the UK has an effective regulatory that provides safety but also offers freedom for innovation and to accelerate (or at least not hamstring) the realisation of fusion energy.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

IRR 2017 and EPR 2016 seem to provide adequate external oversight.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

There are many factors that apply to fission reactors that do not apply to fusion. The large magnitude of regulation could represent itself a risk to fusion due to time delays and extensive paperwork, which crucially would not necessarily reduce risk. A tailored regime would firstly better assess and mitigate risk, as well as making it fit for purpose to support innovation.

Small scale fusion reactions have been run in university settings internationally and in the UK.

Siting large reactors on nuclear sites as has often occurred historically, which can be useful to benefit from trained expertise, and could provide extra assurance for managing the larger tritium inventories.

Lengthy site licencing processes could limit the ability for the UK to attract international fusion research, we must be agile.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

The approach is sensible to enable safe innovation.

The UK government regulatory process should include independent experts with experience of JET and MAST (UKAEA facilities), e.g. EU experts from EUROfusion, who are separated from STEP but have the hands on experience. This should be in addition to the substantial expertise and semi-independent STEP/UKAEA experts can offer, which combined with UK Gov can provide oversight and support commercial companies (Tokamak energy, General Fusion, First Light Fusion).

Secondment of regulators to UKAEA / companies would also be sensible.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

I would agree that a nuclear licensed site would not be needed for fusion, due to the different risks to fission (namely unstable chain reaction, meltdowns and accident evolved gas explosions – which cannot occur in fusion).

However, it may be that existing nuclear licensed sites represent a convenient location for fusion reactors (e.g. access to infrastructure and skilled employees) and that this is permitted by the regulation without complex procedures.

Appropriate care for fusion siting will be important for public perception that it is being done with caution, however, siting distinctly from fission may help to emphasises that the technology and risks are different.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

Yes this seems appropriate given that review is included to assess & adapt over time.

9 What other issues should a Fusion NPS address?

Appropriate public consultation.

10 Do you believe that a third party liability regime is required for fusion?

Yes

I agree that classification of a fusion power plant as a high hazard site seems disproportion in relation to fission – with fusion being intrinsically safer. A complete tritium release would not be possible.

A hazard cap seem sensible.

11 What are your views on the principles and issues around third party liability as set out in this paper?

I do not have legal expertise, but as an engineer the approach seems sensible to adequately appraise the risk.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

(Not at this time)

13 How can the Government promote the development of suitable commercial fusion insurance?

Quantification and monitoring in a transparent manner, recording of incidents (and whether they represented a 'real' risk).

In depth consideration of the likelihood and training of insurers in the specifics of fusion. Mediation between companies, UKAEA and insurers.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

I would agree with the approach that NIS 2018 would not apply until fusion power plants are realise and more widely deployed to the grid generating >2GW, from the perspective of UK energy security and safety, but also that its principles would be sensible to follow.

Another aspect would be whether fusion in the future becomes an international competition, we have seen how cyber attacks have been successful at delaying Iran's fission developments, what if another country decided to act to limit the UK's lead in fusion development?

15 What in your view should cyber security regulations for fusion cover?

Fusion plants should be sensibly protected from disruption by cyber attacks, and UK fusion IP defended.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

I agree.

It could be clearer whether the net generating capacity refers to "generating 50 MW electricity to grid", or "fusion reaction outputting 50 MW of heat", i.e. is this for power plants vs experimental reactors.

Larger experimental reactors (which may approach 50 MW) but that use limited tritium quantities, and limited run times should maybe still be considered as R&D with reduced regulation.

In is appropriate that the regulations change as a rector changes from basic & scaling R&D, to reactors intended to be functional long-term power plants.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

Yes. Regulators will need to be able to discuss the variety of fusion reactors and their nuances and gain from in depth knowledge of designers.

Regulators will need to be experts themselves. Secondments, especially to UKAEA should be encouraged.

Regulatory independence should also be ensured, and third-party advisers/checkers used to reinforce this (e.g. from ONR, AWE, DoE, IAEA, EUROfusion).

Care should be taken that companies (and the UK) can still maintain appropriate commercial sensitivity and IP maintained.

The work of UKAEA STEP provides a useful test case that can benefit commercial entities.

18 What are your views on how such engagement should work?

(Discussed in 17)

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

It would be beneficial for fusion specific Uk Government guidance. This would clarify what requirements are required of fusion enterprises, and put them all in one place. Having discrete guidance for fusion is in fitting with the UK world leading position of fusion and is likely to attract further commercial investment into the UK.

Having its own carefully considered guidance and assessment shows to the public that the UK Gov is seriously considering the potential risks of fusion are safety met.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

Information explained to a general audience on what a fusion reactor is, why it is safe and the benefits it offers, should be readily available through all

parties: Regulator, UK Gov, developers.

UKAEA has been highly active on wide public engagement.

Local community consultation and buy-in will be important.

Regulation can be separate, but the decisions could be transparently shown.

Engagement is self beneficial to developers and as comments is undertaken in fusion widely already, and in related industries.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Regulators have access to many nuclear experts who are well placed to re-apply their skills to fusion whilst ensuring they are aware of the specifics of fusion.

NIRO and NIRAB may offer appropriate advisors.

Two-way exchanges between regulators, developers (and universities) should be encouraged.

Third party advisors should also be sought to balance between the specialist expertise required and their objective independence.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

The UK is near-uniquely placed with having a government research organisation that is at the absolute cutting edge of the science, engineering and commercialisation of fusion. UKAEA as a developer offers a fantastic advisor to government compared to what a pure commercial entity, particularly in regard to how open it can be with a regulator, and its willingness to semi-independently advise regulators – including on aspects that go beyond their own developments but that might also benefit to commercial entities. The regulator and UKAEA should have good capacity to enable two-way secondments.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

It is sensible that the Government consult with CoRWM and NDA. Fusion developments have already made extensive efforts to limit waste inventory, particularly by utilising materials that do not become HLW or ILW. That said, there is likely to be LLW created especially on decommissioning. It should also be noted that post shutdown activated structural materials exposed to fusion neutrons may take up to 100 years before they decay to the LLW threshold, which may need to be stored with extra care until that point. It could be reasonable to monitor the activity & quantity created (computational predictive tools exist and can be expanded upon) – taking care that this does not put on an onerous limitation on the development.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

Yes this is reasonable, especially toward commercial larger-scale & higher grid uptake when the number of reactors increases.

For R&D reactors LLW thresholds should been the aim, however, there should be a mechanism to alloy for quantities of ILW/HLW if this can accelerate the development & also reduce other risk (e.g. the use of materials demonstrated to have improved properties, but that contain activating elements, e.g. Ni as an activating element is often used in steels).

25 What are your views on how a fusion facility should be decommissioned?

The shorter half-lives of the elements selected for use as structural materials mean their activity will decay rapidly post shutdown. A two-step initial ‘cool down’, days-weeks for heat, but then potentially years for activity cool down, which will substantially reduce the activity of the structure in what is already a safe and secure environment. Predictive tools for activity should be assured, but already give confidence as to the activity of different materials, when combine with effective irradiation dose simulations.

There may be ~four waste streams: (1) Waste with no hazard as it has seen no irradiation (main structure), which is likely to be the majority by volume/mass, that could likely be recycled/reused, (2) Waste that is LLW immediately post shutdown, i.e. has seen only limited dose, which can go straight to a suitable disposal/reprocessing. (3) Waste that can be demonstrated to decay to LLW, suitable for near surface disposal facilities – a dedicated facility/section could be envisioned that provides ILW security/assurance for the <100 years it takes for the waste to become LLW where it can thereafter be left safely, without having to move the waste multiple times, or relying on action in the future, (4) ILW/HLW, whilst anticipated to be avoided, limited quantities of ILW may result from R&D efforts (also as per (3) waste that will take time to decay to LLW, further, it may be that small amounts of material that becomes ILW/HLW offer performance/safety improvements essential to fusion and its rapid deployment, which may represent a necessary compromise.

Certainly much can be gained benefiting from existing efforts from fission decommissioning, where close communication is clearly necessary, there may also be opportunities to pair for new efforts driven by fusion but that also benefit fission.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

Outline plans should be stated, but fixed plans even for fission are ever evolving, period review should be made, and efforts made now to minimise the future burden.

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

I agree that fusion specific technology can be largely separated from safeguard aspects. As pointed out, depleted uranium may be needed to store tritium.

It should be considered what fusion technology may be dual use and how to efficiency manage this whilst ensuring the rapid and transparent deployment of fusion. This could benefit from existing safeguarding experts paired with fusion experts to consider areas of where fusion technology that have particular concerns, and those that do not.

28 What should the Government consider when developing guidance for export controls and technology licensing?

My own experience relating to basic science research, low TRL R&D, that is applicable to both fusion and generation IV where there are concerns for dual use has been problematic. This has included both limitations/rejections and how long the process takes (over 2 years with no resolution). There is a substantial need to better support the pool of trained experts who can, firstly, act quickly so that we are not held back in deploying new technologies, and secondly, that the necessary expertise is available to evaluate whether exports / technologies are truly of concern, and to devise controls mechanisms. It should further be made clear the cost/limitation that export control restrictions can have on innovation and an outcome focussed view encouraged.

Fusion is highly international in nature and so additional support to the export and licensing teams should be made available. It could be useful for fusion specific criteria developed for licencers, and explained to the back to the R&D community.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

Review at the point of substantial change in the sector, or <10 years feels appropriate. The progression of R&D (including varied reactor designs)

experienced gained in this time will allow for better informed regulation. Regulators should keep abreast with the state of fusion development, both

public and private.

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

35 What is your country's / organisation's planned approach to regulating fusion energy?

Please explain your planned approach:

UK based

Individual C

1 Are there other critical regulatory areas that the government should address when considering the regulatory framework for fusion energy in the UK?

Response

It is true that FPPs are currently not defined as nuclear installations, but this could change given the recognition of the differences in hazard potential and unmitigated risk between an

FPP and the current fusion research facilities such as JET, MAST and the Tokamak Energy ST-40 facility.

As will be shown later, it would be relatively simple to prescribe FPPs under the NI Act given that fusion comes within the definition of Atomic Energy. Future international obligations regarding the safety of FPPs could require the UK to implement some form of nuclear site licensing should the IAEA produce FPP specific safety standards to support the global deployment of FPPs.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

No. I do not believe that the conclusions drawn in relation to the hazards posed by fusion power plants and their similarity to hazards posed by other industries regulated by HSE and EA are correct. Fusion Power Plants have, as shown in this document, in the UKAEA Technology Report and in the work on my research (See Lukacs and Williams, Nuclear Safety Issues For Fusion Power Plants, Fusion Engineering and Design, vol.150, 2020 and Lukacs and Williams, A Sensitivity Analysis of the Factors that Influence the Hazard Potential of Fusion Power Plants, Fusion Engineering and Design, vo.164 December 2020), that FPPs have a significant radiological hazard potential, albeit much lower than that from an NPP, and that the hazard potential is not comparable with the hazards posed by other industrial activities regulated by HSE. I focus here on HSE because it is HSE that is the responsible regulator for public safety relating to industrial activities, except those that occur on nuclear licensed sites. The EA will be responsible for regulating routine radioactive discharges and the disposal of radioactive waste from FPP sites as it currently does for nuclear licensed sites in England.

My reasons for this view come from the potential for unmitigated risks from an FPP to require evacuation of people and the radioactive contamination from HTO and activated dust. The psychological impact on the public of exposure to ionising radiation is different from any other industrial activity and is one of the reasons why we have a nuclear site licensing regime in the UK for activities with this type of hazard potential. It is also why there are international Conventions, which the UK is a signatory, to ensure radiation hazards are effectively managed and regulated.

It is important to understand the difference between hazard potential (unmitigated risk) and risk. NPPs have a high hazard potential but have risks to the public that are acceptably low (ALARP) and are therefore judged to be safe. The reasons for this are the extensive engineered safety systems that are provided in the design and the subsequent nuclear safety management arrangements for construction, commissioning, operation and decommissioning as required by the conditions attached to the nuclear site licence. These extensive design and operation requirements need competent and expert scrutiny by the safety regulator to give the public and politicians confidence that these technologies are being adequately controlled.

FPPs, as can be seen, are complex machines which if inadequately designed, constructed or operated have the potential for public harm and as such their safety case and supporting safety arguments will need expert regulatory scrutiny.

3 Do you agree with the proposal to maintain the existing regulatory approach?

No. I do not agree with the proposal to maintain the existing regulatory approach.

The authorisation of routine radioactive discharges and the disposal of radioactive arising from FPPs is not in question here. The EA in England and SEPA in Scotland and NRW in Wales have established credentials to demonstrate that they can carry out similar regulatory activities associated with FPPs as they currently do with NPPs.

It is the safety regulation by HSE that concerns me. My reasons are as follows.

1 As shown above, whilst the hazard potential of an FPP will be considerably less than that of an NPP it is not insignificant. FPPs are large complex power plants, and it will require considerable engineering design, and careful control over construction, commissioning and operation to ensure that the risk to the public from an FPP is acceptably low and ALARP. Given this, it is not unreasonable for society to expect that there is a robust regulatory framework in place to ensure that this technology is being properly managed.

2 There is a world of difference between the day-to-day regulation of industrial health and safety of the fusion research facilities at Culham and the regulatory oversight that will be needed for a large complex FPP project during design, construction, commissioning and operation. One only has to look at the complexity of the safety case for ITER, and the developing concept design safety case for DEMO, to see the range and scope of technical issues that need to be considered to ensure that the risks to both workers and importantly the public are acceptably low and ALARP.

3 The range of skills needed to effectively assess the safety case and the supporting safety arguments is considerable and at present these skills and experience reside in ONR. Yes, ONR will need to expand is knowledge of some of the fusion specific technologies, but the core skills needed to assess complex safety cases are already embedded in ONR.

4 ONR also has the regulatory management experience and inspection skills needed to oversee the construction, and commissioning of large power plants with radiation hazards, especially the transition when the plant goes from inactive to active commissioning and the associated increase in security and safeguards oversight. This experience and know how on how to manage the regulatory process from cradle to grave will provide the licence applicant, owners, vendors and investors with the required level of regulatory certainty for large capital-intensive projects.

5 Hearing the HSE Inspector for Culham state at an NRC meeting on fusion regulation that it would only take a few weeks to assess the safety case for an FPP does not fill me with confidence.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

No. I do not agree that the use of IRR 2017 on its own is sufficient to provide effective regulation of a large and complex FPP with a non-trivial hazard potential and significant unmitigated risk to the public. Engineered, control and protection systems, together with multiple engineered containment barriers will be required to mitigate the hazard potential to ensure that the mitigated risk to the public is low and ALARP.

The key issue here is what is meant by proportionate and appropriate. As I have shown above, FPPs are large complex machines with a variety of interconnected radiation and non-radiation hazards. Conventional system or equipment failures can initiate accidents that can result in the release of radioactive materials into the atmosphere. Hence the development of a comprehensive understanding of initiating fault sequences and subsequent fault tree analysis that is needed, not only to determine design basis accidents, design extension accidents and more onerous beyond design basis very low probability accidents, is not a trivial task.

Designers, when evaluating their designs will be expected to use appropriate fault analysis tools to demonstrate that risks to the public are ALARP. The tools and approaches will not be too dissimilar to those used for the analysis of nuclear facilities.

Designers need to know what safety, security and safeguard requirements they are expected to comply with. Therefore, the key issues are, what are proportionate levels of defence against faults (defence-in-depth requirements), what are proportionate engineered system to deliver these requirements; and what level of fault analysis is required to demonstrate that risks from an FPP are ALARP. These are not trivial issues. Their resolution will require competent design teams and competent and experienced regulators well versed in fault analysis.

Complex facilities such as FPPs will also require PSA to show not only risk associated with the design but also design and operational sensitivities.

The success of large, regulated projects such as FPPs require a cradle to grave approach and experience has shown that permissioning at the start of a project such as the granting of a nuclear site licence, and subsequent permissions as set out in an agreed regulatory schedule is the best and most efficient way forward.

There are problems with relying solely on IRR 2017 to regulate the safety of FPPs. Whilst the regulations require the duty holder to carry out a “radiation risk assessment” before commencing any new activity that involves work with ionising radiation, a radiation risk assessment is not the same as an FPP safety case. It is also not clear what is meant by “commencing a new activity involving work with ionising radiation”. The regulations imply that this refers to the point of commencing work with ionising radiation. In the case of an FPP this would be at the point of DD or DT commissioning. This would be far too late and after the FPP had been constructed. Similarly, the powers for the regulator to permission the commencement of work with ionising radiation, would mean that there would be no regulatory control over the design, construction and inactive commissioning of an FPP. This would be inferior regulatory control offered by the nuclear site licensing process, and it would not give the owners and operators the regulatory certainty they require.

Regarding environmental permitting, the environmental regulators have experience in regulating a variety of nuclear and non-nuclear facilities to ensure that routine radioactive discharges result in risks to people arising from these discharges are ALARP. The only issue is the regulatory permission is required at the point of operation again after the FPP has been built.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Yes. FPPs should be considered as nuclear installations and brought within the UK's highly successful and well-regarded nuclear site licensing regime under the Nuclear Installations Act and regulated by ONR and the appropriate Environmental Regulators.

FPPs should be brought within the nuclear licensing now as it will give ONR the opportunity to engage with the fusion industry early in the FPP journey and help develop not only safety standards that are proportionate to the FPP hazards, but also a cradle to grave regulatory schedule that is proportionate to industry requirements and ONR's regulatory responsibilities for public protection. It will also enable ONR to engage now with their counterparts in the US, Canada, France, Germany, Korea, China and other major nuclear safety regulatory authorities that are engaged with the IAEA discussions on FPP regulation and standards.

Bringing FPP regulation within the scope of ONR will enable an effective and efficient regulatory "one stop shop" for safety, security safeguards and transport and by building on ONR's high reputation in the UK and abroad it will provide the public and politicians with the confidence that this new technology is being properly regulated.

My reasoning is as follows.

The public are not stupid, and they will not take kindly to be told that an FPP can be regulated as an industrial radiation facility and not as a nuclear facility. It would be a mistake to lose public trust at the start of this exciting time when FPPs can contribute to the UK's high tech industrial strategy and offer so much to the long-term security of mankind and safety of our planet.

We should remember that ITER stands for the "International Thermonuclear Experimental Reactor" and we should not be afraid to acknowledge that fusion is a nuclear process and be prepared to explain the differences between fission and fusion,

Fusion falls within the definition of Atomic Energy given in the 1946 Atomic Energy Act. Hence FPPs already fall within the scope of the NI Act. All that is required is for Ministers, using secondary legislation, to prescribe FPPs as nuclear installations and prescribe tritium and activated dust as nuclear matter and the nuclear site licensing can be instantly applied to FPPs.

The Nuclear Installations Act sets a high-level goal such that anyone that wishes to construct or operate a nuclear installation must first obtain a nuclear site licence. A nuclear site licence can only be granted to a corporate organisation that has the capability of being the "controlling mind" for all the activities that are carried out on the site and has the capability of being an intelligent customer for all the services and equipment it procures. The granting of a site licence gives the public confidence that FPPs are being properly managed by a competent organisation.

The Nuclear Installations Act not only gives the nuclear safety regulator (ONR) the power to grant such licences to a duty holder (licence applicant /licensee) it also gives ONR the powers to attach conditions in the interests of safety and in relation to the handling, treatment and disposal of nuclear matter. The NI Act also allows the scope of what is meant by nuclear matter to be prescribed

The UK's nuclear site licensing regime, whilst robust, is incredibly flexible as it enables a wide range of nuclear installations (from large-scale nuclear power plants, large spent fuel reprocessing facilities, nuclear fuel fabrication facilities to small university research reactors) to be regulated using a proportionate goal setting approach. The licence conditions (LC) allow the licensee to tailor his arrangements for compliance with the LCs in a way that is proportionate to the hazard presented by the licensee's activities. The level of regulatory oversight provided by the nuclear safety regulator is again tailored to match the hazard potential of the activity being regulated in a way that does not unduly place regulatory burdens on the licensee.

The Flexibility of the NI Act and the nuclear site licensing regime operated by HSE/HMNII (now ONR) accommodated the regulation of new activities:

nuclear fuel cycle facilities (1970);

the refuelling of nuclear submarines (1987);

the UKAEA nuclear fission research sites (1990); and

the manufacture of the UK's nuclear weapons (1997),

without change to the nuclear site licensing approach.

The application of the nuclear site licensing approach has also not been a bar to innovation and change within the nuclear industry. On the contrary, the UK approach to nuclear site licensing has enabled considerable change to take place without undue regulatory burdens being placed on licensees whilst at the same time maintaining high standards of public and worker safety. It is clear that the nuclear power plants of today e.g. Hinkley Point C, bear no resemblance to the early Berkeley and Bradwell nuclear power stations that were licensed in 1960. Similarly, over the years the flexibility of the nuclear site licensing regime has enabled considerable innovation in technologies relating to nuclear fuel reprocessing, uranium enrichment, nuclear fuel manufacturing, radioactive waste treatment and storage, nuclear submarine refuelling, and decommissioning of nuclear installations, whist at the same time improving safety standards. The evidence has shown that licensing FPPs under the UK's nuclear site licensing regime will not inhibit or stifle innovation. I have always believed that good safety is good business and the challenge of the goal setting nuclear site licence conditions can drive innovation by allowing licensees the freedom to shape their arrangements to suit their business.

Although designed in the 1950's the NI Act was ahead of its time and it and its nuclear site licensing regime, has over the years, contributed, not only to high levels of public safety (that are respected worldwide), but also to a dynamic and innovative UK nuclear industry. I would argue that the UK's nuclear site licensing regime is fully aligned with the Government's, 2019 White Paper – Regulation for the Fourth Industrial Revolution as it has been shown to be capable of being agile, enabling innovation and providing world class protection of citizens and the environment. We should not lose sight of the fact that in spite of having one of the world's largest, complex and diverse nuclear programmes the UK's nuclear site licensing regime has ensured that there have been no major nuclear accidents in the UK since the NI Act was introduced. This is more than can be said for other industries.

6 What are your views on the Government's proposals in relation to the regulatory Justification of fusion?

Yes. I agree that it would be beneficial to have a technology neutral FPP justification. I could never understand why there needed to be separate Justifications for different types of nuclear power stations. It should be the generation of electricity from the nuclear fission process that was the practice not the type of fission reactor.

I have advocated that the UK FPP industry should work together to produce an application for the Justification of FPPs. It is however, not clear what is meant by the Governments proposal "generation of net energy". What we are talking about here is the practice of using nuclear fusion in an FPP for the production of electricity or heat for industrial applications.

It should also not be forgotten that the nuclear fusion process is also used in some devices to produce neutrons for medical isotope production. I am all in favour of having as broad a Justification as possible, but given the considerable differences between and FPP and a nuclear fusion based medical isotope production device, it is possible that there could be a need for a separate Justification for the medical isotope production practice.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

No. I do not agree.

What are the industry and the Government afraid of such that they deem it necessary to exclude FPPs in Law from the nuclear site licensing regime? It sends a clear message that the Government and the industry want less regulatory oversight for FPPs.

Changing legislation to exclude FPPs from the UK's nuclear site licensing regime is unnecessary, wrong in principle and would send a wrong and negative message to the public that FPPs were not going to be regulated by the process that has kept them safe from the use of atomic energy for over 70 years.

I have made compelling arguments in my responses to questions 3,4 and 5, that the safety of FPPs should be regulated by ONR under the UK nuclear site licensing regime.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined above?

Yes and No.

Yes, I agree that a technology neutral NPS for FPPs in England and Wales would be beneficial.

No, I disagree, for the reasons given in my responses to questions 3,4,5 and 7 that the NPS should exclude FPPs from the UK nuclear site licensing regime.

9 What other issues should a Fusion NPS address?

I think the NPS should be comprehensive and include FPP fuel cycle issues such as the supply of fusion materials (Tritium, deuterium and lithium) and the management of radioactive waste.

10 Do you believe that a third party liability regime is required for fusion?

Yes. I believe a third-party liability regime is required for FPPs. The hazard potential of an FPP is not trivial and hence there is the potential to release radioactive materials into the atmosphere in the event of accidents or external events. The release of radioactive materials presents a risk to people due to exposure to ionising radiation.

11 What are your views on the principles and issues regarding third party liability set out in this paper?

In general, I agree with the principles as set out in the paper, my detailed comments are set out below.

Capping FPP liabilities

I agree with the concept of capped liabilities.

Setting the liability cap at an appropriate level

When the quantity of tritium is added to the quantities of radioactive tungsten dust in the VV an FPP would most likely be classified as an intermediate risk facility under NIR 2018.

Strict liability

I agree strict liability should be applied to FPPs

Financial Security

I agree with the application of financial security, LC 36 attached to a nuclear site licence requires licensees to have adequate financial resources

Channelling Liabilities

I agree with the Government's view on "channelling" - this argument reinforces the need for FPPs to be subject to nuclear site licensing.

Liabilities across borders

I agree but as discussed above more work needs to be done on the dispersion of Tritium and activated dust particles to determine the distance FPPs can be sited from international borders. Our calculations would indicate that a release of around 10% of the tritium inventory and about 2% of the dust inventory in the VV of an FPP would trigger the 30mSv evacuation level at 1Km from the site.

Timeframe for compensation

I disagree with the Government's proposed approach to this issue.

The 30-year rule is related to latent cancer development and hence given that both tritium and activated dust are radioactive materials with the potential to induce cancer, rather than looking at other hazardous industries, the Government should commission work on the radiological impact of the radionuclides that can be released from FPPs under accident condition to see if the 30-year rule still applies.

Regulatory Harmonisation

I agree the Paris Convention approach of a harmonised legal liabilities framework should be applied to FPPs.

Established rules

I agree the established rules are tried and tested but given my comments above on the potential radioactive inventories of FPPs it is possible that FPPs will fall under intermediate and not low risk facilities.

Ease of developing a fusion insurance market

I agree.

12 What issues in addition to those described in this paper should any fusion third party liability regime address?

No comment.

13 How can the Government promote the development of suitable commercial fusion insurance?

No comment.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

No. I do not think the cyber security regulations should be applied to FPPs as there are better ways of providing the required levels of protection.

Cyber security is only one element of security and the protection of FPPs requires a holistic approach to security.

It is a big mistake for the Government to exclude FPPs from the NISRs. As discussed above FPPs have the hazard potential to cause harm to the public. It is inconceivable therefore that the Government would not require high levels of security for FPPs given:

their radiological inventory,

in the event of a widespread deployment of FPPs for electricity generation, their importance to security of supply to the nation,

their inventory of tritium and

the political embarrassment should terrorists or activists take control of an FPP.

I believe that FPPs will require high levels of security (physical protection) to prevent sabotage and the theft of tritium, which is booster material for nuclear weapons. Whilst the Convention of the Physical Protection of Nuclear Materials and Nuclear Facilities does not currently apply to FPPs it is only a matter of time before it will be. In any case the principles of nuclear security are applicable to FPPs and can be applied in a proportionate way.

The NISR enable a comprehensive approach to be taken to the regulation of cyber security and hence there would be no need to change NIS 2018 to accommodate FPPs.

Bringing FPPs within the NISR (and safeguards) will not only provide the necessary security for this technology but also negate the need for the Government to make new security arrangements specifically for FPPs.

15 What in your view should cyber security regulations for fusion cover?

As discussed above the security of FPPs covers more than simply cyber security.

In addition to physical protection, nuclear security includes the protection of sensitive information and sensitive technologies. Tritium production and handling are sensitive activities given the role tritium can play in nuclear weapon.

In the fission world there is a growing recognition of the importance of having an integrated approach to safety, security and safeguards at the design stage and during construction, commissioning and operation of nuclear plants. The advantages of having an integrated approach would also apply to FPPs.

As I have pointed out in my response to previous questions FPPs should be subject to nuclear site licensing and the NISR. This would enable ONR, who have expertise in all these areas to develop a proportionate, integrated regulatory approach for FPPs.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

No. This approach is not necessary as there is already an existing regulatory regime that is fit for purpose and would not require this definition which is solely to facilitate the Government's desire the use the HSE/EA regulatory approach.

Care needs to be exercised here. A 50MW fusion reactor is generating a lot of heat that needs to be removed. We should distinguish between planning controls and safety requirements, after all the nuclear licensing regime has been successfully used to regulate the safety of small research reactors with power outputs much lower than 50 MW.

It is also important to recognise that the IAEA is currently working on how to define fusion installations, which include FPPs, and the regulatory approach that should be applied to the different types of Fusion Installation.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

No. I do not agree that there should be formal engagement in the design process between fusion developers and regulators.

There are real dangers with this approach. It is vitally important to understand the dangers of too much engagement by regulators in the design process. Without adequate control this can lead to regulators

enthusiastically or inadvertently participating in the design process;

dictating design solutions;

laying themselves open to regulatory capture by the developer; and

at a later date "marking their own homework" thereby undermining regulatory independence and objectivity.

The accident a Fukushima showed us that we blur the lines between the industry and the regulator at our peril.

It is also important to understand that under UK law it is not the developer that is held responsible for safety, it is the operator / licensee. Hence the formal opportunity to engage with the duty holder in the nuclear site licensing regime is well structured and controlled to minimise the chances of regulatory capture.

The way developers / vendors gain understanding of safety requirements is usually via access to design safety guidelines and design safety standards that are recognised by the safety regulator. It is usually the industry that develops these safety guidelines an example being the European Utilities Requirements for LWRs. I have long advocated that the fusion industry should be developing these design safety guidelines that will deliver risks to the public that are ALARP. The TOR framework for nuclear installations is universal – a risk of death is risk of death whatever the cause.

18 What are your views on how such engagement should work?

As shown in my response to Question 17, I disagree fundamentally with the concept of formal engagement between regulators and developers. Formal engagement should be in the context of the nuclear site licensing regime.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

No. The application of the nuclear site licensing regime to FPPs will not require any additional guidance on the regulatory approach as it is well known and well respected by the nuclear industry and the public.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

No. The public should not be involved in the regulatory process. Keeping the public informed of development of FPPs is of course important but participation in the regulatory process is not the way to do this.

In the planning process for the siting of an FPP there is the opportunity for public engagement. At planning inquiries for nuclear installations, it is usual for the safety regulator (ONR) to explain the regulatory process and answer questions on how the facility will be regulated. At the licensing stage, again it is usual for the licence applicant / licensee to set up a local liaison committee (LLC) that includes the public and their local representatives. At LLC meetings the ONR inspector provides updates on regulatory activities and answers questions. This approach should be applied to FPPs.

My concerns about allowing the public to engage in safety regulatory decision-making stem from the duties of a regulator and the ability of regulators to perform their functions in an independent and effective manner.

Regulators are appointed to:

enforce the law;

monitor compliance with the law;

provide permission to the licensee to undertake specific activities in a timely manner, but only after careful consideration of safety documentation submitted by the licensee;

take urgent regulatory action when necessary;

act independently without fear or favour;

act proportionately; and

take enforcement action in the case of non-compliance.

These activities require technically competent inspectors and an effective and efficient regulatory management system. Participation of the public in these activities would undermine regulatory responsibilities and inhibit regulatory effectiveness. An example of having public participation in the regulatory process is the case in the USA where the practice was to have a construction licence and an operating licence for an NPP. NRC the nuclear safety regulator, was required to hold public hearing before an operating licence could be granted. These public hearing led to long delays between the completion of construction and the commencement of operation. These delays not only adversely affected the nation's access to electrical power from the plant but also added greatly to the cost.

The UK nuclear licensing system provides regulatory certainty through a continuous process from design, construction, commissioning operation and eventual decommissioning.

Fusion investors, owners and operators/licensees of FPPs need regulatory certainty and effective and efficient regulation. The public and politicians also need to know that FPPs are subject to effective and efficient regulation.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

I believe ONR has the technical capability to effectively and efficiently regulate FPPs, hence it would be counterproductive for the UK to be duplicating ONR's capabilities.

The skill needed to regulate an FPP from design, through construction, commissioning, operation and decommissioning are essentially the same as that for an NPP. ONR would need to build up its skill and expertise relating to the fusion process, magnets and cryogenics would be a relatively small addition to the overall skill base that would be needed to regulate an FPP.

Using ONR to regulate FPPs would be far more effective in terms of UK scientific, engineering, and technical resources than duplicating ONR's skills in an HSE fusion focussed organisation.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

We need to be very careful here as regulatory independence is vitally important for public confidence and to the successful deployment of FPPs in the UK.

Regulatory independence is a requirement of IAEA Fundamental Safety Principles, the Nuclear Safety Convention, the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management and the Convention on the Physical Protection of Nuclear materials and Nuclear Facilities.

I have long argued that the public can have confidence in the use of atomic energy (which includes fusion energy) in the UK because of a nuclear triple lock.

The first lock is having a technically competent organisation operating the nuclear installation that is the “Controlling Mind” and an “Intelligent Customer” i.e. a nuclear site licensee.

The second lock is having an effective internal safety assurance department which is independent of operational responsibilities within the licensee organisation.

The third lock is having a strong, technically competent and independent nuclear safety regulator – ONR.

In counties where major accidents such as Chernobyl and Fukushima have occurred, several if not all of these locks were broken.

The UK is fortunate to have this triple lock in place for its nuclear installations and given the hazard potential of an FPP the triple lock should also be applied.

In the case of STEP the UKAEA will be the Controlling Mind and Intelligent Customer. The Fusion Safety Authority is the internal, independent assurance department – hence two of my three locks are already in place. If the Government accepts my proposal that the safety regulator is ONR then the UK will have the necessary triple lock in place for FPP development and deployment.

Regarding the issue of UKAEA acting as a Technical Support Organisation (TSO) to the safety regulator this is not advisable because UKAEA will be the duty holder that is being regulated and this would compromise the necessary independence of the regulator.

In the early days of the launch of the UK’s nuclear power programme the UKAEA did play the role of a TSO because it was the UK’s leading nuclear research organisation and was not the duty holder for the nuclear power stations. ONR is now a mature nuclear safety regulator and I would argue that it has sufficient in house capability not to need an external TSO unlike some other countries with different Regulatory Body structures.

In the future should the STEP project be run by an organisation different from the UKAEA then the UKAEA could take up the role of the UK’s Fusion Technical Support Organisation for ONR if it was needed, and possibly the TSO for the industry.

In the meantime, it would be in order for UKAEA to play a leading part in the development of fusion design safety guidelines and standards and to lay on technical courses on fusion technology for ONR inspectors.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

The current UK arrangements for the management of radioactive waste are suitable for the wastes that will arise from FPPs.

The Government's proposals for the management of radioactive seem to be appropriate. However, it must be recognised that because of the nature of the fusion process, FPPs will produce thousands of tons of ILW that will require interim storage for more than a century. ILW arises from such things as the plasma facing components, breeder blankets and divertors, which will need to be replaced at regular intervals because of material damage caused by neutron irradiation. As FPP designs develop in the future with new materials it is possible that the amount of ILW will be reduced.

It is important not to make the mistakes of the past and hence, so as not to place unnecessary burdens on future generations, these ILWs will need to be placed in passively safe waste stores that are designed for full retrievability of the waste after 100 or so years. These stores will require close regulatory scrutiny to ensure that are fit for purpose. Such storage facilities are usually licensed under the NI Act. To ensure a comparable approach to public protection, the facilities for the handling treatment, storage and retrieval of FPP ILW, should be prescribed under the NI Act. They would become nuclear installations and hence subject to the UK's nuclear site licensing regime.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

In principle the answer is yes, but there may be dangers in trying to prescribe solutions that could inhibit innovation of FPP designs and impinge on safety or operability or both. I think it would better to gain a firmer understanding of the nature of the radioactive wastes, the types of radioactivity involved and the amounts of wastes with long half-lives before policy decisions are made.

25 What are your views on how a fusion facility should be decommissioned?

It should be noted that in the case of a fission NPP defueling is part of the plants operation phase and not the decommissioning phase. Hence there is no material difference between the decommissioning of NPPs and FPPs. I agree with the Government's proposal that decommissioning should be taken into account at the FPP design stage. This is in line with the requirements for all nuclear installations that are licensed in the UK. This is another reason for FPPs to be subject to nuclear site licensing. The current decommissioning funding arrangements for NPPs could be extended to cover FPPs.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

As the current UK arrangements for the management of radioactive waste and for the decommissioning of nuclear installations are directly applicable to FPPs there is no need for specific guidance to be developed for FPPs in these areas.

The application of the UK's nuclear site licensing regime to FPPs would demonstrate to the public that there was a robust regulatory framework from "cradle to grave" to ensure their protection and that radioactive waste and decommissioning were being controlled to minimise the burden on future generations.

27 Do you agree with the Government's proposals on safeguards for fusion?

I agree with the Government's proposals relating to the application of the current non-proliferation safeguards arrangements to FPPs. I also agree that the Government should keep this policy under review given the potential safeguards issues associated with the global deployment of FPPs.

The widespread deployment of FPPs would mean a much larger use of tritium than at present and as tritium is a material used to boost nuclear weapons, there could be proliferation of thermonuclear weapons should tritium or tritium production technologies fall into the wrong hands. Therefore, it is possible that in the future the IAEA could include tritium in its safeguards requirements.

Also, it is possible for FPPs to be modified to illicitly produce fissile materials such as 233U and 239Pu from thorium and uranium in the breeder blankets. Given this potential, the IAEA are likely to take an interest in FPP design and operation to ensure that currently defined nuclear material that come under safeguards are not being produced or diverted for the illicit production of nuclear weapons.

Hence, regulatory scrutiny of FPP breeder designs and operation will be required by safeguards inspectors under the existing safeguards arrangements and possibly new safeguards arrangements for tritium. As ONR are responsible for safeguards regulation it would again be not only sensible but also regulatory efficient, for ONR to be responsible for safety, security and safeguards at FPP sites.

28 What should the Government consider in developing guidance for export controls and technology licensing?

I agree that some of the technologies used in FPPs, especially relating to tritium production and handling can be considered as dual use technologies and hence should be subject to export controls. I also agree that the Government should work with the regulator (ONR), industry and the appropriate international organisations to establish the rules that will be needed to enable the export of FPPs. These rules will need to cover such things as

tritium production, handling and treatment – system design and operation;

plasma operations;

fusion reaction control systems;

plant operating rules;

breeder blanket design;

breeder blanket operations;

plant modification especially breeder modifications; and

materials accountancy arrangements.

Having an integrated approach to safety, security and safeguards would help enormously in the development and regulation of FPP designs that could comply with non-proliferation safeguards and associated export controls.

29 Do you agree with this proposed approach for keeping the fusion regulatory framework under review?

No. I do not agree with the Government's proposal because I believe FPPs should come under the UK nuclear safety licensing regime and hence there would be no need for regular reviews.

There is ample evidence that the hazard potential of any type of FPP that could be used for electricity or heat production on a commercial scale is far in excess of current UK fusion research facilities. FPPs, if not designed, commissioned or operated properly, have the potential to require offsite emergency counter measures to protect the public in the event of:

accidents whether as a result of plant malfunction, human error or external events such as earthquakes; or security incidents such as sabotage or aircraft crash.

As shown in my response to questions 27 and 28 that FPPs not only have to be safe and secure they also need to be robust in relation to non-proliferation to prevent the production and diversion of materials that could be used in nuclear weapons or other improvised nuclear devices.

It is also not meaningful to compare FPPs with particle accelerators or industrial chemical plants. FPPs are power stations fuelled by a nuclear process that produces ionising radiation and radioactive materials that are dispersible into the atmosphere. Whilst the hazard potential of an FPP is considerably less than that of an NPP, it is not trivial and there is the potential to expose the public to ionising radiation via these radioactive materials. The public are more averse to exposure to ionising radiation than chemicals.

I have presented ample evidence to show that the Government's currently prosed regulatory framework as set out in the green paper should be changed to one that brings FPPs into the UK's nuclear site licensing regime. Making this change would negate any need for a policy to keep FPP safety regulation under review.

It is better for everyone, the industry, the public, the Government and the regulators to get the regulatory framework right fist time. There is also an added benefit in adopting this approach. The International community, IAEA, the European Commission, the US, Canada, China, Korea and others are actively discussing how to regulate FPPS. Having ONR, a globally respected nuclear safety regulator, as the UK's safety regulator for FPPs would enable the UK to effectively engage and influence international developments in relation to FPP regulatory, safety, security and safeguards requirements to ensure they are proportionate to FPP hazard potential. In the early days of the nuclear fission programme the UK played a leading role in the development the IAEA safety standards and in the nuclear related internal Conventions. The UK should do the same for the emergence of FPP technologies.

30 Do you believe there is anything else the Government should consider with regard to fusion energy regulation?

In my responses to the questions in this consultation document I have endeavoured to show that there are compelling reasons why the current Government proposals for the safety regulation are not fit for purpose and that FPPs should be subject to licensing under the NI Act with safety regulated by ONR.

Had the UKAEA not been exempt from nuclear site licensing, JET would have been licensed under the NI Act

UKAEA were required to conduct its activities to standards equivalent to those at licensed nuclear installations and hence the design and construction and operation of JET have followed procedures similar to those expected of an equivalent nuclear installation.

FPPs are not fusion research facilities, they are more complex and have much larger hazard potential.

Regulating the safety of the design, construction, commissioning and operation of an FPP will be far more demanding than the current day to day safety regulation of JET and other facilities at Culham.

FPPs will need to regulated in relation to security and safeguards and hence having ONR provide safety, security and safeguards regulation will enable licence applicants / licensees to have an effective and efficient a "one-stop-shop" approach to regulation.

The International community (including the EU and the IAEA) are actively debating how FPPs should be regulated and hence the Government should not do anything that would hinder the ability of the UK to influence the international thinking on how FPPs should be regulated for safety, or to influence the development of safety standards that are proportionate to safety standards

The fusion industry should not be afraid of nuclear site licensing, it is a very flexible regulatory framework that allows regulatory oversight to be developed to match the hazard potential of the activities being regulated. Experience over decades has shown that its flexibility is conducive to innovation, and it provides effective and efficient safety regulation by a competent and well-respected safety regulator. Regulatory engagement through the design, construction and operation phases of an FPP project provided investors, vendors, licence applicants and licensees with certainty that there will be no regulatory surprises during project.

31 Before today how much did you know about fusion energy?

I knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

I know a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

I strongly support fusion energy – but it will need a better safety regulatory system than is proposed in this paper

Individual D

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

The UK government has a long history of supporting groundbreaking development whilst other profit. The system whereby Institutions and not the government owns the Property Rights needs reviewing so that it benefits the UK population in general and not individuals or organisations.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

No

We have a history of overzealous regulation where it doesn't matter. The government should make organizations take out insurances to cover hazards and let the insurance companies dictate risk avoidance rules.

3 Do you agree with the proposal to maintain the existing regulatory approach?

No

Minimal regulations suffice.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

No

As stated before it is best to insure against risk. Though IRR 2017 does offer a good start for insurance companies to base their risk assessment on.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

These plants generate little or no radiative materials or waste.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

Overkill and creation of more bureaucracy at a time when the development of fusion power is critical to the energy needs of the UK.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

No

These plants create minimal risks to the population a risk that can readily be insured against.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

No

Does not require the increase in Bureaucracy that this proposal would create.

9 What other issues should a Fusion NPS address?

No Comment other than those above.

10 Do you believe that a third party liability regime is required for fusion?

Yes

11 What are your views on the principles and issues around third party liability as set out in this paper?

Given the limited risks associated with Nuclear Fusion, there is no reason to cap the liability.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

Leave it to the developers and the insurance companies.

13 How can the Government promote the development of suitable commercial fusion insurance?

It's not the government's business to comment on insurance contracts it is just its business to ensure that the insurance companies have adequate reserves to cover the potential risks.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

I don't think they should be alone though, I am amazed how lightly the government has treated Cyber security and how little it demands from commercial organizations to ensure their systems are secure.

15 What in your view should cyber security regulations for fusion cover?

Cover any risk of breach of firewalls.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Don't know

The question is confusing to many 'that's but the definition is appropriate in that it defines commercial boundaries for operational units.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

No

To much beaurocracy.

18 What are your views on how such engagement should work?

As risks are exposed during R&D the insurance covers should be updated.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

No

The government ultimately dictates what can be developed on a large scale even if local communities oppose this posturing is just another bureaucratic nightmare.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

No

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

NO

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

We should focus on the UK and not give away our commercial property rights.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

The Canadian system is both proven and workable just adopt it.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Don't know

See answer to 23.

25 What are your views on how a fusion facility should be decommissioned?

A decommissioning and maintenance plan should be part of the construction process. The insurance companies should be trusted to make sure that these aspects are suitably funded.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

The regularity aspect should be minimized.

27 Do you agree with the Government's proposals on safeguards for fusion?

No

No, too bureaucratic. We need to stop hindering the developing process and do everything possible to make fusion technology a source of energy and its intellectual property rights a source of wealth for the UK.

28 What should the Government consider when developing guidance for export controls and technology licensing?

We should protect our property rights to the full.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

All regulatory frameworks should be kept as minimalistic as possible and reviewed that they remain so.

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

35 What is your country's / organisation's planned approach to regulating fusion energy?

It's the biggest commercial opportunity on earth let the UK make the most of it.

Individual E

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

Fusion is utterly stupid when the threats to humankind are so great. Wasting time and money on a dream is contemptable. The risks from nuclear fission are bad enough but going into temperatures and pressures in pursuit of a dream which may never happen and if it did how could it be useful when the country needs smart technology, more localised and resilient to climate change.

Water we have not got. projects based on jobs and financial benefits are suspect

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

No

3 Do you agree with the proposal to maintain the existing regulatory approach?

No

Use a strengthened ONR

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

No

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

There is no need for nuclear technology regardless.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

Scrap the tech.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

No

Scrap the tech.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

No

We cannot get a sensible EN6 which is out of date, sites in flood zones, needing potable water damaging the marine environment and no waste solutions so yet another distraction from combatting climate change.

9 What other issues should a Fusion NPS address?

-

10 Do you believe that a third party liability regime is required for fusion?

Yes

Ridiculous tech.

11 What are your views on the principles and issues around third party liability as set out in this paper?

No comment

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

No comment

13 How can the Government promote the development of suitable commercial fusion insurance?

Uninsurable?

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

15 What in your view should cyber security regulations for fusion cover?

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Sorry I give up here!!

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Obviously yes

18 What are your views on how such engagement should work?

-

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Not Answered

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Not Answered

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

-

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

The history of nuclear in the UK is financial disaster all companies should be hung out to dry and financial costs to date truthfully investigated

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

Back to the same myths of safe disposal .

What a shocking legacy

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Disposed not!

25 What are your views on how a fusion facility should be decommissioned?

-

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

-

27 Do you agree with the Government's proposals on safeguards for fusion?

-

28 What should the Government consider when developing guidance for export controls and technology licensing?

-

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

-

31 Before today, how much did you know about fusion energy?

Not Answered

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly oppose

33 What is your level of knowledge about fusion after reading this paper?

Not Answered

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly oppose

Individual F

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

Regulatory areas to be covered should include the full lifecycle. Concept, Feasibility, Design, construction, operations, maintenance, upgrades and life extension, and decommissioning and disposal.

A cohesive approach is needed to take an overarching view across all areas. There are various examples from other U.K. regulated industries such as rail, civil nuclear and defence nuclear, where boundaries have built up along interfaces between lifecycle stages. This has lead to poor handover, additional CAPEX and OPEX spend, delays to programme and eventually not delivering a product or service against the original requirements

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

No

There is insufficient evidence to show how the latter stages of the lifecycle (long term operations, upgrades and decommissioning/disposal) would be adequately managed

3 Do you agree with the proposal to maintain the existing regulatory approach?

No

We need to be more thorough and make provision for future technical development

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

No

There doesn’t seem to be a cohesive approach combining technical, commercial and programme approaches and interfaces.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Yes

Due to the by products of the fusion process.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

It should be treated the same way as a conventional nuclear fission reactor

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

Appropriate oversight is needed to avoid exploitation by commercial stakeholders

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

9 What other issues should a Fusion NPS address?

Addressing commercial as well as technical interfaces

10 Do you believe that a third party liability regime is required for fusion?

Yes

11 What are your views on the principles and issues around third party liability as set out in this paper?

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

13 How can the Government promote the development of suitable commercial fusion insurance?

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

This is due to the development of cyber technology and that it underpins the commercial viability of a fusion reactor

15 What in your view should cyber security regulations for fusion cover?

All aspects from operations of the reactor to the commercial entity or entities which owns and runs the reactor

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

18 What are your views on how such engagement should work?

A Systems Engineering approach should be taken to ensue that all stakeholders are appropriately represented

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

Ability to use the energy generated for multiple commercial and research benefits

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

Having a panel made up from members of the public

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

By taking a systems engineering approach to make sure a holistic approach is taken

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

Using the experience and expertise to comment about different parts of the whole lifecycle

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

As far as possible, it should be recycled, reused, minimised. Provision should be made for a waste storage facility for anything that can’t be reclaimed

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

Cost should be a consideration.

25 What are your views on how a fusion facility should be decommissioned?

Where possible, it should be able to be recycled with minimal waste that needs to be handled securely

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

Taking a system engineering approach will allow for future technical development and capabilities not yet available

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

28 What should the Government consider when developing guidance for export controls and technology licensing?

Similar to other U.K. regulated industries

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Support

Individual G

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

Waste heat. If this technology really takes off, this will be the most significant hard-to-handle waste. As far as I am aware there are no current regulations on dumping heat into the environment in general. Clearly all (or nearly all) fusion power plants should also provide district heating. The waste heat should also be used in summer to provide air conditioning using absorption refrigeration.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

No

As far as I can see the possibility of very small scale generators (producing, say 10kW or less) has not been considered in the context of regulation. It is already the case that private individuals round the World construct amateur Farnsworth–Hirsch fusors though, of course, none have yet achieved energy parity. However, once large commercial plants achieve this, the technology will trickle down.

The main danger from small fusors is X-rays, which are easily shielded using lead. Many amateur engineers are extremely competent. But not all. I can see no practical way to regulate this area; you can't stop people making machines in their sheds from everyday materials and equipment.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

The existing regulatory approach strikes the right balance between safety and over-caution in the face of the unfamiliar. And (see my previous answer on small fusors) it does not attempt to regulate the unregulatable.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

I can see no reason to treat ionising radiation from fusion plants any differently to the way it is already treated in existing industries.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

The principal problem that the Nuclear Installations Act 1965 seeks to address is the safe control and containment of fissile material. That is not relevant to a fusion reactor except in the case of radionuclides generated in the material of containment vessels by the fusion reaction. These come from high energy neutron fluxes (typically 2.5 and 14 MeV from deuterium-deuterium and deuterium-tritium fusion reactions, respectively). But this problem is much less severe than the corresponding one for fission, and so should be treated in a separate and targeted way.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

This seems a very general question. See my specific answers elsewhere. Broadly the government seems to have mainly got it right with minor exceptions.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

See my answer to 5. above.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

Why not? What harm can it do?

9 What other issues should a Fusion NPS address?

One it SHOULDN'T address is the question of amateur reactor construction (see my answer mentioning small fusors). This would generate a big distraction, as it would be the single thing that the press and social media would latch on to, leaving much more important and significant matters undiscussed. (For a parallel, see 3D printed guns...)

10 Do you believe that a third party liability regime is required for fusion?

Yes

We have it for motor cars, so why not? This may also be a good way to approach amateur construction of fusors.

11 What are your views on the principles and issues around third party liability as set out in this paper?

See 10. Third party car insurance cannot, and so does not, anticipate all the ways in which a driver and a car may cause damage, so the liability is general and catch-all. Fusion reactors should be treated in the same way. Attempts to enumerate the dangers are bound to be both incomplete, and also to include absurdly improbable possibilities.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

See answers above.

13 How can the Government promote the development of suitable commercial fusion insurance?

By requiring it, again as with motor vehicles.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

No

A garage selling petrol is not subject to cyber security regulation. A solar farm selling electricity is not subject to cyber security regulation. Why should fusion power? It should be treated the same way in this regard as any other commercial activity.

15 What in your view should cyber security regulations for fusion cover?

Nothing. See above.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

No

It's not practical. When fusion development is being done by individual hobbyists there is no way that that can be subject to this sort of activity. This might as well be anticipated from the start. I can do CRISPR-Cas9 genetic engineering in my kitchen with equipment I can make myself - a much more dangerous technology that is similarly un-regulateable.

18 What are your views on how such engagement should work?

See above.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

Why not? It can do no harm.

Every area of the technology from X-ray and neutron emission to dealing with waste heat and the end-of-life of the irradiated containment materials.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

Climate Assembly UK is a very good model.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Regulators don't build technical capability. Engineers do.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

Publication of proven open-source royalty-free designs by UKAEA would be a very good idea.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

Most have short half lives. Tritium is a gas, and so the simplest way to get a handle on it is to burn it to make heavy water, which is easy to manage.

However, it is far too valuable a material to be considered waste. It is fuel. Clearly the choice of reactor blanketing and shielding is critical in minimising radioactive waste.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

As with fission, the volumes will be tiny.

25 What are your views on how a fusion facility should be decommissioned?

Depends entirely on scale. 200,000 10KW reactors in garages present an entirely different problem to one 2 GW one in a big field.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

Broadly yes, except for the points above.

28 What should the Government consider when developing guidance for export controls and technology licensing?

For a climate emergency solution, which fusion would be, there should be no export controls. It needs to be as widely adopted as possible.

Any research and development that is taxpayer funded should be carried out under an agreement that the results will be released open-source and free of patent or other IP restrictions for the same reason.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

Individual H

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

Several immediately relevant areas that must be stated:

REPPIR regulations, Ionising Radiations Regulations (IRR, 2017), Nuclear Installations Act (NIA, 1965), Less immediately obvious areas:

Planning Act (2008) - There is a question as to whether the limits currently applied to power plants is appropriate. The infrastructure required for power plants of an equivalent output level already vary between thermal and wind/solar power plants, but it is generally expected that fusion reactors (at least in early configurations) will require significantly more infrastructure. While a 50MW electrical generating capacity is applied as the limit, this currently represents different applications to thermal power plants:

1. a 50MWe fission power plant would be ~150MW thermal power

2. A 50MWe gas plant may be closer to 100MW thermal power

3. A 50MWe fusion power plant may be closer to 750MW thermal power, as significant amounts of electrical power are required to sustain the fusion reaction. For this reason, even a non-NSIP fusion power plant could be larger in thermal capacity than many NSIP thermal power plants.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

The level of hazard presented to the public is broadly in line with my expectation. The modelling carried out at CCFE/UKAEA has good basis and has been peer reviewed to an appropriate level at the moment.

There is one major feature of the assessment that I encourage caution on, which is the use of a 1km distance from source to the public. There are increasing calls for advanced technologies to be used for products other than electricity and which benefit from proximate siting. Any regulations which prescribe or assume a 1km distance from source to the public may unduly limit the scope of fusion applications OR be overly optimistic. The regulatory framework should not prescribe or assume a site envelope, but instead allow this as something for an applicant to propose and justify.

3 Do you agree with the proposal to maintain the existing regulatory approach?

No

There are significant shortcomings of the current approach that will become more apparent over time. There are currently no recommendations or requirements for codified design rules in fusion. Best practice is to use equivalent design rules in the civil fission sector, but these are generally not well defined to support fusion, as materials, load conditions and environmental factors are significantly different in fusion than fission. Maintaining the current regulatory approach would almost ensure that fusion power plant development carried out will bring individual assessment methods and no central platform to collaborate on design rules. Regulators can be very useful in defining accepted methods of assessment, giving guidance on best practice or hosting collaborative working groups.

Another feature that is not well captured by the current fusion regulations is the storage, processing, or otherwise treatment of radioactive waste. Fusion generates different waste than fission, both at the current level of development and the required level of development for a fusion power plant. This cannot be left underdeveloped, as it will almost certainly lead to a similar waste legacy and challenge in decommissioning 1st generation fusion power plants as 1st generation fission power plants.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

No

As tritium is treated as a dual-use military/civilian material (as well as equipment for the production or extraction thereof), the level of security checks offered by IRR2017 and EPR2016 are not in keeping with the level of risk that tritium is assumed to have, as per current legislation.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

Fusion power plants are sufficiently different from fission power plants that the intent and language of the NIA 1965 does not seem appropriate. New legislation is needed in this area. NIA 1965 should be updated to clarify whether the SoS and government see fusion as subject to the act and update the text appropriately, or draft separate legislation on fusion power installations.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

This is a sensible approach. However, there seems to be a wide range of technologies covered under the "classes or types of practice", e.g., operation of the Sizewell B PWR is justified under this definition, but would a UK SMR also be justified under the same definition? Furthermore, would the justification from the STEP programme also justify later endeavours of entirely unrelated programmes? As it reads, that answer appears to be yes, although carrying over justification between designs/programmes separated by an entire generation does not seem logical.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

As discussed above w.r.t. The NIA 1965, yes.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

An NPS will give clarity on policy and approach to organisations developing fusion power. As per my response to a previous question, the threshold for a "generating station" should be reconsidered as the implications of generating stations of different technologies have vastly different impacts to planning activities.

9 What other issues should a Fusion NPS address?

In line with NPS EN 6, a fusion NPS should cover the interaction with the Habitats Directive. The levels of tritium leakage into waterways should be addressed w.r.t. habitats and wildlife, as this has been perceived as a significant issue from Fukushima.

10 Do you believe that a third party liability regime is required for fusion?

No

Fusion has been justified as a candidate technology and development goal due to the intrinsic safety features. If fusion power plants are also given a 3rd party liability regime, the public perception of fusion will be damaged regardless of whether it is a feature that is used.

11 What are your views on the principles and issues around third party liability as set out in this paper?

The justification used to develop fusion will be undone if fusion power plants are given the same types of protections as are present in the fission industry.

Furthermore, I would question whether "low level" NIR limits on tritium inventories are appropriate to apply to fusion power plants before fusion power plants have been designed.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

N/A

13 How can the Government promote the development of suitable commercial fusion insurance?

N/A

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

Cyber security of plants with highly energised systems must be a primary consideration in the design of the control systems, security protocols and more.

15 What in your view should cyber security regulations for fusion cover?

This is a question that the government should consult cyber security experts about. At a minimum, the control systems used, access of personnel to computer and control systems, plant layout. Please speak to professionals in the field about this.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

No

The limits should not be applied to electrical generating capacity, but instead recirculated loads and/or thermal power generation

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

Regulators can play a pivotal role in establishing best practice or accepted methods.

18 What are your views on how such engagement should work?

Regulators should ensure that designs are sufficiently safe to prevent harm to plant operators, the public or the wider environment. The regulators should NOT be responsible for ensuring that asset protection measures are in place, as this is due diligence that investors and developers should apply to their commercial products.

Regulators should be facilitators and chairs of working groups to define best practices, as well as actively challenge the approaches taken to ensure that sufficient rigour is applied by developers.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

Please see responses to previous question.

Please see responses to previous questions for more in depth answers. To generally recap, regulators should recommend best practices or accepted methods of assessing systems/components for safe design. The regulators should also develop guidance for best practice and engage with standards agencies to develop engineering standards for fusion, such as ISO or ASME.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

The answer is by default yes, because there is currently no regulatory process for fusion.

There should be a similar level of opportunity as with fission. Engagement in the DCO process and in any equivalent to the GDA process, as well as during licencing (if relevant) and build phase of a plant. Fusion would similarly benefit in engaging with the public through life, as is the case with many fission power plants.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Early engagement with developers to understand major risks and challenges. This should be followed with work to establish similarities in adjacent fields and involvement of technical staff of the regulatory body in work to de-risk those fields. An example would be the failure mechanisms of candidate materials and loading conditions (such as RAFM steels under high energy neutron irradiation), where a regulatory body could gain insight by cofounding research, gaining insight and experience as the project progresses and building links with experts with the most experience. This would also be a route to fund such projects with EPSRC grants or similar.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

Similar engagement as prior question. Involvement of regulator technical staff in projects run by UKAEA would be a valuable way to share such insight.

Another way would be for a regulator to start create working parties to establish codes and standards, possibly with support from ISO or other standards bodies.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

Waste classifications from fission are broadly applicable, although there would be value in additional categories to provide options for recycling after a reasonable and appropriate decay period. This is the intention behind many of the materials developed for contemporary fusion programmes, such as EU DEMO. Without an opportunity or option to reduce the long term waste legacies, there will be limited benefit in pursuing fusion as opposed to Gen IV fission.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

Fusion developers should be encouraged or mandated to limit the time that the waste remains hazardous. This would then enable near-surface disposal and reduce the need for a GDF

25 What are your views on how a fusion facility should be decommissioned?

1. At no additional expense of the taxpayer

2. To established best practices for fission, when appropriate to the buildings and equipment

3. In ways to minimise tritium retention or release to environment

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

Developers should provide a funded decommissioning plan and be encouraged to plan for decommissioning as part of the design. Many issues and unexpected decommissioning costs are due to design choices that did not account for decommissioning.

27 Do you agree with the Government's proposals on safeguards for fusion?

Don't know

Given that tritium and tritium producing assemblies are listed on the strategic export control list under dual military/civilian use, it would make more sense that tritium fell under similar safeguards OR the export control list was clarified to reduce potential conflicting information

28 What should the Government consider when developing guidance for export controls and technology licensing?

The government may want to consider reducing the barriers for civilian use of tritium, enriched lithium, and associated materials and technologies with respect to export control

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

A <10yr review period is sensible, although ideally the regulations would move to a point of maturity where stability can be expected and that changes would become more minor and continual than requiring a major review/revision.

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

Individual I

1 Are there other critical regulatory areas that the government should address when considering the regulatory framework for fusion energy in the UK? Please explain what these are and why they are important.

The current regulatory environment is well summarised, where this might be described as somewhat binary I.e. either “in” or “out”. However, I have concerns about the suitability of this framework for certain fusion technologies, such as (and notably) inertial confinement fusion (ICF), which is radically different to magnetic confinement fusion (MCF) and historically closely associated with the military industrial complex and the manufacture and testing of nuclear weapons. I have provided a more detailed response later at question 2. In the above response I have used “in” to mean subject to the full regulatory regime currently applicable to any UK licensed nuclear site. Hence, MCF technologies as represented by current mainstream tokamak designs (including spherical examples) and stellerator implementations would be outside, which I agree with.

2 Do you agree with the Government’s conclusions regarding the expected hazards of future fusion power plants?

The approach is well balanced, and in my opinion, broadly correct. However, as alluded to above, the UK Government may wish to consider whether certain types of nuclear fusion generation are suitable for regulation outside of the current regime applied to nuclear fission. The development of inertial confinement (ICF) techniques using laser targeted pellets held in a holloraum has its provenance in the development of nuclear weapons. For example, facilities like the Nation Ignition Facility (NIF) in the US and Laser Megajoule facility in France, are facilities funded by the military and although they have quasi civil research missions, remain more military than civil assets. With ICF, the laser targeting technique gives rise to a subsequent implosion/explosion which is a confined reaction (fusion ignition) event and gives rise to considerable local seismic disturbance to the buildings housing the event, plus considerable x-ray burst. The possibility of such inertial events exceeding the permissible level and the likely public hostility to such regular seismic shockwaves may render inertial confinement unsuitable for regulation outside of the proposed regulatory framework. There are other security concerns attached to ICF which I have addressed later in this response. The UK Government may wish to consider a separation of certain fusion technologies such as inertial confinement and subject them to the full rigour of the existing regulatory process under the purview of the ONR and NDA.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Excluding ICF (previously referenced) the approach is broadly correct in my opinion due to the implications of using the alternative regulatory regime which would have negative implications for some large organisations. This is because such organisations will have a risk based approach which will use a formal risk review process. Such processes are highly structured and will seek to separate nuclear from non-nuclear business according to ascertained risk criteria, one of which will be "is the end use application one which could give rise to a nuclear incident?" The answer to this question has to be validated using a set of criteria, one of which will be whether the end use application is based at a site subject to formal nuclear regution I.e. does the country where the application is based rate the site as giving rise to risks which require formal nuclear regulation? Any such process will involve the use of internal (like me) versus external experts (normally certified TUV safety engineers), who will make a formal determination. Such expertise will normally regard any non-regulated site as not posing a risk of the kind referenced above (I.e. giving rise to a nuclear incident), thus allowing to application to be differentiated from those other nuclear applications which do fall within such regulated and licensed sites. For instance, we would regard nuclear fusion using conventional magnetic confinement as inherently safe due the physics involved, noting that the radiological and other hazards discussed in your consultation paper are considered within reasonable contemplation for regulation outside of the ONR i.e. EA and HSE.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes, the approach is broadly correct, with the exception of the referenced Inertial Confinement Fusion, which the government should consider as necessary for regulation under the alternative regulatory regime for regulated nuclear sites AND also because of the military nexus of this technology. Note, ICF would also be a high value target for espionage by hostile actors so should be subject to additional military oversight.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit

of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No, I think on balance convention nuclear fusion sites should remain outside the regime. As indicted in the response to question '3' above, placing nuclear fusion within the remit of formal nuclear regulation would render it subject to a more risk averse process within large risk managed organisations. This is because even though there are significant benefit to having a site and the associated nuclear application regulated under the UK's Nuclear Installation Act 1965 (the channelling principle which routes all liability regardless of fault to the site licensee being the main one) there remain significant concerns held by such organisations based upon a combination of factors. These include the residual risks which historically maintain regardless of the convention protection and arising from "gaps"in the original Paris convention drafting of the term "nuclear damage", notably:

1. Costs associated with implementing measures to reinstate the impaired environment

2. Pure economic loss associate with a direct economic interest in the use or enjoyment of the environment

3. The costs of taking measures to prevent a grave and imminent threat...

It should be noted that whilst all of these gaps are in theory now addressed under the 2004 protocols to the 1960 Paris convention, these will only come into effect upon full ratification of those amendments once all parties have ratified, which they now have, hence the ratification date is agreed to be 01/01/22. These protocol amendments will be enacted under the UK's Nuclear Installations (liability for Damage) Order 2016. However, speaking as someone who formally engaged with these changes as they emerged in the mid 2000's, large organisations' remain slow to change and nervous about embracing nuclear business when it is not core to what they do, hence there is a lot of inertia to overcome. On that basis, it remains advantageous to leave conventional fusion power plants outside of that regulatory regime as it de facto increases the participation rate due to the simplified treatment within the risk management process of large and complex organisations.

6 What are you views on the Government's proposals in relation to the regulatory justification of fusion?

The regulatory criteria is well founded and remains valid for fusion. However, since the advent of early nuclear fission we have become increasingly aware of the problems associated with burning fossil fuels and the anthropogenic contribution to global warming, which is not any longer in doubt by those amenable to scientific rationale. Therefore, we have a number of imperatives which are key drivers for such justification, for example:

1. Removing fossil fuel from the the electricity generation cycle

2. Providing the UK with high yield base load power generation which is immune to the variability arising from renewables

3. Providing the UK with a reliable source of secure energy which decouples the UK from reliance upon imported energy to levels which are acceptable from a national security perspective

Additionally, as there is a limited understanding across broader society of what nuclear fusion is and its potential benefits, the regulatory process should seek to stimulate a wide engagement with society about fusion and why it is essential to the UK and mankind in general for the future viability of the planet for all species.

Additionally, and as indicated in my earlier response to Q1, we should be alert to the strong possibility that fusion equilibrium may well be demonstrated well in advance of 2040, and that such an event, followed by the commercialisation of fusion reactor would be profoundly disruptive to parts of the energy sector which did not seek to adopt such technology. Hence, the societal benefits of fusion need to be discussed at length and misconceptions regarding the long lived radioactive wastes from fusion need to be placed firmly in context as significantly lower than fission and as a process which is inherently safe in the absence of a sustained chain reaction.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes, this is the correct approach in general. However, as noted, some fusion technologies like ICF, plus others which are pursuing alternative approaches from conventional tokamak MCF (using D,T fuel), may require a risk based approach to allow for the possibility that such technologies are of sufficient risk or concern as to place them within the site licensing regime for nuclear power generation.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined above?

Yes, this is the correct approach in general. However, please note that the NPS, whilst not being technology specific, should be clear that all fusion technologies are not treated equally and that the planning system will be capable of differentiating those technologies that are of sufficient concern (ICF), thus able to allow for derogation in planning to mandate site licensing under the UK’s nuclear regulator where appropriate.

9 What other issues should a Fusion NPS address?

Because there is broad consensus across the main political parties in the UK, regarding the veracity of anthropogenic climate change, the UK Government should seek to reflect this consensus (I.e. seek to recognise this issue as genuinely non-partisan to reflect the needs of energy policy continuity for at least a generation) and emphasise that the UK’s commitment to net zero carbon by 2050 cannot be achieved in the absence of high yield base load power generation from nuclear sources. Assuming the case for deployment of fission based SMR’s is made separately (as the technology is already well advanced and licensable) then this would emphasise the deployment of nuclear fusion as a successor technology which would retire fission power generation from the UK power fleet. If crafted in this way, where the benefits of a nuclear technology which is inherently safe, with lower level and shorter lived radioactive wastes, then this would enhance the appeal and acceptance to the wider public.

10 Do you believe that a third party liability regime is required for fusion?

Yes, such a regime would be highly beneficial for the following reasons. The Paris convention of 1960, has been very successful in promoting participation by key industrial technology providers, especially those companies who manufacture a wide portfolio of products which are not necessarily designed for nuclear end use, but which have provenance in fission power stations and other nuclear applications (reprocessing, enrichment, spallation, storage, submarines...).

11 What are your views on the principles and issues regarding third party liability set out in this paper?

As discussed earlier, the channelling principle and strict liability which are central tenets of the Paris convention as enacted in the UK's NIA 1965, are highly beneficial. In my capacity as nuclear liability advisor for ABB in the UK, I can confirm that the additional risk mitigation provided by these features was a key consideration for participation in many instances. Additionally, the UK's implementation of the Paris Convention was superior to that of other ratifying countries, in that the UK NIA 1965, also provides an indemnity for the on-site property under section 12(3A), a feature which is absent from most other Paris convention implementation of the treaty. Again, this has proved an enormous benefit to those risk averse organisations who might otherwise reduce their participation in the nuclear industry.

12.What issues in addition to those described in this paper should any fusion third party liability regime address?

With reference to the information provided in Q11, whilst the use of such a third party liability regimes is without doubt very beneficial, there is an anomaly with regard to their adoption for fusion sites. This is because currently the regulation of nuclear sites where the NIA 1965 applies, is limited to applications which require formal site licensing (fission power generation, reprocessing, enrichment etc). To apply such a third party liability regime to fusion, but at the same time NOT mandate site licensing, would possibly be a unique derogation for the UK, unless this were to form the basis of a further amendment to the Paris Convention to allow other countries to ratify and keep all countries in lock-step. Whilst this is not entirely necessary (note the UK's unique position on site property in the NIA 1965), it is always desirable to keep convention countries closely converged wherever possible. The matter of insurance itself I believe would fall into place once the market became operative I.e. there were approved nuclear fusion generation sites for grid connection and identified operators. As the risk from fusion sites are perceived to be significantly lower and the UK Government would probably act as the initial guarantor of last resort (where any insurance failure arose or an event exceeded the cap), such insurance would be highly beneficial, providing it was ONLY the site operator who was required to hold it. A risk managed organisation would not wish to hold such insurance unless it was core to it business, which for many large industrial companies, it is not.

13 How can the Government promote the development of suitable commercial fusion insurance

This is more a question for the insurance companies, but as someone who needed to specialise in different classes of insurance, I can give my opinion. The comparison of those risks arising from fission versus those arising from fusion are understood to be highly asymmetric in their consequences, where fission is regarded to be a significant order of magnitude greater than fusion. Whilst this is based upon our current understanding of how fusion will be deployed (I.e. most likely of the MCF type using tokamaks) it is reasonable to assert that this significant reduction in both risk probability (where fusion technology is not vulnerable to a chain reaction or loss of coolant event) and consequences, that the appetite in the insurance market should respond accordingly, noting that such insurance is generally viewed as lucrative by the insurance industry. If consensus were to be achieved whereby fusion was incorporated under the Paris Convention (and equivalent Vienna Convention) then this would underpin the fusion insurance regime as being attractive due to the presence of the channelling principle and associated absence of adversarial defence behaviours by those who would otherwise be trying to defend any findings of causation against them.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

As previously stated in my earlier response to questions regarding the need to regulate (or not) certain types of fusion technology, all fusion technologies are not equal with regard to both their risk and target value for espionage. Inertial Confinement Fusion, as indicated, is (in my opinion) worthy of both formal nuclear regulation and oversight under the NIS 2018. ICF is one of the key enabling technologies for optimising nuclear weapons design and is of interest to hostile actors even prior to the realisation of any viable energy generation potential (which seem currently unlikely at this stage to me).

15 What in your view should cyber security regulations for fusion cover?

Due to my assertions regarding the key nexus with the military industrial complex and nuclear weapons development, my opinion is that ICF technology should be subject to full regulation, including those measures applied to the UK’s current key defence site. This is less so for MCF, but noting that as has been suggested, such technology is a high value target to foreign actors and measures should be taken to ensure very robust cyber security measures are maintained at all times on such sites. Note, there is a wider humanitarian imperative to ensure that nuclear fusion as a viable and safe technology is deployed globally as quickly as possible, so this need must be balanced against the IP interests if individual nation states and rent seeking commercial fission investors who my not share such egalitarian principles.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

I would agree that the proposed definition is reasonable, noting the previously stated concerns regarding ICF technologies. Early engagement is always a sensible approach and especially where there will need to also be a parallel public education and consultation to avoid any misinterpretation of the hazards arising from nuclear fusion.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Early engagement is always a sensible approach and especially where there will need to also be a parallel public education and consultation to avoid any misinterpretation of the hazards arising from nuclear fusion. As there is a growing number of fusion startups, many displaying novel and technically challenging approaches to harnessing fusion, the regulator and developers should have a formal process of consultation prior to site allocation and construction/productionisation of such technology onto the grid. For example, one of the more mature startups is General Fusion (founded 2002) of Canada, who follow a magnetised fusion reactor approach, whereby a plasma injector converts hydrogen fuel into plasma which is retained within a magnetic field, via a liquid metal wall, which compresses the plasma using a piston array to collapse the liquid metal vortex leading to shockwave formation by plasma compression. This use of very high pressures necessitates high integrity pressure containment, hence a different level of scrutiny of the plasma containment than might be applied to this type of hybrid MCF.

18 What are your views on how such engagement should work?

This could work via the statutory planning and approval process with a formal oversight of the proposed process, fuel titration cycle, containment, radiological hazards and lifecycle hazards. It remains to be seen if the IAEA will adopt a formal classification system for fusion techniques and a formal certification of the proposed production reactor design. Such a certification process would be very helpful as it would provide a gateway model to the review and planning process here in the UK.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes, as indicated above, this would be along the lines of a gate model for the planning approval based upon the class of fusion device and risk categorisation.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes, as indicated in my response to Q17, such engagement is fundamental to the wider appreciation and acceptance of nuclear fusion. The imperative should be to view nuclear fusion within the wider paradigm of the energy transition and mankind’s response to the emergent dangers of climate change and biosphere destruction. The real challenge is not acceptance, but acceptance of the need to accelerate all processes across the cycle to bring fusion onto the grid in the shortest feasible time: 2040 is too late.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Those working in the formal regulation of hazardous industrial processes would already be expected to possess a specialised skill-set associated with the understanding and risk assessment of such processes. There is already a well structured methodology for evaluating the different risks arising from nuclear fission power generation, which has been promoted by the regulatory oversight approach of the IAEA, which imposes design approval and standardisation of critical functional components, which gives is a generic reactor design evolution commonly recognised as Generation 1, 2 and 3. As alluded to in my response to Q18, it remains to be seen if the IAEA will similarly shape the design process for the productionisation of fusion. The techniques for the risk assessment can be taught or learned as I myself am evidence of, noting that fusion physics can be taught to a reasonable level as an adjunct to a safety assessment qualification. We should note that whilst the fusion reactors would be the uniquely specialised functional area of a fusion station, the conversion of the fusion energy yielded will be via more conventional heat transfer, steam generation and turbine generation of electricity. This means all such stations (until humans are able to directly extract electrical energy potential from the plasma as may be possible in so called “mirror machine” designs using a possible reverse cyclotron approach) will reflect a more conventional backend set of technologies, using turbines and electromechanical balance of plant, all of which are subject to regulation by the agencies you refer to in conventional thermal power station.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

As previously indicated in my responses to Q’s 18 and 21, the UKAEA, would be responsible for enforcing any international classification and standardisation of fusion technologies. The commercial generation of power from nuclear technologies is rightly their domain and they should be regarded as the independent authority on all such matters. There should already be established conduits through which their knowledge and expertise flows into the regulatory and risk assessment process and these existing channels should be utilised to do the same for fusion. We should recall that nuclear fusion is not a new concept and has been seriously contemplated since the 1920’s, hence it is only the inertia of human society and the dominant paradigm of “cheap” (noting that fossil fuels have never been cheap due to a failure of the pricing mechanism to reflect the externalities of carbon emissions and other pollution, which Lord Stern referred to as the greatest ever failure of economics) fossil fuels that has retarded its development as slowly as we see to date.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

I broadly agree that that it is reasonable at this stage to anticipate that the types of radioactive wastes produced by fusion power plants could be dealt with by existing facilities. However, we note that there remains uncertainty in this area and the UK government should keep this under review.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes, I believe this is a reasonable expectation, as there are expected to be no very long-lived radioactinide wastes. The public's acceptance of such disposal would be key to the ability to do so and hence the crucial link to public education and consultation.

25 What are your views on how a fusion facility should be decommissioned?

As previously indicated, through an agreed lifecycle approval process at the outset of the planning process. We would expect such a process to seek longer term financial security from the operators such that they are unable to avoid the long-tail decommissioning costs by retaining abnormal profits during the the main energy generation phase of a fusion station.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

This would be via an integrated set of agreed review criteria at the planning approval stage such that the lifecycle of the fusion station would be subject to full scrutiny and where each authority could impinge upon the process to ensure a satisfactory level of compliance.

27 Do you agree with the Government's proposals on safeguards for fusion?

The proposed regulations should be updated to account for the need to have very accurate inventories of both tritium and depleted Uranium. This is because both materials have a nexus with the military industrial complex, and noting additionally that tritium is extremely difficult to store as a gas and naturally decays into helium 3 with a half-life of 12.3 years, hence precise time logging of all such inventory will need to be available and mapped accurately onto all supplies by real time dates to account for the decay occurring over longer periods of storage.

28 What should the Government consider in developing guidance for export controls and technology licensing?

As previously stated in my response to Q15, due to its nexus with the military industrial complex and nuclear weapons development, my opinion is that ICF technology is a high value target to foreign actors and measures should be taken to ensure that the need to propagate this technology for peaceful ends associated with power generation, does not erode the ability of the international community to track and control this spread. Some of this technology is probably already on both the military and dual use control lists of the advanced industrial nations and should remain so. The existing Wassenaar arrangement which represent the international community's foundation for civil export controls using an agreed classification system and nomenclature should already be capable of providing the basis for any additional controls or licensing where necessary. Note, there is a wider humanitarian imperative to ensure that nuclear fusion as a viable and safe technology is deployed globally as quickly as possible, so this need must be balanced against the IP interests if individual nation states and rent seeking commercial fission investors who may not share such egalitarian principles. That said, the export of all nuclear fusion technology should be subject to license control even to allies of the UK, for monitoring and reporting purposes, including the need to detect any subsequent diversion for nefarious military purposes.

29 Do you agree with this proposed approach for keeping the fusion regulatory framework under review?

Yes, this is essential, though ten years may be too great an interval; perhaps a five yearly review would be more appropriate. I say this because I note the government holds the conventional view that fusion technologies will not mature until the 2050's. In a sense this is both true and wide of the mark. Nuclear fusion will appear on the grid (probably in the US) well before 2050 (see my earlier response to Q1). If we utilise the classic evolution approach to fusion technologies, then it is very possible that by the 2050's, a second generation of fusion technologies would be available and ready for productionisation. These technologies will possibly begin to erode the current technical deficits in energy conversion at source I.e. the need to convert kinetic to thermal energy and then into steam to drive a turbine, which is where most of the losses are in the current energy generation process. The back-end of a thermal or nuclear power station has remained largely functionally the same for 100 years, so we should expect innovation in this area. The key message here is that the UK government's thinking regarding timescale to grid maturity is conditioned by the old technology being used by JET, and the successor ITER project. This is because of the political inertia which long delayed ITER, dictating that it would use old low temperature magnet technology which necessitate liquid helium cooling, hence large energy input and a large scale cryostat confinement regime. This is no longer the case and the earlier referenced Commonwealth Fusion project at MIT (SPARC tokamak) has already adopted and proven the successor REBCO high temperature superconductor magnet technology. This will facilitate a high field path to fusion which enables similar or higher levels of plasma performance using a tokamak device of considerably smaller size, hence greatly reduced capital cost (e.g. ITER's tokamak has a toroidal magnetic field strength/major/minor radius/Q (net yield) of 5.3T/6.2M/2M/10 where SPARC has 12.2T/1.85M/0.57M/11, but will produce equal or greater net energy yield). Note, the programme for SPARC to construct by 2025 (construction began in 2021) commission and generate by 2027/8. As they will use a modular design (a la STEP) it would not take a great deal of post prototype update to productionise such a design, giving them potentially a decade lead in the race to seed the market with their design.

30 Do you believe there is anything else the Government should consider in regard to fusion energy regulation?

Most of the key issues are well covered in this consultation document and the associated Q&A. However, I would emphasise that fusion will not succeed and be accepted by the UK public simply because it is the zenith of nuclear power generation. On that basis, it needs to be presented as part of a piece of the well crafted UK energy transition programme, where the nuclear leg of that energy mix will inevitably be preceded by further innovation in the role of nuclear fission, via the already invested UK SMR programme; probably first represented via the Roll-Royce PWR SMR. This is the first key challenge as SMR's may be presented to the UK public as capable of deployment on sites not previously designated as nuclear sites i.e. decommissioned coal fired power stations. This is both an opportunity and a threat, as inevitably the hostility to these SMR's by some local communities could set a precedent for how communities are then conditioned to react to fusion reactors being deployed later, but on the same basis. On that basis, it is vital to present a connected pathway along the nuclear leg from large fusions stations, down through SMR's through to first generation fusion stations. The advantage of this is to trade-off the dangers of fission against the imperative to reduce the UK's carbon footprint, but only as a necessary bridge to the arrival of fusion, which eventually retires many of the greatest risks presented by fission. Viewed through this lens, fission is the culmination of more than 100 years of scientific an technological research and development and something which the UK public can cautiously embrace. Fusion should not be presented as a clean, inherently safe and carbon neutral technology, as it certainly is not, but over a complete cycle it is certainly very advantageous and with a much reduced hazard profile.

31 Before today, how much did you know about fusion energy?

A. Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

F. Strongly support

33 What is your level of knowledge about fusion after reading this paper?

A. Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

F. Strongly support

35 What is your country's / organisation's planned approach to regulating fusion energy?

I am UK citizen and have answered this consultation in the context of my knowledge of the UK, but noting that ABB is a global entity and hence my experience is valid across widespread geographies, including where convention protection applies. I am reasonably confident that the behaviours I have described in my response are a reasonable approximation for large risk managed international business.

2.3 Anonymised Responses

Anonymised Response A

1 Are there other critical regulatory areas that the government should address when considering the regulatory framework for fusion energy in the UK?

High strength magnets can be dangerous.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Don't know

3 Do you agree with the proposal to maintain the existing regulatory approach?

No

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Don't know

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

-

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site license would not be needed for fusion power plants?

Don't know

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined above?

Don't know. Don't use acrynims in questions.

9 What other issues should a Fusion NPS address?

Ukaea should not be the regulator, the are bias and outdated. The management is basically a collection of people who couldn't find a better job elsewhere so they stayed. A new independent body needs setting up.

10 Do you believe that a third party liability regime is required for fusion?

Don't know

11 What are your views on the principles and issues regarding third party liability set out in this paper?

-

12 What issues in addition to those described in this paper should any fusion third party liability regime address?

-

13 How can the Government promote the development of suitable commercial fusion insurance?

Enforcement of all ukaea software and data to be made openly available. We have invested a great deal of money in those experiments and software. We want access to it.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

No

15 What in your view should cyber security regulations for fusion cover?

Uneessecary

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Don't know

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Regulators should be clear about the tests they want passing and the assessment methods used. Only open standards should be utilised.

18 What are your views on how such engagement should work?

-

19 Do you agree that additional guidance should be developed on fusion energy regulation?

Don't know

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Don't know

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

By funding fusion education more. We have experts in industry who could participate if funded. Funding directly to individuals not organisations (which take a cut)

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

Best to cut them out entirely. They actually don't have great expertise as the best people all leave for better paided jobs at NEA, IAEA, ITER, private fusion etc. So the remaining people are not particularly good. They have a tendancy to not allow new approaches, introduce to s of extra paperwork, introduce extra processes and act like they are in charge. It think the A for authority has gone to their heads a bit to much. Best to make a new body and advise jobs directly at that new body, fusion regularly body. Ukaea will only know about small magnetic reactors

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

Now you can send that to ukaea

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Don't know

25 What are your views on how a fusion facility should be decommissioned?

-

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

-

27 Do you agree with the Government's proposals on safeguards for fusion?

-

28 What should the Government consider in developing guidance for export controls and technology licensing?

-

29 Do you agree with this proposed approach for keeping the fusion regulatory framework under review?

-

Anonymised Response B

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

Lithium mining - competition between tritium fuel and Li-ion batteries could be an issue, and there are already growing environmental concerns around mining Li. Just because the fuel won't be sourced from within the UK doesn't mean that mining effects don't need careful consideration.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

From my studies of fusion science I believe fusion to present very few hazards. I fully support removing all possible roadblocks.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Don't know

I lack knowledge of the regulatory landscape. Certainly fusion doesn't need to be regulated like fission, so in principle it sounds good to me.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Don't know

See above

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

No meltdown risk, minimal & short lived radioactive byproducts, and no byproducts can be weaponised - I feel strongly that fusion power should notsimply be 'lumped in' with fission

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Don't know

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Don't know

9 What other issues should a Fusion NPS address?

10 Do you believe that a third party liability regime is required for fusion?

Don't know

11 What are your views on the principles and issues around third party liability as set out in this paper?

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

13 How can the Government promote the development of suitable commercial fusion insurance?

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Not Answered

15 What in your view should cyber security regulations for fusion cover?

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Don't know

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

Of course - what possible use are uninformed regulators?

18 What are your views on how such engagement should work?

Regulators should meet with developers to outline their initial approach and receive feedback. Drafted regulation should be made available for review as many times as are necessary.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

New practices will need to be codified for waste containment

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

No

I don't see that there's anything to be gained from public opinion in matters where the public is uninformed

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Collaborate early and often with universities. New grads looking to join the industry should have prior exposure if possible.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

They should be a principal consultant in the regulatory process, and promote the results to their international counterparts.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

Short-term storage is likely appropriate given the half-lives of the products. No extraordinary measures should be needed.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

Absolutely. Long-term waste has been stored at Sellafield for decades in this manner, and the time scales for fusion waste are manageable.

25 What are your views on how a fusion facility should be decommissioned?

Irradiated structural elements in/around the reactor will likely be the most difficult part of the waste disposal process, but processes already exist. Not a new problem - fission plants produce the same issues, I imagine existing precedents will be adequate.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

28 What should the Government consider when developing guidance for export controls and technology licensing?

Ethics. Care should be taken to assume all developing countries can benefit.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Don't know

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

Anonymised Response C

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

Scope for the generation of Organically Bound Tritium (OBT) and potential for transfer through the food chain. Historical concerns over OBT in the Severn Estuary

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

I agree with the assessment based on previous role as a regulator and familiarity with REPPIR and regulation under the Environmental Permitting Regulations

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

The combination of regulation by the HSE and Environmental Regulators of high hazard industries e.g. petrochemical industry demonstrates a proportionate approach to regulation.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

The use of the goal setting regime under IRRs and EPR allows a flexible approach to both protection of the workforce, public an the environment without the restrictions required under regulation by the ONR site licensing regime.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

The ONR regulatory regime is disproprtionate given the level of hazards set out in the consolation document

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

Based on the information provided high level justification of the principles behind fusion is acceptable. I and the public would expect a separate justification case for the both the demonstration reactor, and any subsequent commercial design.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

No

No, as current nuclear site licensing regulation excludes fusion based reactor systems from regulation under that regime.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

Fusion power plants, meet the broad definition of a national infrastructure project, the NPS regime sets out a framework and process to enable the smooth integration of planning aligned with other regulatory requirements in a one stop shop.

9 What other issues should a Fusion NPS address?

Given the proposal is for a power reactor , integration of power lines to ensure a one stop shop. The management of and disposal strategy of other hazardous materials e.g. Beryllium, long term storage of tritiated wastes give the mobility of tritium in materials and the environment.

10 Do you believe that a third party liability regime is required for fusion?

Yes

A third party liability regime would ensure the availability of fund to decommission the site at the end of operation, and manage the interim storage of wastes prior to disposal and to provide funds in the unlikely event of a major accident.

11 What are your views on the principles and issues around third party liability as set out in this paper?

see above in relation to extension of the regime to specifically include hazardous materials

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

See above in relation to decommissioning and disposal plan for hazardous materials

13 How can the Government promote the development of suitable commercial fusion insurance?

Based on recent difficulties in the insurance market linked to Covid 19, and case law linked to Administrators discarding onerous assets in relation to forms being placed in administration a State Based/Backed Insurance plan would appear appropriate rather than a market based alternative

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

The scope for a minor incident or loss of control to cause significant disruption would be signification. Embedding proportionate Cyber security controls, in the design philosophy would enable scaling up of the the power reactor design and integration in to the ESI networks to to undertaken without significant re-design.

15 What in your view should cyber security regulations for fusion cover?

Reactor operation, Tritium recovery and Recycling loops, Interface with National Grid

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

Generic Design Assessment has proven to be a valuable mechanism to identify at an early stage and eliminate, safety security and environmental constraints associated with Fission Reactor systems the sae benefits would accrue to Fusion plants.

18 What are your views on how such engagement should work?

For the proposed demonstration Reactor - a Staged approach, looking at the design in principle then moving onto the design prior too construction. To ensure public confidence engagement between the regulators and fusion developers should be publicly accessible.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

No

Current guidance as issued by HSE and the Environmental Regulators is sufficient.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

See above in relation to application of GDA, by the Environmental Regulators, this could be extended to require public consultation, by the HSE.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Regulatory secondment to UKAEA and ITER

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

None

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

See above in relation to liability insurance and the creation of a decommissioning fund. Insurance such that if the plant shuts down prior to the end of its design life- funds are available to manage the wastes; Decommissioning fund so that if the plant operates throughout it design life path the end of generation sufficient funds are in place to manage the waste. In managing the wastes the emphasis should be of the fusion plants design enabling

recycling/reuse of materials

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

This is subject to the claim that wastes will have short half lives in comparison to fission reactor wastes and that any such near surface disposal sites will have an appropriate period of institutional control.

25 What are your views on how a fusion facility should be decommissioned?

Fusion facilities decommissioning and dismantling should be subject to a funded decommissioning plan as with new build fission reactors. Give the stated generation of short-lived radioactive wastes, the period of institutional control should be shorter than that required for fission reactors and preferably so short as to prevent the intergenerational transfer of liabilities to future generations

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

Through arrangements for Nuclear Insurance Liabilities Scheme and a Funded Waste Management and Deccomissionging plan

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

28 What should the Government consider when developing guidance for export controls and technology licensing?

Same as the current regime - Export Controlled Technology transfer scope for use of materials in programmes that could lead to the development of nuclear weapons.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Support

Anonymised Response D

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

Most important regulatory framework should come from integration of fission nuclear regulatory framework with fusion. Currently., the definition of "low activation" for fusion is not well established. This guidance is needed for materials designing to ensure what elements are ok in structural materials and what are not

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

The hazards from fusion are very low because of primarily low level waste generation and absence of breakaway reactions as in fission

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Don't know

I think this is an open question depending on what or how fusion technology matures. At the very lease we need guidance on low activation criteria for radioactive waste.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Yes

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

I welcome this with open arms. Fusion is the future and we should be ready for it

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

Absolutely

9 What other issues should a Fusion NPS address?

There are critical issues related to materials surviving the harsh environment inside a nuclear power plant. Without those materials, fusion will not be succesful. A Fusion NPS should focus on materials development and deployment activities, that will generate high paying jobs in future from materials supply chain etc.

10 Do you believe that a third party liability regime is required for fusion?

No

This is jot necessary.

11 What are your views on the principles and issues around third party liability as set out in this paper?

i am neutral to it

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

Materials and hydrogen storage technologies

13 How can the Government promote the development of suitable commercial fusion insurance?

This will Ultimately depend upon a stable regulatory framework. The current fission reactors are licensed /insured for 40 years typically based primarily on the science related to in-service degradation of components inside the nuclear reactor. The insurance of fusion will ultimately be based on how long the reactir vessel can safely last. This again becomes a materials and metallurgy issue

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

No

15 What in your view should cyber security regulations for fusion cover?

This is an open question. But fusion prototypes most likely do not need this

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

This is a must

18 What are your views on how such engagement should work?

This will require close coordination between the national labs, universities and nuclear regulatory body.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

1. Low activation criteria for fusion in-vessel components.

2. Guidance on tritium handling and disposal.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

No

The science is best left to scientists

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

The regulators need to engage in an international framework. The biggest concern for fusion is neutron irradiation degradation on in-vessel components.

The knowledge in the UK of such neutron effects is little compared to the US, Japan and EU. This knowledge base development is the key. The UK should think about engaging in reverse brain drain - attracting knowledgeable folks in this area from abroad (such as the US).

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

UKAEA needs to actively engage on regulatory issues regarding in-vessel irradiated materials, tritium transport, waste handling and storage at the very minimum.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

This is not a major issue given the expertise in handling fission radioactive waste.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Don't know

This is a open question. This regulatory issue should not stifle innovation. The low or reduced activation criteria if imposed means very little choice of materials left to develop advanced radiation materials.

25 What are your views on how a fusion facility should be decommissioned?

In a similar manner to fission facilities.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

There is significant guidance available from fission reactors. Given that material activation in fusion is significantly lower than for fission reactors, this should not be that complicated

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

28 What should the Government consider when developing guidance for export controls and technology licensing?

Fusion being an open technology till today should not suffer from too much redtape.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Don't know

I am not clear on this point

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

35 What is your country's / organisation's planned approach to regulating fusion energy?

Strong support for fusion energy

Anonymised Response E

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

The history of inertial confinement fusion is closely connected to the development of nuclear and thermonuclear weapons. Indeed, the first published paper on ICF was from a group at the Lawrence Livermore National Laboratory (LLNL), a US nuclear weapons laboratory, in 1972. Work in the area was conducted by LLNL for several years before that date, although up to 1972 even the idea of compression of thermonuclear fuel was considered secret.

Since 1972 a number of other ideas that were formally secret have been made public, notably the use of thermal radiation to drive the implosion, which was declassified in the 1980s. In the 1990s and 2000s the fact that nuclear explosions had been used to drive small thermonuclear implosions was also revealed. Because of this close connection between ICF and nuclear weapons the question of whether the development of ICF into an energy source has implications for nuclear proliferation is sensible and pertinent. This issue has not been overlooked and, for example, the UK Ministry of Defence has a role in ensuring that proliferation issues are kept under close review.

More broadly, the technology associated with tritium handling, and the associated material inventories, which are most likely required for all methods of fusion power production, potentially have implications for nuclear proliferation.

We recommend that any decision on the future regulation of fusion should request input from MoD on any potential nuclear proliferation issues associated with the development of fusion energy, and the export of any associated technologies. We can envisage various areas this might cover, these include: tritium handling and the provision of user access to simulation codes. A set of proportionate guidelines covering these areas may be appropriate (a useful reference is 'Long-term proliferation and safeguards issues in future technologies' Keisch et al, Brookhaven National Laboratory, 1986).

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

MFE tritium inventories are anticipated to be significantly higher than those of IFE. Therefore, as long as IFE tritium containment measures are broadly similar, the provided analysis will cover both MFE and IFE scenarios.

Whilst there are differences between IFE and MFE, we do not anticipate any radioactive waste generated by IFE being worse than MFE. Consequently, we do not envisage any IFE regulatory framework requirements being different from those for MFE.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

Broadly yes. The existing regulatory approach seems proportionate at present and will facilitate rapid innovation. Again, any policy should account for nuclear non-proliferation requirements.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Don't know

We defer any decision on this to the appropriate experts.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Don't know

Given the tritium inventories required for foreseeable fusion power plants, safety and security are clearly a concern. Given our expertise is on fusion physics, not regulation, we defer the decision as to whether this should be classified under the NIA 1965 Act to the appropriate experts.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

The justification seems appropriate.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Don't know

We defer any decision on this to the appropriate experts.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

Yes – this seems appropriate.

9 What other issues should a Fusion NPS address?

None.

10 Do you believe that a third party liability regime is required for fusion?

Don't know

We defer any decision on this to the appropriate experts.

11 What are your views on the principles and issues around third party liability as set out in this paper?

We defer any decision on this to the appropriate experts.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

We defer any decision on this to the appropriate experts.

13 How can the Government promote the development of suitable commercial fusion insurance?

Don't know

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

Yes, due to the safety and security implications of tritium inventories.

15 What in your view should cyber security regulations for fusion cover?

One potential area regards the simulation codes used for Inertial Confinement Fusion. A set of guidelines as to how these codes can be securely used on open computing clusters, whilst maintaining appropriate security controls would be welcome.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Don't know

We defer any decision on this to the appropriate experts.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

Such an approach should initially enable relatively light-touch broad regulations but as technologies progress this will mean regulators can be closely engaged in developments and update regulations as required. It is essential that all impacted parties, and in particular the public, have confidence that the regulatory processes lead to safe design, operation and disposal of fusion facilities.

18 What are your views on how such engagement should work?

We defer any decision on this to the appropriate experts.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

this seems appropriate

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

It is essential that all impacted parties, and in particular the public, have confidence that the regulatory processes lead to safe design, operation and disposal of fusion facilities. Perhaps this could be achieved through public consultations?

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

By training more engineers and physicists in the relevant subject areas.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

Without familiarity of what the technical expertise of UKAEA covers, it is hard to comment on this. Inertial confinement fusion requires specialist knowledge, which given UKAEA's focus on magnetic confinement technologies, may limit UKAEA's ability to develop an appropriate regulatory framework which covers inertial confinement and various diverse approaches to fusion energy.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

We defer any decision on this to the appropriate experts.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Don't know

We defer any decision on this to the appropriate experts.

25 What are your views on how a fusion facility should be decommissioned?

We defer any decision on this to the appropriate experts.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

We defer any decision on this to the appropriate experts.

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

The ONR would seem to be the appropriate body to decide on this.

28 What should the Government consider when developing guidance for export controls and technology licensing?

We recommend the government seek advice from MoD on this.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

The proposal to review the framework every 5-10 years would seem appropriate given that regulators will be formally engaged in the design process of fusion facilities. This engagement process should also have the capability to feed into/update any regulations as and when any issues are identified.

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

35 What is your country's / organisation's planned approach to regulating fusion energy?

We are UK-based, so will conform with UK regulations

Anonymised Response F

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

Please explain what these are and why they are important.:

The County Council is not aware of any other regulatory areas and would agree with the Regulatory Horizons Council findings regarding the evolution of current regulatory framework under Environment Agency etc.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

The Governments conclusions regarding the hazards of future fusion power plants appear to be comprehensive. The Governments approach of continued work with fusion technical experts and regulators to monitor the development of fusion technology is positive. Ongoing research and monitoring would enable the regulations to be kept up to date to ensure the overall hazard and risk profile of fusion power plants in the future

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

The County Council would agree that the existing regulatory approach appears to be an appropriate approach and should be maintained. The Governments broad proposals on fusion energy regulation (p45) are also supported. However, the County Council would defer to the relevant specialist bodies i.e. The Environment Agency and the Health and Safety Executive.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Don't know

The County Council would defer to the specialist regulatory bodies, however it would appear that IRR 2017 and EPR 2016 would be an appropriate approach.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Don't know

The County Council feels it would be appropriate to keep the situation under review. This would allow the regulatory framework to respond to changes in technology or design the future.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

The County Council would agree that fusion should be confirmed as a new ‘justified practice’ before the operation of any fusion power plant in the UK.

The highest levels of environmental and social protection should be maintained, and any potential hazards should be fully justified.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

The County Council would agree with the legislative approach as set out.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

The County Council agrees with the proposal to establish a Fusion NPS. This would provide a constant approach and add transparency to the decision-making process.

9 What other issues should a Fusion NPS address?

Nothing further to add

10 Do you believe that a third party liability regime is required for fusion?

Yes

The County Council understands the need to minimise the liability on developing and operating fusion power plants, however there will need to be a mechanism in place to ensure that should an accident take place adequate measure are in place to address any issues. The County Council agrees that any regime should be agreed on an international basis to ensure consistency across the industry and supply chains.

11 What are your views on the principles and issues around third party liability as set out in this paper?

The principles and issues set out in the paper would appear to be appropriate however the County Council would defer to the appropriate specialists.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

No further suggestions

13 How can the Government promote the development of suitable commercial fusion insurance?

No further suggestions

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

The County Council feels that it is very important to ensure that key infrastructure such as this should be covered by the cyber security regulations. This would minimise the impact of potential disruption or accidents occurring during operation of a very high- tech process.

15 What in your view should cyber security regulations for fusion cover?

No suggestions

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

The County Council agrees that a formal definition to determine the facilities that it believes should be in the scope should be developed. However, it cannot comment on the exact detail of the definition.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

The County Council considers that a formalised engagement process for the industry and regulators would be beneficial as this could add clarity and make the process more efficient.

18 What are your views on how such engagement should work?

No further suggestions

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

The County Council agrees that broader guidance for fusion would play a role in providing constructive information, clarity, and transparency.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

The Council Council would fully support any opportunities for local communities and stakeholders to be involved in the development of large infrastructure schemes such as fusion developments. This would aid understanding and transparency.

However due to the complexity involved in the regulatory process it is not clear if seeking views on regulations would benefit the parties involved, however the proposal for developers to inform and educate local communities on their designs as well as maintaining ongoing relationships is welcomed.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Maintain ongoing relationships with the industry to ensure that they are aware of advancements in technology and materials used.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

As q21. Maintain close working relationships with the industry and regulatory bodies to ensure everyone is aware of the latest technology and developments.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

Radioactive waste should be dealt with in the safety and most appropriate way to ensure the impacts on communities and the environment are minimised.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Don't know

The County Council considers this is a question for the appropriate / specialist regulating bodies

25 What are your views on how a fusion facility should be decommissioned?

The County Council considers this is a question for the appropriate / specialist regulating bodies

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

The topics should be covered in detail to ensure that the process is clear and transparent.

27 Do you agree with the Government's proposals on safeguards for fusion?

Don't know

The County Council considers this is a question for the appropriate / specialist regulating bodies

28 What should the Government consider when developing guidance for export controls and technology licensing?

The County Council is not suitably qualified to comment on this. Guidance should be prepared alongside regulators and the relevant experts in this field.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

The County Council agrees with the Governments approach to keeping the regulatory framework under review. This will ensure the regulations remain relevant as fusion technology evolves in the future.

31 Before today, how much did you know about fusion energy?

Knew a little

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Support

33 What is your level of knowledge about fusion after reading this paper?

Knew a little

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Support

Anonymised Response G

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

The Green Paper on the Governments proposed Regulatory framework for Fusion covers the main technical areas that should be considered as part of a future regulatory approach. One area that appears to have been omitted is the capability of the entity (commercial or otherwise), developing or operating the facility, to do so safely for the life of the facility, including decommissioning. For nuclear licenced sites, the Licensee has to demonstrate their organisational capability across a defined set of Licence Conditions. In order to deliver through life safety a proportionate arrangement should be considered for fusion. This does not have to be fully analogous with the Nuclear Site licencing regime but should consider which aspects of that regime can be applied to fission in relation to its reduced risk profile.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

The conclusions on the hazards that use of fusion gives rise to and the consequential risk are in line with what can be predicted from the current understanding of the technology that is likely to be deployed.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

The current approach to the regulation of fusion is based on alignment of the regulators /regulation with the hazards created by use of fusion technology.

This is a regulatory regime that is working well and for which the principal regulators (HSE/EA) have built up technical expertise. In moving from the R&D phase to commercial deployment there is no change to the hazards (conventional & radiological) but the consequences are increased. The current regime is judged as adequate to manage these hazards and deliver risk that is ALARP. ONR should retain regulation of off-site transport as they have the technical expertise and knowledge to regulate that aspect. As new projects come forward, a greater emphasis on bringing the separate regulators together in a project specific regulatory office could be considered along the lines of the model used between the ONR and EA/ NRW for the GDA process for fission reactors.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

The regulations are graduated based on the maximum radiological impact and so provide a proportionate regulatory framework.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

As discussed in response to Q2, Q3 the current regime is working and there is an alignment between the hazards and the regulator with the knowledge, processes and vires to regulate those hazards. The Nuclear Installation Act 1965 is designed to ensure the safe operation of sites with a very distinct set of hazards that give rise to a very long-lived risk profile. The hazards and risk profile for fusion is significantly different to that of fission and there does not appear to be a strong basis for arguing that fission should be drawn into the Nuclear Site Licencing regime.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

A general justification for fusion should be made based on its potential benefits as an energy source versus the potential dis-benefit from the conventional and radiological hazards. Each individual fusion plant would then have to demonstrate that risk as ALARP within this overall justification.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

NIA65 lacks clarity in a number of areas and over the years, this has caused difficulty in ensuring its correct application within a changing nuclear industry (fission). It would be timely to clarify NIA65 to clearly establish whether it applied or not to fusion sites. Related legislation should also be examined.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

Establishing a fusion NPS will remove uncertainty for developers of fusion sites and support the entrance of commercial operators into the UK.

9 What other issues should a Fusion NPS address?

No additional comments.

10 Do you believe that a third party liability regime is required for fusion?

Yes

The commercial backers of fusion will want to understand the commercial risk, which they are exposed to. It would be expected that liability in event of an incident/accident would be part of this and so a third party liability regime would allow that liability to be quantified and insured against.

11 What are your views on the principles and issues around third party liability as set out in this paper?

The insurance industry may not have sufficient understanding of the inherent risks from fusion to be able to price the risk. It may require an initial involvement of Government to allow a commercial market to develop through Government indemnities.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

No additional comment.

13 How can the Government promote the development of suitable commercial fusion insurance?

No additional comment. See Q11.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

No

For prototype plants of very low power the risk that is being controlled does not warrant application of significant cyber security controls. The controls should be proportionate to the risk rather than independent of it.

15 What in your view should cyber security regulations for fusion cover?

The cyber security regulation should cover the same range of regulatory issues as for fission plant but informed by the reduced risk of an event on a fusion plant as compared to a fission plant.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

Based on the current definition plants that fall below 50MW and the tritium level of 7xE16 Bq would still be classed as R&D plants. It will take a significant time for plants to progress beyond this level.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

Regulatory engagement in the design and development phase de-risks the regulatory process for the developers if conducted in an open and informed way. The regulatory engagement can be used to ensure that risk is examined and reduced early in the design process at a lower cost than if left to later when designs are finalise and manufacturing may have started. Learning can be taken from the GDA process both positive and negative to design a suitable phased engagement for fission projects. A phased engagement with defined regulatory steps that provide design acceptance are also beneficial in demonstrating to commercial backers of projects that regulatory risk has been reduced.

18 What are your views on how such engagement should work?

See Response to Q17. A review of the GDA model would be beneficial.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

While regulation of fusion is adequately addressed by HSE and EA, together with ONR concerning transport there may be a need for the a signposting of applicable regulation to be created to assist any new entrants to understand how the UK approach to Fusion regulation operates. This is not to create new regulation but to draw together applicable parts of existing regulation that apply to fusion for those fusion hazards. The practicality of this should be explored.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

The public should be involved in the process by which an individual plant is approved for build through a regulatory design assessment process in the same way that significant elements of the GDA assessment of fission reactors involved the public. In addition local area public/expert panels could be created to enhance local understanding of the fusion sites technology, risks and mitigations. This model is used for all French nuclear sites and operates well, improving local engagement and understanding of nuclear issues and operations.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Regulators have to be engaged in technology scanning and have close interactions with those groups, such as UKAEA and universities, which are directly involved in developments. Funding for this should be available to allow the regulators to develop their understanding and interact with the industry at an early stage. This early engagement allows the industry to understand regulatory concerns before a technology or design progresses too far.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

The UKAEA has a preeminent position in the UK based on its knowledge of fission research and operations. The future regulation of an expanded fusion sector should make full use of this knowledge. The Green Paper notes that the UKAEA will establish a Technical Support Organisation to deliver this knowledge. Establishing a formal TSO in accordance with recognised international best practice would greatly enhance the regulatory construct for fusion. Applicable guidance has been established by the IAEA for nuclear TSO's and this should be agnostic of whether it is fission or fusion. A UKAEA TSO would have to demonstrate independence from UKAEA to be able to operate effectively. This can be done with appropriate and rigorous processes and procedures. The Regulatory Support Directorate within Jacobs is an internationally recognised TSO in the nuclear fission field and has experience in working closely with UK regulators (ONR/DNSR) while demonstrating independence.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

The radioactive waste hierarchy should be applied to waste arising from fusion as it is in other nuclear environments.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

If the waste meets the acceptance criteria for the near surface disposal, facility then it should be disposed of there. If this is the government expectation then the design should take that as a design expectation and address it during the design process.

25 What are your views on how a fusion facility should be decommissioned?

Decommissioning should be addressed during the design phase to minimise the risks from decommissioning at end of life. This would require a series of questions to be addressed from the minimisation of waste, the proposed time from fusion ceasing to decommissioning and the proposed decommissioning process. Minimisation of risk to individuals and the environment would be addressed at this stage and then revisited through life to form the initial decommissioning risk assessment. This does not answer the how but it provides the process that will provide the answer.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

The guidance should set out the waste management hierarchy and then set out principles that should be met. Detailed prescription should be avoided, asit does not align with a goal-setting regime.

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

The proposal builds on current arrangements for Tritium and aligns with the UKs current safeguards programme.

28 What should the Government consider when developing guidance for export controls and technology licensing?

Any guidance should provide clarity of the regulation and its implementation without being so prescriptive that it un intentionally encompasses alternative applications and technologies. The regime should also be tested prior to ensure that it does not have an undue adverse effect on international collaboration and information exchange where no proliferation issues arise

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

A regulatory regime is being proposed in advance of any significant change in fusion. As the fusion industry, starts to progress from the current generation of R&D facilities into new technology and plant sizes it would be expected that the regulatory model should be examined to ensure that it remains fit for purpose.

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

Anonymised Response H

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

When considering what form of regulation is appropriate, you must consider the unmitigated risk (i.e. the risk when no protection systems operate) rather than the mitigated risk. Many of the accident scenarios considered in the literature you have used rely on protection and mitigation systems operating effectively. The true hazard potential of an FPP is significantly larger than made out in your report.

Nuclear security issues, such as deliberate loss-of-coolant events, attack on the tritium plant/tritium storage or the political ramifications of a potential security breach at an FPP have not been considered.

Nuclear safeguards issues - breeder blankets can be used to breed fissile material. Therefore, there will clearly need to be some form of safeguards measures implemented at FPPs (regulated by ONR).

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

No

As stated previously, many of the hazards you have considered (and their radiological consequences) rely on protection systems operating effectively (such as the detritiation systems and vacuum vessel pressure suppression system). This is therefore the mitigated risk.

When considering the expected hazards you must consider the unmitigated risk, i.e. what happens if the safety and protection systems don't operate as intended. With the significant quantities of radioactive material expected an FPP (coupled with potentially radioactive chemi-toxic products such as WO3 forming) it is naive to compare the hazard potential of an full-scale FPP with an experimental reactor such as JET. There is also the potential for hydrogen and dust explosions to occur within the vacuum vessel. I have attached a paper on the nuclear safety issues expected at an FPP.

3 Do you agree with the proposal to maintain the existing regulatory approach?

No

The current regulatory approach is appropriate for experimental fusion reactors - machines designed to be operated on a pulsed basis with limited quantities of radioactive material. It is naive to compare the hazard potential of a full scale FPP, with extremely large stored magnetic energies, significant quantities of radioactive material, multiple breeder blankets and primary and secondary cooling requirements, with that of experimental reactors. The current regulatory approach is not appropriate to regulate FPPs for the following reasons:

Regulatory effectiveness - ONR will be required to regulate safeguards (as breeder blankets have the potential to breed fissile material). This would require ONR oversight of the design, construction, commissioning and operation of an FPP. If IAEA then defines FPPs as nuclear installations (likely given that other countries treat FPPs as nuclear facilities), then ONR would also be required to regulate nuclear security. You would then have EA/HSE/ONR each regulating various parts of an FPP. This will lead to many regulatory interfaces which in turn leads to ineffectiveness. It is much simpler and more effective to have ONR regulating all areas of an FPP, with EA regulating routine discharges.

Regulatory certainty - Lack of regulatory powers involved in Health and Safety at Work Act (and its regulations) and Environmental Permitting Regulations 2016 to control the design, construction and commissioning processes. Lack of regulatory certainty is a concern for investors, owners and operators who want assurances that there will not be unexpected regulatory demands further down the line.

Industry focus - Generalised regulatory regimes (such as the HSWA) are a less than ideal approach to regulating high hazard industries. Given that FPPs, if inadequately designed or operated, can result in an off-site release of radioactive materials that would result in emergency countermeasures, having an industry focused regulator would have many advantages.

Public confidence - Fusion is a nuclear process and it is naive to assume the public will not recognise this and expect it to be regulated by the UK's nuclear regulator.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

No

There are a lack of permissioning powers granted to the regulator(s) in the IRRs and EPR. In the IRRs, duty holders do not have to apply for regulatory consent until the "point of use", by which time the design has been finalised and construction is more than likely at an advanced stage. There is also nothing in the EPR to stop an operator commencing construction before an environmental permit has been issued. It is not hard to envisage scenarios in which duty holders are nearing completion and apply for regulatory consent, only to find a significant safety or environmental issues that could have been rectified at minimal cost at the design stage but at this point requires significant modifications adding considerable cost and delays.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Yes

The current nuclear licensing framework is primarily goal-setting, i.e. goals are set and it is up to the licensee to set up its own arrangements for meeting that goal. This allows for a proportionate approach to regulation. It is incorrect to suggest that prescribing FPPs as nuclear installations (which would not require an amendment to the NIA as ministers can prescribe installations that make use of atomic energy as licensable - atomic energy as defined in the Atomic Energy Act includes fusion) would result in a fission-style approach where safety and protection measures are required that are disproportionate to the hazard potential. The proportionate nuclear site licensing approach means that FPPs can easily fit into the current regime and it is up to the licensee to demonstrate that the measures it has put in place are sufficient to demonstrate the health and safety of workers and the public is protected.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

The Government's views on based on a misguided view of the hazard potential of FPPs. It has not considered the security and safeguards issues, both of which will likely require regulation by ONR at some point.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

No

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

No

9 What other issues should a Fusion NPS address?

10 Do you believe that a third party liability regime is required for fusion?

No

Significant unlikely chance that an accident at an FPP could result in cross-boundary consequences; therefore, the Paris and Brussels conventions will not apply to FPPs.

11 What are your views on the principles and issues around third party liability as set out in this paper?

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

13 How can the Government promote the development of suitable commercial fusion insurance?

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

Political ramifications of a potential cybersecurity breach will need to be considered.

15 What in your view should cyber security regulations for fusion cover?

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Don't know

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

18 What are your views on how such engagement should work?

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Not Answered

25 What are your views on how a fusion facility should be decommissioned?

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

27 Do you agree with the Government's proposals on safeguards for fusion?

Not Answered

28 What should the Government consider when developing guidance for export controls and technology licensing?

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Not Answered

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

Anonymised Response J

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

In considering the regulatory framework Government will clearly want to consider the NAO's Good practice guidance: Principles of effective regulation, which outlines the key steps in developing an effective framework and provides a range of case studies on other regulatory frameworks. The case study from the the Better Regulation Executive and the National Audit Office report which reviewed the progress that various regulators, including the Health and Safety Executive (HSE), had made in implementing the principles of effective inspection and enforcement set out in Philip Hampton’s 2005 report: Reducing administrative burdens: effective inspection and enforcement, highlighted the HSE’s use of a tool to assist inspectors to make enforcement decisions (the Enforcement Management Model). Independent research commissioned by the HSE found that this model improved the consistency, proportionality and transparency of decisions - this appears to strongly align with Government's requirements for a framework for fusion regulation.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

CLEP is an applicant to UKAEA's siting competition for the prototype Spherical Tokamak for Energy Production (STEP) and all information provided during the development process would support Government's assessment regarding the expected hazards of fusion power plants.

Government's position is supported by the International Atomic Energy Authority which states that "Nuclear fission power plants have the disadvantage of generating unstable nuclei; some of these are radioactive for millions of years. Fusion on the other hand does not create any long-lived radioactive nuclear waste. A fusion reactor produces helium, which is an inert gas. It also produces and consumes tritium within the plant in a closed circuit. Tritium is radioactive (a beta emitter) but its half life is short. It is only used in low amounts so, unlike long-lived radioactive nuclei, it cannot produce any serious danger. The activation of the reactor’s structural material by intense neutron fluxes is another issue. This strongly depends on what solution for blanket and other structures has been adopted, and its reduction is an important challenge for future fusion experiments.

Fusion cannot cause a nuclear accident because fusion energy production is not based on a chain reaction, as is fission. Plasma must be kept at very high temperatures with the support of external heating systems and confined by an external magnetic field. Every shift or change of the working configuration in the reactor causes the cooling of plasma or the loss of its containment; in such a case, the reactor would automatically come to a halt within a few seconds, since the process of energy production is arrested, with no effects taking place on the outside. For this reason fusion reactors are considered to be inherently safe."

However, I do think that there is a public information campaign that needs to be undertaken as there remains confusion between fission and fusion, with environmental bodies that should understand the difference publicly stating fission risks in relation to fusion.

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

Adopting the current approach appears to best meet Government's objectives for the regulation of fusion activity. This approach has been trialed through existing activity. In particular, this regulatory approach is more likely to facilitate future commercialisation.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

Government's proposal outlines that these "regulations form a part of the regulatory framework that ONR also use to regulate nuclear sites that come under its remit. Therefore, from a health and safety perspective, the underpinning regulatory principles for fusion sites are similar to that for nuclear (fission) sites". It would therefore appear that the test of appropriateness has been met and that the focus needs to be on proportionality.

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

No

The ONR framework has been designed for fission, which presents a very difficult challenge in terms of regulation. It also predominantly 'publicly funded sector' whereas the intention is that fusion will be predominantly commercially led. The HSE is more used to and well versed in dealing with commercial interests and responding to rapidly changing technologies.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

Agree with these proposals.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

As outlined in the consultation this will provide the necessary clarity to industry and help stimulate the commercial appetite for fusion development.

Industry needs certainty on the approach and a legislative approach would provide the necessary transparency. Importantly, Government commits to be open to review the legislation, should this prove necessary in the future.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

This will provide a clear planning framework for the development of the industry, which is appropriate for an industry in which the intention is to achieve significant future scale up.

9 What other issues should a Fusion NPS address?

At this stage agree with the scope as outlined, other than the need for inclusion of the socio-economic case for the development. Beyond that further extending the scope might inhibit scale up and commercialisation.

10 Do you believe that a third party liability regime is required for fusion?

Yes

On the basis that any operator must take responsibility for any adverse impact of their operations.

11 What are your views on the principles and issues around third party liability as set out in this paper?

Agree with these at headline level,. In particular capping liability at an appropriate level.

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

No comments.

13 How can the Government promote the development of suitable commercial fusion insurance?

Working directly with the insurance industry to create understanding of fusion and the risks associated with this; alongside promoting the commercialisation opportunities and potential growth in the market.

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

Agree on adherence to the principles of the Network and Information Systems Regulations 2018 (NIS 2018).

15 What in your view should cyber security regulations for fusion cover?

No comments.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

In any emerging technology it is essential that the regulation is developed in conjunction with the technology as it emerges. Otherwise, there is a danger that the framework is not fit for purpose.

18 What are your views on how such engagement should work?

The NAO's Good practice guidance Principles of effective regulation provides a helpful framework for developing the regulatory regime.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

See response to Question 18.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

There should be an opportunity to test community appetite for the siting of fusion. However, this would require a very clear education process as there is an assumption that all nuclear is the same, and little understanding of the difference between fusion and fission.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Starting the process early in terms of recruiting individuals with sufficient expertise and developing a significant induction and development programme for appointed individuals.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

UKAEA could be a statutory consultee on the development of the regulatory framework.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

This needs to be managed in the same way that existing fission waste is managed in the NDA family and remain under the auspices of ONR.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

This is on the basis of the current assumptions on the type of waste that will be generated.

25 What are your views on how a fusion facility should be decommissioned?

There is considerable expertise in the NDA and this expertise should be tailored to developing suitable processes for fusion.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

No comment

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

These appear proportionate but flexible enough to respond should any increase in increase.

28 What should the Government consider when developing guidance for export controls and technology licensing?

No Comment

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

Anonymised Response K

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

3 Do you agree with the proposal to maintain the existing regulatory approach?

Yes

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Don't know

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

Wholeheartedly support

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Yes

9 What other issues should a Fusion NPS address?

10 Do you believe that a third party liability regime is required for fusion?

Yes

11 What are your views on the principles and issues around third party liability as set out in this paper?

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

13 How can the Government promote the development of suitable commercial fusion insurance?

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

15 What in your view should cyber security regulations for fusion cover?

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Yes

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

18 What are your views on how such engagement should work?

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

I believe the best way to do this is to, as soon as possible, recruit people from a wide range of backgrounds in STEM industries (e.g. engineering, communications, AI, robotics) who don't just have technical knowledge but operational, regulatory and compliance knowledge who can work effectively with companies and organisations as the regulatory framework develops.

I am concerned that the UK may already be slipping behind in terms of leading on fusion regulation, development and deployment. Whilst this consultation is the first in the world, the government is not ambitious enough for STEP which is only scheduled to be operational by the 2040's whereas there are private companies like Commonwealth Fusion Systems (in the US) who are targeting commercialisation between 2025-2030 and Tokamak Energy in the UK targeting commercial scale by 2030.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

25 What are your views on how a fusion facility should be decommissioned?

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

27 Do you agree with the Government's proposals on safeguards for fusion?

Yes

28 What should the Government consider when developing guidance for export controls and technology licensing?

Please explain your views:

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

Please explain your response:

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

Anonymised Response L

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

It is stated that

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

No

Figure 2 is not relevant to a fusion power station as it does not include consideration of any coolants that would be required to extract heat. It is only relevant to a physics experiment in fusion (i.e., JET). Without consideration of a coolant it is not possible to fully consider the expected hazards of a power station. For example, for fission power stations the main hazards are all related to the coolant (steam explosions, hydrogen explosions, loss of coolant causing reactor melting, even sodium fires depending on choice of coolant, etc) which would presumably be relevant for fusion albeit on instantaneous time scales.

3 Do you agree with the proposal to maintain the existing regulatory approach?

No

IRR17 says that the ONR is the appropriate authority for "nuclear premises". This term is defined in IRR17 as a "GB nuclear site" in the Energy Act 2013.

Within the Energy Act 2013 a "GB nuclear site" means a "nuclear site" in England, Wales or Scotland. Google "nuclear site culham legislation uk" takes you to the Energy Act 2004 whereby "nuclear site" is literally defined with explicit reference to the UKAEA site at Culham as an nuclear site.

Therefore, it appears that ONR should be the regulator for IRR17 and not HSE contrary to the proposal to maintain the existing regulator approach with HSE as the appropriate authority.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Don't know

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Don't know

The Energy Act 2004 states that "... sites which require a licence under the Nuclear Installations Act 1965 and sites which would require a licence if they did not belong to the Crown, this category includes a site on which there is a fusion reactor (there is only one site with a fusion reactor in the UK which is in England)".

This appears to indicate that NIA65 applies in theory but not in practice as UK law allows Crown exemption. There was a historical exemption for UKAEA that was used for fission research sites and which was lost when fission research moved to a commercial setting. Therefore, it could be argued that moving fusion to a commercial setting should also result in losing Crown exemption.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

No

There needs to be more clarity on UK legislation in terms of fusion.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Don't know

9 What other issues should a Fusion NPS address?

10 Do you believe that a third party liability regime is required for fusion?

Don't know

11 What are your views on the principles and issues around third party liability as set out in this paper?

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

13 How can the Government promote the development of suitable commercial fusion insurance?

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Don't know

15 What in your view should cyber security regulations for fusion cover?

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Don't know

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

The design stage is where the best opportunity exists for influencing safety. There needs to be oversight of this stage to ensure that these opportunities are taken. For example, the filters at Windscale mitigated the release of radioactive material but were not wanted by the designers who believed their design to be clean such that they couldn't see how particles would be generated - then a fire happened.

18 What are your views on how such engagement should work?

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Don't know

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Don't know

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Not Answered

25 What are your views on how a fusion facility should be decommissioned?

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

27 Do you agree with the Government's proposals on safeguards for fusion?

Don't know

28 What should the Government consider when developing guidance for export controls and technology licensing?

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Don't know

Please explain your response:

31 Before today, how much did you know about fusion energy?

Knew a little

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Support

33 What is your level of knowledge about fusion after reading this paper?

Don't know

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Oppose

Anonymised Response M

1 Are there other critical regulatory areas that the government should consider when considering the regulatory framework for fusion energy in the UK?

Safety - workers and the public

Environment

The above two areas have been dealt with adequately within the regulatory horizons document; extension of EA and HSE current arrangements from JET according to the hazard of the scale for a power plant is sensible.

Omitted - no clear proposals relating to the dual use of tritium and ensuring the neutron fluence present in a DT reactor is not used to render fertile isotopes fissionable.

This response therefore mainly considers the latter issues.

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

Yes

Yes - with regard to all aspects other than dual use.

However, the need to evacuate a nearby population under a beyond design basis accident situation, should be removed by minimising the tritium inventory present in a fusion power plant, and limiting the amount of other releasable radioactive materials such as tritiated tungsten dust.

A neutron fluence can be used to convert easily available fertile isotopes such as U-238 and thorium to fissionable material, so making it possible for fission weapons to be constructed by a state in possession of a fusion facility, if not monitored by an external body such as the IAEA. Similarly, if excess tritium were created in a fusion facility and diverted, it could be used to boost a fission device

3 Do you agree with the proposal to maintain the existing regulatory approach?

No

The existing regulatory approach needs to be extended to encompass the need to ensure non-proliferation of nuclear weapons via production of tritium and fissionable materials in fusion devices. Whilst such a requirement is not relevant for a nuclear weapons state such as the UK, the UK should lead by example and align its regulatory approaches to those of the IAEA and Euratom. Noting that the IAEA does not yet have a clear position on the regulation of fusion power plants which in itself creates an opportunity for the UK to lead responsibly in this area.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

Yes

Yes - though I do not have a deep understanding of these regulations

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Yes

Possibly. They either should be brought under the remit of the ONR, or the ONR or a similar body should become a further joint regulator. This comment only relates to the dual use aspects of fusion facilities.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

Good with regard to environmental protection and safety of workers and the population. Largely missing with regard to preventing diversion of tritium and misuse of neutrons.

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

Yes

Yes. A fusion power plant need not be regulated in the same way as a fission plant. But the dual use aspects must be included in specific regulation for fusion power plants.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Don't know

No views

9 What other issues should a Fusion NPS address?

No views

10 Do you believe that a third party liability regime is required for fusion?

Don't know

Care must be taken to ensure liabilities are covered in the event of an accident, but if too onerous, this could deter operators from entering the market.

11 What are your views on the principles and issues around third party liability as set out in this paper?

As above

12 What issues in addition to those described in this paper should any fusion third part liability regime address?

n/a

13 How can the Government promote the development of suitable commercial fusion insurance?

No views

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes

They will both become a critical part of a country's energy generation infrastructure, and systems relating to tritium and neutron accountancy, must not be subject to attack and distortion.

15 What in your view should cyber security regulations for fusion cover?

Ensuing availability of a fusion power plant, ensuring safety and prevention of hijacking for the purposes of diversion of tritium.

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

Not Answered

No views.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

Yes

This is essential. Regulators need to become educated about fusion facilities and developers need to understand the future requirements that are to be

placed upon the operators of a fusion power plant. Otherwise disconnection will occur, surprises will result and delays in deployment of fusion power plants will result.

18 What are your views on how such engagement should work?

Briefings by fusion R&D staff to regulators; set up of future fusion regulatory development groups within regulators who work with R&D developers and

involvement of international bodies such as the IAEA.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation?

Yes

1) Scale compared to existing fusion R&D facilities needs to be considered, especially with regard to REPIR, or through correct design, that evacuations of

populations will not be required.

2) Ensuring methods of ensuring tritium and neutron accountancy are developed should be encouraged/mandated.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion?

Yes

Openness with regard to the opportunities and hazards. Facts will emerge anyway if players seek to cover anything up.

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Secondment of staff from fusion developers (e.g. UKAEA, EU DEMO) into regulators to assist with the building of a capability.

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

As above. But talk to those involved in R&D, not just high level teams. A great deal of work in this area is taking place at a detailed level within UKAEA in support of EU DEMO and STEP.

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

This matter is being adequately advised upon by the waste, safety and environmental teams at UKAEA. Key is choice of materials to limit neutron activation.

All waste including structural components at end of life should be detritiated through appropriate processes which are under development. Tritium should be recovered for future use in other facilities.

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

Yes

The only exception may be a small amount of ILW that exceed the limits for LLW and surface disposal

25 What are your views on how a fusion facility should be decommissioned?

All mobile tritium should be removed from the facility as a first step. All components should then be detritiated before passing on for processing to size reduce according to standard waste hierarchy principles.

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

The fusion power plant developer must be able to show how detritiation and waste minimisation is to be achieved in the design of their power plants.

27 Do you agree with the Government's proposals on safeguards for fusion?

No

The current proposals are weak and do not reflect the risk of nuclear weapons proliferation that could occur through the misuse of neutrons and the diversion of tritium. If these areas were strengthened then the UK could be described as a leader in the development of regulatory frameworks for fusion power plants.

28 What should the Government consider when developing guidance for export controls and technology licensing?

Fusion power plants should only be exported to countries that agree to having their facilities inspected by the IAEA or other international safeguards enforcer, with regard to the production of fissile material from misuse of neutrons and production and diversion of tritium.

International agreement should be sought on the enforcement of this matter through the IAEA and relevant treaties.

29 Do you agree with the proposed approach for keeping the fusion regulatory framework under review?

Yes

Please explain your response:

Yes - but the field is moving fast (at last), so reviews should take place every 5 years rather than the proposed 10 years.

31 Before today, how much did you know about fusion energy?

Knew a lot

32 From what you know, or have heard about fusion energy, do you support or oppose the UK developing this technology?

Strongly support

33 What is your level of knowledge about fusion after reading this paper?

Knew a lot

34 What is your level of support for the development of fusion energy technology in the UK after reading this paper?

Strongly support

Anonymised Response N

2 Do you agree with the Government's conclusions regarding the expected hazards of future fusion power plants?

The inventory of radioactivity upon with the large amount of energy stored in the plant make fusion power plant a Nuclear power plant that should be subject to the same rules of fission NPP. In fact, the energy stored is potentially capable to breach the barriers that perform the radioactivity containment function. For sure there are no problems from point of view of reactivity accident, but any how there are other potential sequences that could determine radioactivity spreading (tritium essentially) and these sequence must be analysed according the the methodology adopted for the fission NPP.

3 Do you agree with the proposal to maintain the existing regulatory approach?

In order to proceed on this direction, more description on the risks, accident scenarios abd consequences should be performed, since the risks associated with fusion reactors would be much higher than the ones from the current fusion facilities.

4 Do you agree that IRR 2017 and EPR 2016 provide for the consenting and permitting (respectively) of fusion power plants in a way that is proportionate and appropriate?

The alternative approach, with a goal seeting regulations appears to be both flexible, and more representative of the risks involved in fusion reactors.

Both responses are no, because the fusion is a Nuclear Power plant (see notes above)

5 Do you think that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965 and so be brought within the remit of the nuclear licensing framework led by ONR, either at this stage or in the foreseeable future?

Even though the risks would be much reduced compared to fission reactors for long term accident scenarios (no thermal power to evacuate at a long term) and waste impact, fusion plants may lead to higher risks than many non fission reactors facilities managed by ONR. There would be a communication misunderstanding if the members of the public apprehend these regulations only as pro-fusion regulations.
Therefore, regulating fusion reactors under ONR umbrella seems more appropriate, with a goal setting approach proportionned to the risks.

6 What are your views on the Government's proposals in relation to the regulatory justification of fusion?

The justification could include as well words on the much lower production of long lives radioactive waste. It could be "generation of net energy by fusion power stations in an approach reducing long lived radioactive waste "

7 Do you agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for fusion power plants?

A nuclear site licence would be needed if the risks and consequences from a fusion recator are at the same level as the other non fission reactors facilities managed by ONR. In terms of comparison, a fusion reactor may present the same type of risks as a non fission reactor facility, such as fuel cycle facilities, or nuclear laboratories.

Again: the presence of the large radioactive inventory upon with large energy stored makes the fusion NPP no intrinsic safe NPP and for this reason there should be no discount in approaching its development. This discount may be justified later, when the radioactivity inventory will be drastically reduced or barriers demonstrated unassailable.

8 Do you agree with the proposal to establish a Fusion NPS based on the planning assumptions outlined?

Fusion NPS has to be established, but point 3 (i.e. no Nuclear approach) is not appropriate

13 How can the Government promote the development of suitable commercial fusion insurance?

Àlso as far as the liability, the same regime applied for fission should be put in place

14 Do you agree that prototype fusion power plants should be subject to cyber security regulations, regardless of their energy generating capacity?

Yes, for safety reasons.

Fusion plants should be protected against any type of hazards, including cyber-attacks.

15 What in your view should cyber security regulations for fusion cover?

The same as for fission

16 Do you agree that the proposed definition of fusion energy facilities that should be in scope for enhanced regulatory engagement and new guidance is appropriate?

No, because there is none criterion to select 100 times.

For tritium, the amount seems reasonnable to consider it as a fusion energy facilities. But, fusion reactors will also include high levels of activation and therefore may lead to large variety of (relatively short-medium lived) nuclides that would need to be considered for establishing the level of risks of the facility.

17 Do you agree that there should be formal engagement in the design process between fusion developers and regulator(s)?

18 What are your views on how such engagement should work?

The regulator should provide guidance in establshing general goad-based objectives, but should not be involved too deeply in the design process, otherwise there would be a dangerous tendency on non objectivity in the regulator views on the proposed design.

The regulator should listen the point of view of the developer, but must be obviously independent and take decision in the interest of the public interest and developer too, moreover from safety point of view, that sometime can be misleaded since associated to the risk evaluation. This is why it is better establish the rule of games before starting the process.

19 Do you agree that additional guidance for fusion energy facilities should be developed on fusion energy regulation? Please explain your response. If you agree, what should the guidance cover?

Yes, essentially relevant for safety

yes, the guidance could cover the goals, the type of defense-in-depth to be proportionate to the actual lower risks than those for fission reactors.

20 Do you believe that there should be greater opportunity for the public to engage in the regulatory process for fusion? If yes, what are your suggestions for how this could be achieved?

Public views are important to show transparency, but without being actors of the regulations themselves

21 How do you think regulators can best build technical capability around emerging technologies such as fusion?

Yes, Involving public representatives in the process.

Increasing the knowledge of the regulators with regards to fusion risks will always provide a benefit since it would lead to better adapt the regulations to the proportionned risks.

Being part of its development with a dedicated staff, through a continuous review process of development

22 What are your views on how the technical expertise of UKAEA could best be used to support the development of a regulatory framework for fusion energy in the UK and around the world?

IN the way said above: constituting the satff that provides continuos review on the work performed by the developers

UKEA may be a technical support of the nuclear regulator, the responsibility remaining still at fusion safety authority side

23 What are your views on how radioactive waste from fusion should be safely and sustainably managed?

radioactive waste from fusion should be treated as the other low or medium radioactive waste, when their levels of tritium is low (criteria to be defined). When their level of tritium is high, the waste should be sumitted to an increased outgassing such as to come back to the previous case. Therefore, there would not be any additional difficulty with fusion waste.

In the same way adopted for fission NPP

24 Do you believe that Government policy should reflect an expectation that radioactive waste from fusion can be disposed in near-surface disposal facilities?

There is no need to make difference between what foreseen for fission NPP and fusion NPP waste

25 What are your views on how a fusion facility should be decommissioned?

A decommissionned fusion plant is similar to NPP for which nuclear fuel has been removed. There should not have additional regulations on this. Through a process that asuure a final green field

26 How should these topics be covered in any guidance developed for the fusion regulatory framework?

Licence for realizing fusion NPP should impose the final green field

27 Do you agree with the Government's proposals on safeguards for fusion?

Self production of tritium, malevolence acts and control of fusion induced materials (such as the ones used in getter beds) would need to be regulated.

Safeguard regulation for tritium should be developed

28 What should the Government consider in developing guidance for export controls and technology licensing?

The culture and political stability of the acquiring country

29 Do you agree with this proposed approach for keeping the fusion regulatory framework under review?

Sure, but I would prefer to maintain higher attention first and release after, avoiding mistakes performed in fission NPP, where the "Safety Culture" has been recongnised as foundamental after several Nuclear disasters

30 Do you believe there is anything else the Government should consider with regard to fusion energy regulation?

List seems exaustive

3. Other responses

3.1 Groups

Nuclear Free Local Authorities

Nuclear fusion has beenjust a long-held ambition of the nuclear industry and governments who support nuclear power for decades. Since the end of the Second World War, governments around the world, backed by elements of their scientific communities, have always lauded fusion power as the ‘next step’ above and beyond fission that is almost within reach, yet many billions has so far been spent over the past seven decades on what has often been called by its critics an ‘energy pipedream’.

NFLA has rarely commented on nuclear fusion, given such energy projects have yet to be commercially realised. All have foundered around the complex challenges in developing such technology, many of which in the third decade of the 21st century remain unsolved.

In summary, to date, none of the experimental reactors in operation have produced more energy than was put into them.

However, given the current UK Government’s declared intent to invest further money in fusion reactor development with the aspiration to develop a commercially viable design within two decades, it would be remiss of NFLA not to comment on this consultation.

Operating a fusion reactor presents many challenges and risks.

In response to concerns expressed by member authorities, the NFLA itself commissioned a special briefing on this subject (Edition 62, published in September 2020) ‘NFLA New Nuclear Monitor Policy Briefing - NFLA Response to the UKAEA call for potential sites to host a nuclear fusion reactor in England’

The full briefing can be found here: https://www.nuclearpolicy.info/briefings/nfla-new-nuclear-monitor-62-nfla-response-to-the-ukaea-call-for-potential-sites-to-host-a-nuclear-fusion-reactor-in-england/

CoRWM has also recently published a preliminary position paper ‘Radioactive Wastes from Fusion Energy’ (6 December): https://www.gov.uk/government/publications/radioactive-wastes-from-fusion-energy-preliminary-position-paper

Many of the following comments are taken from the NFLA paper, particularly from pages 4-6, but reference is also made to specific sections of the CoRWM report.

As Earth lacks the intense pressure generated by the Sun’s gravity, and so cannot replicate the conditions favourable to fusion found there, there would be the requirement to super-heat the interior of the reactor to 100 million degrees centigrade, or six times the Sun’s temperature, to generate the reaction. Such a temperature and the subsequent reaction would have to be safely contained with the reactor vessel.

In addition, a fusion reactor has high operating costs as the system itself ‘gobbles up’ much of the energy that it generates to run its coolant, containment, pumping and other engineering systems. Any failure of these systems at any time would compromise the safe operation of the reactor.

The reaction generated through the employment of neutron-rich isotopes of deuterium and tritium would produce harmful by-products such as:

Progressive radiation damage to structures impacting on their long-term integrity. The neutron radiation produced knocks atoms in the surrounding structure out of alignment creating swelling, embrittlement and fatigue, and prolonged exposure would put the very integrity of the reactor vessel in peril.

CoRWM said: ‘The primary components of the fusion reactor system are likely to require disposal, including the activated front wall, blanket, divertor and vacuum vessel materials.’

The generation of radioactive waste. Fusion will generate huge masses of highly radioactive material that must eventually be safely disposed of. Many non-structural components inside the reaction vessel (and, in liquid-metal cooled fission reactors, the lithium blanket) will become highly radioactive by neutron activation. In addition, molten lithium represents a fire and explosion hazard. While the radioactivity level per kilogram of waste would be much smaller than for fission-reactor wastes, the volume and mass of wastes would be many times larger.

CoRWM also challenged the presumption in the consultation paper that fusion does not generate significant nuclear waste:

‘Nuclear fusion technology is advocated as not being compromised by the burden of generating long lived nuclear wastes. It is evident that this claim is challenged by the expected generation of some significant volumes of LLW and likely ILW arisings.’

The ever-present threat of the release of radioactive tritium. Tritium will be dispersed on the surfaces of the reaction vessel, particle injectors, pumping ducts, and other appendages. Corrosion in the heat exchange system, or a breach in the reactor vacuum ducts could result in the release of radioactive tritium into the atmosphere or local water resources. Tritium exchanges with hydrogen to produce tritiated water, which is biologically hazardous. The release of even tiny amounts of radioactive tritium into groundwater would significantly compromise public health.

The possible production of weapons-grade plutonium 239, adding to the threat of nuclear weapons proliferation. The open or clandestine production of plutonium 239 is possible in a fusion reactor simply by placing natural or depleted uranium oxide at any location where neutrons of any energy are flying about. Fusion reactors will also have an inventory of many kilograms of tritium, providing potential opportunities for diversion for use in nuclear weapons. Just as for fission reactors, IAEA safeguards would be needed to prevent plutonium production or tritium diversion.

In addition, as plant workers would be otherwise exposed to significant doses of radiation the plant would require heavy biological shielding even when it is not operating.

In our response specifically to Consultation Questions 5 and 7 in the consulation, the NFLA is gravely concerned that the government appears intent upon ‘watering down’ the regulatory regime applicable to fusion and demands that fusion power plants should be considered to be nuclear installations under the terms of the Nuclear Installations Act 1965, and so subject to the same licensing and regulatory regime overseen by the Office of Nuclear Regulation that applies to fission reactors.

The paper concedes that ‘with the uncertainties involved in fusion power plants, it is possible that the regulatory approach based on NIA 1965 could become more appropriate as the regulatory basis of fusion power plants if fusion design choices in the future involve a considerably higher degree of radiological hazard’ (p46).

Given the challenges and risks associated with operating fusion reactors, the NFLA has no doubt that the same regulatory approach to fusion should apply from the onset as it does to fission, and that this should extend to operations and the treatment and transport of arisings.

There is no logical reason to exclude fusion on safety grounds, and the NFLA can therefore only conclude that the government’s motive is to reduce the administrative and cost burdens placed upon commercial operators entering the market.

The NFLA believes that consideration for the safety of plant operators and the public should come far above plant operators’ profits.

In addition, the paper makes several proposals which are of concern to the NFLA:

A lesser regulatory regime has the potential to compromise security, as well as safety, at fusion plants. We have already highlighted the proliferation risks and believe that sites should be subject to greater levels of security and IAEA safeguards.

The waiver of licensing and the proposed cap on liability appears only to give ‘carte blanche’ and reduce costs to operators and runs contrary to the usual policy of making the polluter pay.

Companies involved in nuclear transportation will have no liability as the government claims this will be a ‘disincentive to supply’.

It is unclear how the long-term responsibility and costs of decommissioning will be apportioned between plant operators and the UK Government.

CoRWM also shares these concerns:

‘It may be noted that the recent call for expressions of interest to accommodate siting the STEP facility makes no mention of management of the arising radioactive waste. Future dialogue with local communities needs to ensure it is as open and transparent as possible on such matters.’

The Government seems intent upon permitting operators to dispose of waste in shallow disposal sites. Though this may be an attractive and less-costly option for commercial operators, the NFLA remains unconvinced that this will represent a disposal method that is safe and secure for the long-term.

This view was again supported by CoRWM in its recent report:

‘From a radiological perspective, it is reasonable to consider that, conceptually, wastes from a nuclear fusion power programme should be compatible with geological disposal, however, they may prove challenging for disposal in a near surface facility, given the long half-life and potential mobility of 14C and 94Nb.’

‘…some key activation products of concern, such as 14C and 94Nb, which are long lived, should be limited in near surface disposal facilities, given the reliance on engineered barriers to assure containment.14C poses a particular challenge given its potential mobility in the near subsurface.”

Office for Nuclear Regulation (ONR)

Thank you for the opportunity to comment on these proposals for a regulatory framework for fusion energy. This letter provides The Office for Nuclear Regulation's (ONR) response to this consultation[1]. Our mission is to protect society by securing safe nuclear operations, which we do by delivering our five statutory purposes:

- nuclear safety
- nuclear site health and safety;
- nuclear security;
- nuclear safeguards; and
- safety of transport of nuclear and radioactive materials

Any future decision on the regulation of fusion energy is a matter for government. ONR does not currently have a role regulating fusion activities, which are regulated by the Health and Safety Executive and the Environment Agency. We have a regulatory role in relation to safeguards and transport for fusion, as we have across a range of sectors where radioactive substances are used.

We have been providing advice to the Department for Business, Energy and Industrial Strategy (BEIS) and the Regulatory Horizons Council on our experience of regulating fission to inform policy development on the future regulation of fusion. From our experience of the Generic Design Assessment (GDA) process we know the value of design assessment to ensure the final design has reduced regulatory risk. GDA considers the full lifecycle of the design from construction, through operation to decommissioning and waste management, providing a steady increase in regulatory certainty which we think would be relevant for fusion, especially considering the highly complex nature of fusion reactor design.

In our recently published response to our consultation on our revised interpretation of bulk quantities[2] we agree that a legislative approach is appropriate for clarifying that a nuclear site licence would not be needed for a fusion power plant. As such, we have not sought to address this through our revised interpretation of 'bulk quantities'. We will work closely with government to inform any changes to our legislative framework as a result of the proposals in this consultation being taken forward.

From our significant experience of proportionate, outcome focused and enabling regulation we recognise the benefits of applying these principles in the future regulatory framework for fusion. Setting clear regulatory expectations, as we do with the publication of our Safety Assessment Principles[3] and Security Assessment Principles[4] together with supporting internal guidance (Technical Assessment Guides[5]), enables safety and security risks to be effectively managed and will be import for the growing fusion industry.

[1] Towards Fusion Energy (2021) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1032848/towards-fusion-energy-uk-government-proposals-regulatory-framework-fusion-energy.pdf
[2] Response to consultation on ONR's revised interpretation of 'bulk quantities'. Available at: https://www.onr.org.uk/consultations/2020/bulk-quantities/bulk-quantities-consultation-response.pdf
[3] ONR safety assessment principles for nuclear plants. Available at: https://www.onr.org.uk/saps/index.htm
[4] ONR security assessment principles. Available at: https://www.onr.org.uk/syaps/index.htm
[5] Technical assessment guides. Available at: https://www.onr.org.uk/tagsrevision.htm

Operational experience from fission can be used to inform the safety and security of fusion and we would be pleased to take part in future engagement to support this.

Parents Concerned About Hinkley

We don't need nuclear fusion or any new nuclear. We've already got nuclear fusion; it's called 'the sun'. The UK is in line to achieve 100% renewables using wind, solar and tidal power well before 2050.

Nuclear waste must be transferred to Sellafield for immobilisation and near surface storage. Existing containers corrode internally and collapse releasing widespread radiation into local populations as happened in New Mexico.

Radiation Free Lakeland

Radiation Free Lakeland add our voice to the call from Nuclear Free Local Authorities that the already inadequate nuclear regulations are not watered down when it comes to dangerous fusion reactors. Fusion experiments require enormous amounts of heat and energy. The nuclear wastes from the fusion experimental reactors already amounts to 3000 cubic metres of nuclear wastes from the Culham experimental reactor alone. Nuclear Free Local Authorities say the following and RaFL agree that:

Public safety must come before profit: Nuclear Free Local Authorities call for 'no watering down' of nuclear regulation for fusion reactors

The Nuclear Free Local Authorities Network has called for 'no watering down' of the safety regulations that will be applied to future fusion reactors in its response to a public consultation by the Department of Business, Energy, and Industrial Strategy[6].

In his letter to the BEIS, Councillor David Blackburn, Chair of the NFLA Steering Committee, outlines the many challenges and risks that would be posed by operating nuclear fusion, including the risk posed by the large quantities of radioactive wastes that would result and the danger of radioactive tritium entering the water supply[7].

Most frightening is the requirement to constantly and safely contain the immense temperatures needed to spark and sustain a fusion reaction and the long-term damage that the whole structure will suffer from prolonged exposure to neutron radiation, a situation which if not

---

[6] Towards Fusion Energy (2021). Available at: https://www.gov.uk/government/consultations/towards-fusion-energy-proposals-for-a-regulatory-framework

[7] The letter sent by email by Cllr David Blackburn, Chair of the NFLA Steering Committee to the BEIS Fusion Team 15 December 2021

carefully monitored could result in the very integrity of the reactor vessel being placed in jeopardy.

Commenting, Cllr Blackburn said:

“Fusion has been for seven decades an elusive pipedream for nuclear scientists and governments wedded to nuclear power. Despite the determination of the Johnson Government to invest hundreds of millions in fusion development, there is still no guarantee that this technology will ever come to commercial fruition. For at this time, there has been no fusion reactor which has ever generated more than a fraction of the power that it has taken to operate. Nonetheless, this is not a technology to trifle with and the NFLA believes that the government should impose the most rigorous regulatory regime upon it.”

Given the dangers, the NFLA most specifically wants new fusion reactors to be licensed and regulated as a nuclear installation by the Office of Nuclear Regulation (ONR) under the 1965 Nuclear Installations Act, like current fission reactors. Instead in its green paper the government seems determined to waive this requirement.

Cllr Blackburn concluded:

“In the view of the NFLA, there is no logical reason on safety grounds not to apply the same regulatory regime to fusion reactors as apply to fission reactors, and the NFLA can therefore only conclude that the government’s motive is to reduce the administrative and cost burden on commercial operators entering the market to put their profits before public safety.”

3.2 Responses received from individuals

Individual C

Individual C provided information in their response in in addition to the answers to the questions produced above. This additional information is included here.

Preamble

Regulation is in effect Law Enforcement. Regulators rarely make laws it is Parliament that makes laws and hence it is up to Parliament to make effective laws that are clear and place obligations on duty holders that are fair, deliverable and proportionate to the hazards presented by the activity being regulated. In a time of innovation and change laws need to be ideally goal setting, as goals can be clearly defined and justified. Laws at the same time should enable the duty holders to have the freedom to decide how best to meet the goals in a way that suits their business. In this way as goal setting laws, together with goal setting regulation, enable both the duty holder and the regulator to be flexible and enable innovation to take place within a controlled environment.

In the case of nuclear safety regulation, the Nuclear Installations Act (NI Act) sets a high-level goal such that anyone that wishes to construct or operate a nuclear installation must first obtain a nuclear site licence. Ministers have the flexibility to determine what type of activity involving the use of atomic energy should be defined as a nuclear installation. The NI Act not only gives the nuclear safety regulator the power to grant such licences to a duty holder (licence applicant /licensee) it also gives the nuclear safety regulator the powers to attach conditions to the licence (LCs) in the interests of safety and in relation to the handling, treatment, and disposal of nuclear matter. The NI Act also allows the scope of what is meant by nuclear matter to be prescribed.

The UK's nuclear site licensing regime is incredibly flexible as it enables a wide range of nuclear installations (from large-scale nuclear power plants, large spent fuel reprocessing facilities, nuclear fuel fabrication facilities to small university research reactors) to be regulated using a proportionate goal setting approach. The LCs allow the licensee to tailor his arrangements for compliance in a way that is proportionate to the hazard presented by the licensee's activities. The level of regulatory oversight provided by the nuclear safety regulator is again tailored to match the hazard potential of the activity being regulated in a way that does not unduly place regulatory burdens on the licensee.

The flexibility of the NI Act and the nuclear site licensing regime previously operated by HSE/HMNII and now ONR has, without change to the nuclear site licensing approach, accommodated the regulation of several new activities including:

- nuclear fuel cycle facilities (1970);
- the refuelling of nuclear submarines (1987);
- the UKAEA nuclear fission research sites (1990); and
- the manufacture of the UK's nuclear weapons (1997).

The application of the nuclear site licensing approach has also not been a bar to innovation and change within the nuclear industry. On the contrary the UK approach to nuclear site licensing has enabled considerable change to take place without undue regulatory burdens whilst maintain the high standards of public and worker safety. It is clear that the nuclear power plants (NPPs) of today e.g. Hinkley Point C, bear no resemblance to the early Berkeley and Bradwell nuclear power stations that were Licensed in 1960. Similarly, over the years the flexibility of the nuclear site licensing regime has enabled considerable innovation in nuclear fuel reprocessing, uranium enrichment, nuclear fuel manufacturing, radioactive waste treatment and storage, nuclear submarine refuelling, and decommissioning of nuclear installations, whist at the same time improving safety standards.

Although designed in the 1950's the NI Act was ahead of its time and its nuclear site licensing regime, has over decades, contributed, not only to high levels of public safety (that are respected worldwide), but also enabled the UK nuclear industry undergo considerable change. I would argue that the UK's nuclear site licensing regime is fully aligned with the Government's 2019 White Paper "Regulation for the Fourth Industrial Revolution" as it has been shown to be capable of being agile, enabling innovation and providing world class protection of citizens and the environment.

The effectiveness of the UK's nuclear licensing regime is clear for all to see. In spite of having one of the world's largest nuclear programmes, there have been no major nuclear accidents in the UK since the NI Act and its nuclear site licensing regime was introduced.

Fusion Power Plants (FPPs) are large complex installations that are fuelled by a nuclear process and as such they should be subject to effective and efficient regulation to ensure public protection and thereby enable the development and deployment of a vital low-carbon energy industry.

The safety regulatory framework as set out in the Government's consultation document is less than optimal and is not compatible with the UK's proud history of effectively regulating the uses of atomic energy.

It is important for the UK to maintain its high standards of public safety and environmental protection, but if the Government wants the UK to be a fusion industry superpower (which I support fully) with a global export market, the UK needs to be able to, not only set an example of good safety regulation, but also be able to influence the international regulatory community.

The Prime Minister's 10-point plan for a green industrial revolution includes Nuclear Energy but does not specifically refer to fusion power. However, given that the Government's AMR Competition included one fusion power plant (FPP) project and that the Energy White Paper "Powering out net zero future" clearly puts fusion within the context of nuclear power it is reasonable to assume that the Government regards FPPs to be a nuclear technology. This is important.

General Comments on the Consultation Document

The following are my general comments on the content of the Consultation document for your consideration. As you will see I do not agree with some of the statements made in the document. I also think that a more balanced and accurate view of the nuclear site licensing regime could have been given to enable readers to form a more informed opinion of the Government's proposals and a viable alternative regulatory approach for FPPs.

Page 14 Objectives

Agreed, but it is precisely because the development of FPPs is a developing technology that the regulatory framework must be robust and proportionate to hazard potential. Regulatory independence and regulatory competence is vitally important not only for safety but also for public and political confidence in the regulator and, the prevention of regulatory capture. The UK nuclear safety regulator ONR and previously HMNII, have for decades deployed effective regulatory capture mitigation strategies.

Page14 Regulatory Horizon Council report.

I believe the Regulatory Horizon Council's (RHC) report on fusion energy regulation, lacks rigour and is fundamentally flawed. In my view there are major shortcomings in the RHC"s report include the failure to understand the true hazard potential of FPPs, the failure to recognise the difference in the current day-to-day regulation of the safety of JET and other facilities at the UKAEA Culham site, and the safety regulation of a major FPP project, the failure to understand the security and non-proliferation issues associated with FPPs, and the failure to understand the applicability of the UK's goal setting nuclear site licensing regimes to low and intermediate hazard potential nuclear installations. Therefore, I do not believe the RHC findings provide a reliable basis for judging the appropriateness of a regulatory framework for the safety regulation of FPPs in the UK.

I have a much more detailed critique of the RHC's report that supports my observation on the value of the RHC report should the Government wish to see it.

Page 15   Regulatory Strategies

As pointed out above, there is a world of difference between the day-to-day regulation of small fusion research facilities with small hazard potential and the safety regulation of a large complex FPP project that includes design, construction, commissioning and 24/7 operation with a much larger hazard and unmitigated risk potential to the public.

Page 20   Fusion Regulatory Authority

Yes, the Fusion Safety Authority may be independent of the operation and research parts of the UKAEA, but it is still part of the UKAEA. The Fusion Safety Authority has an important internal assurance function to play in the STEP project, but it is not a regulator. The role of internal safety assurance departments within FPP organisations is discussed in more detail later.

Page 20   UKAEA Technology Report

This is an interesting and informative document, but I do not agree with everything that is written. It could be misleading to state that the understanding of the hazards relating to FPPs is well understood. In general it is true to say that the main hazards are known but to determine all the hazards and the subsequent risk to the public from an FPP requires a well-developed design. To date there are only FPP conceptual designs, detailed designs will come later.

I believe it is misleading to say that the potential for harm to the public is low. There is a difference between the potential for harm and the actual risk that the public would be exposed to. The low level of risk usually results from a high level of engineered protection systems

Again, the same point as above routine environmental discharges result from upstream engineering designed and operated to filter out harmful radioactive materials that are being discharged into the atmosphere. The "filtered" are treated and stored and eventallly disposed of as solid radioactive waste. It is important to remember that it is the risk that is low not the potential harm which could be much higher. Without a detailed design is too early to say that discharge levels "will be well below that would require any further significant reduction.

It is important to recognise that the current generation of FPPs are likely to generate large volumes of ILW that will require storage for over a hundred years and eventual disposal after treatment.

Section 5 of the technology report clearly shows that FPPs are complex machines that require “defence in depth” and risks to be reduced to meet the ALARP requirement. Hence, there will be a lot of complex engineering in an FPP and a lot of engineering substantiation to be done to support the production of a robust safety case. In the discussion on accident scenarios, there is little analysis of the potential for hydrogen and dust explosions, or the impact of external hazards.

Section 6 Accident analysis. There is a recognition that it is difficult to give a definitive analysis. Given this, it is hard to see how the claim that the potential harm to the public is low can be made. Analysis done by my student shows that there is the potential for off-site releases that would require off-site countermeasures to protect the public from harm.

The SEAFP results shown are mitigated risks, i.e. the risks after the protection systems have done their job. The form of regulation should not be determined on mitigated risks, it is normally determined on the un-mitigated risks i.e. the hazard potential.

The hypothetical worst-case scenario (1 kg HTO) gives a dose of 450mSv i.e. well above the upper ERL evacuation limit and above levels where mild symptoms of radiation sickness would be observed. For a release of 2 kg HTO and 100kg dust the predicted dose is 1 Sv. This dose would induce radiation sickness and indicated that an FPP has a significant hazard potential especially as a large FPP could have up to 1000kg of radioactive dust in the vacuum vessel.

There is confusion between risk and hazard. The hazard potential is a measure of the harm that would result if the hazard was realised. Risk is the product of the consequences of an event and the probability of that event occurring. Hence, it is possible to both reduce the consequences by engineering design using defence in depth and by reducing the probability of the consequence materialising again by defence in depth via engineered safety protection systems and containment barriers and filters. External hazards are different. An aircraft crash deliberately flown int an FPP could result in the hypothetical release as could a large beyond design basis earthquake.

All this illustrates that the safety of the design of an FPP will require considerable substantiation. It is the role of the regulator to check, on behalf of the public, that the FPP safety arguments are robust. Hence the regulator needs to be competent and experienced in the assessment of complex safety documentation.

Page 26 tritium inventories

This clearly illustrates that an FPP will have about 100x the inventory of tritium than JET therefore bringing into question the wisdom of thinking that the current approach to safety regulation of JET can be applied to an FPP.

Page 28 Accident scenarios

The accident scenarios reflect mitigated risk, i.e. after all the safety features have performed their functions. It should also be noted that the UKAEA approach to safety analysis and the production of safety reports mirrors the approach used in nuclear safety community. It is important not to confuse the release from accidents (safety issue) with routine authorised discharges (environmental protection) they are different and are regulated differently.

Page 31 Table 1

It should be made clear that the doses quoted are after assumed mitigation by the engineered safety systems.

Page 32 Table 2 Hypothetical Scenario

Table 2 is an example of an unmitigated risk which illustrates a significant potential for harm. As regulation is based on hazard potential and not mitigated risk, this analysis would warrant the application of robust regulatory system such as the UK's nuclear site licensing regime.

Page 34 Emergency planning

It is clear that there are accidents with the potential to require off-site countermeasures. This means that emergency planning is required, and hence emergency exercises will also be required. ONR have extensive experience of managing emergency exercises via its nuclear site licensing regime and the implementation of REPPIR arrangements with Government, local authorities and emergency services. This is something that HSE have little experience of.

It is important to stress that licensees operating nuclear installations regulated under the nuclear licensing regime are required to show that all risks are reduced as far as is reasonably practicable (the ALARP principle) in line with the HSW Act.

Page 36 Non-nuclear hazards

It should be noted that there are many non-radiological hazards on nuclear licensed sites and ONR has demonstrated that is capable of effectively and proportionately regulating these types of hazards.

Page 37 Penultimate paragraph

The claim that the hazards associated with FPPs will remain of a similar magnitude to those associated with the other industries quoted is without foundation and meaningless as the hazards are different. The important factor is that the public are more concerned about radiation hazards and the Government is concerned about clean-up costs.

It is again important to note that the nuclear site licensing regime has been shown to be effective, proportionate, innovative and capable of handling new technologies. Working with science and engineering organisations to inform regulatory decision making has been part of the nuclear safety regulators DND for over 6 decades.

Page 39 ALARP and ALARA

It should be remembered that setting a dose limit for routine discharges is prescriptive. ALARP or ALARA requires the duty holder to show that risks associated with the discharge have been reduced so far as is reasonably practicable, therefore it is possible for a duty holder to demonstrate that a risk above some defined regulatory limit is ALARP. The fact that an operator has the capability of deciding how to engineer his plant and how it is operated to meet the discharge limits should not be confused with goal setting non-prescriptive approach.

Page 39   last paragraph

The consultation document up to this point has focussed on the regulation of FPPs. Now the concept of a fusion facility is introduced. This is confusing as this document is focussed on the regulatory framework for FPPs.

The last paragraph assumes that the safety of an FPP will be regulated via the HSE. It is equally plausible that the safety of an FPP could lawfully be regulated under the current nuclear licensing regime. For the reader to be able to make an informed decision, the Consultation document should have included a detailed description of alternative regulatory approaches.

Page 41   Current regulatory proposals

As shown above it is a fundamental mistake to believe that the day-to-day regulation of fusion research facilities is comparable to that which will be required to regulate the design, construction, commissioning and operation of a large technically complex FPP that has a much higher radioactive inventory and higher hazard potential.

Page 44   Proposals on fusion energy regulation

As stated above, this Consultation document is primarily concerned about the regulation of FPPs, not fusion energy. The current regulatory approach is focused of fusion R&D facilities not FPPs.

As discussed previously the RHC’s report is fundamentally flawed, it lacks rigour and critical analysis and therefore is not a good basis for forming a regulatory framework for FPPs.

Page 45   Government’s broad proposals

Proposal 1. I disagree. The radiological hazard presented by and FPP is considerably greater and significantly different from that of current fusion research facilities (JET will have produced seconds of fusion energy over its lifetime, an FPP will deliver fusion energy (and its associated hazards) 24 hours a day 7 days a week at considerably higher power levels.

Proposal 2. I disagree. The existing nuclear site licensing regime is capable of providing effective and proportionate regulation of FPPs and hence there may not be a need to introduce any new provisions for FPP regulation other than to prescribe and FPP as a licensable nuclear installation and prescribe tritium and radioactive waste produced by a fusion process as nuclear matter.

Proposal 3. I disagree that BEIS should work with HSE on FPP safety regulation. I believe BEIS should work with ONR as they are best placed to understand the development of regulatory guidance for the safety, security and safeguards of FPPs. ONR is also best placed, given their long history and the respect in which they are held to work with the IAEA on the development of new international regulatory standards and guides for FPPs. The industry, led by UKAEA are best placed to work with the IAEA and others on FPP design and operating standards and guides.

Proposal 4. I disagree. The goal setting nature and flexibility of the UK nuclear site licensing regime should enable the continuous development of the FPP industry without any significant change in regulatory policy.

Proposal 5. I disagree. Given the comments above it is unlikely that such reviews will be necessary if the Government adopts the nuclear site licensing regulatory approach.

Page 46 An alternative approach

The document gives a very poor and inaccurate description of the UK nuclear site licensing regime. Asking people to comment without an accurate description of what they are being asked to comment on is not good practice and can lead to distorted and misleading results.

The UK Nuclear site licensing regime is incredibly flexible as it enables a wide range of nuclear installations (from large-scale nuclear power plants, large spent fuel reprocessing facilities, nuclear fuel fabrication facilities to small university research reactors) to be regulated using a proportionate goal setting approach. The licence conditions (LC) allow the licensee to tailor his arrangements for compliance with the LCs in a way that is proportionate to the hazard presented by the licensee's activities. The level of regulatory oversight provided by the nuclear safety regulator is again tailored to match the hazard potential of the activity being regulated in a way that does not unduly place regulatory burdens on the licensee.

The tone of the document gives a misleading impression the UK nuclear site licensing regime. The licence does not "impose" conditions. Each nuclear site licence has 36 standard licence conditions attached to it. All 36 licence conditions currently attached to nuclear site licences are applicable to FPPs. The main goal setting conditions aim to envelope all the activities that are necessary to effectively manage safety on the site. As stated above the way in which the licensee develops his arrangements in order to meet the goals set out in the licence conditions allows the licensee to take a proportionate approach that reflects the hazard potential of the activity being undertaken.

It is incorrect to state that licence condition measures are agreed on a safety case basis. As stated above there are 36 standard licencee conditions that are aimed at the management of safety on the site during design, construction, commissioning, operation and decommissioning. The licence conditions require the licensee to make and implement adequate arrangement to deliver the licence condition goal. Several licence conditions require the licensee to produce safety documentation (safety cases) to demonstrate that activities for which permission is being sought can be carried out safety. Examples are the Pre-construction Safety Report

(PCSR) required before construction can commence or the Pre-operational Safety Report POSR required before operation can commence.

FPPs present a completely different and considerably greater hazard potential than the activities that EA and HSE currently have to face at Culham. Hence it is wrong to imply that the current approach to the regulation of Culham is appropriate. The Government's belief is misplaced on this occasion. It does not reflect or recognise the strengths of the nuclear site licensing regime It does not reflect the benefits nuclear site licensing can bring in relation to the regulatory certainty investors and operators need, nor the benefits of public and political confidence. It also does not reflect the need for international recognition and alignment if the UK fusion industry wishes to have a global export market.

Regarding the option to make changes to the regulatory approach later, it is clear that the hazard potential of FPPs are greater than that of JET. There is therefore no benefit to be gained by starting with an inferior regulatory system now and changing later. Adopting a nuclear site licence approach to FPP regulation now would enable the UK to make a leading contribution to the current international debate on FPP regulation, and help shape proportionate regulatory standards as we did (and are still doing) in the case of the IAEA fission safety regulatory standards.

Page 48 amending legislation to provide long-term clarity.

It is not clear what change in legislation is being proposed, but whatever it is, it is wrong and will send the wrong message to the public. As discussed above I believe that the nation and the industry will be better served by bringing FPPs into the nuclear licensing regime.

What long-term clarity does the fusion industry need? I do not understand why the Government is so concerned about regulating FPPs using the UK nuclear site licensing regime given the benefits it would bring to regulatory certainty and public confidence as discussed above. It is also not clear to me what is meant by a consistent basis from which fusion energy regulation can evolve? Adopting the nuclear site licensing regime now will provide a sound basis for safety regulation which will not require evolution to allow the evolution and development of FPP technologies. I do not understand why the Government or the industry is so reluctant to apply the UK's flexible and proportionate nuclear site licensing regime, that has stood the test of time, and is well respected internationally, to FPPs.

Page 50 Fusion and nuclear liabilities

I agree that properly designed, operated and regulated FPPs should not present significant off-site challenges. But, as shown FPPs have significant potential for harm in extreme accident scenarios. More work needs to be done to determine the range over which the release of radioactive materials can cause harm. FPPs directly situated on a border of a country could have transboundary effects.

Page 51/52 Fusion and nuclear liabilities

I agree with the concept of capped liabilities.

When the quantity of tritium is added to the quantities of radioactive tungsten dust in the VV an FPP would most likely be classified as an intermediate risk facility.

I agree strict liability should be applied to FPPs

I agree with the application of financial security, LC 36 requires licensees to have adequate financial resources

I agree with the Government's view on "channelling" - this argument reinforces the need for FPPs to be subject to nuclear site licensing.

Liabilities across borders – I agree but as discussed above more work needs to be done on the dispersion of Tritium and activated dust particles to determine the distance FPPs can be sited from international borders. Our calculations would indicate that a release of around 10% of the tritium inventory and about 2% of the dust inventory in the VV of an FPP would trigger the 30mSv evacuation level at 1Km from the site.

Timing for compensation – the 30-year rule is related to latent cancer development and hence given that both tritium and activated dust are radioactive materials with the potential to induce cancer, rather than looking at other hazardous industries, the Government should commission work on the radiological impact of the radionuclides that can be released from FPPs under accident condition to see if the 30-year rule still applies.

I agree the Paris Convention approach should be applied to FPPs.

I agree, the established rules are tried and tested, but given my comments above on the potential radioactive inventories of FPPs it is possible that FPPs will fall under intermediate and not low risk facilities.

Page 54 Cyber security

I believe it is a big mistake to exclude FPPs from the NISRs. As discussed above FPPs have the hazard potential to cause harm to the public. It is inconceivable that the Government would not require high levels of security for FPPs given, their radiological inventory, their importance to security of supply, the political embarrassment should terrorists or activists take control of an FPP. I believe that FPPs will require high levels of nuclear security (physical protection) to prevent sabotage and the theft of tritium, which is booster material for nuclear weapons. Whilst the Convention of the Physical Protection of Nuclear Materials and Nuclear Facilities do not currently apply to FPPs it is only a matter of time before that will be. In any case the principles of nuclear security are applicable and can be applied in a proportionate way.

It should be recognised that nuclear security also includes the protection of sensitive information and sensitive technologies. Tritium production and handling are sensitive activities given the role tritium can play in nuclear weapon.

Cyber security is only one part of nuclear security.

Comparing cyber security measures for FPPs with those for COMAH sites lacks a recognition that the public regard accidents that expose them to ionising radiation are much more serious than chemical accidents.

Bringing FPPs within the NISR (and safeguards) will not only provide the necessary security for this technology but also negate the need for the Government to make new security arrangements specifically for FPPs.

Nuclear security is vitally important. I cannot see why the Government is so reluctant to apply these regulations as they can be applied proportionately. They are also regulated by ONR.

There is a growing recognition of the importance of having an integrated approach to safety, security and safeguards at the design stage and during construction, commissioning and operation of nuclear plants, and by extension of FPPs. FPPs should be made subject to nuclear site licensing and the NISR to enable ONR, who have expertise in all these areas to develop a proportionate regulatory approach for FPPs. It is difficult to see who better there is to provide the integrated approach to the regulation of FPPs that is needed.

Page 55 enhancing engagement and developing new guidance

If the Government overcame its reluctance and recognised the value on applying the UK's nuclear site licensing regime there would be no need for enhancement of engagement and the development of new guidance.

There is recognition that there is a need to produce a new suit of safety standards and safety design guidelines for FPPs. The IAEA is currently working in this area and there is likely that the IAEA Safety Standards will be extended to include new standards and guides specifically for FPPs along with the identification of which of the existing Safety Standards are also applicable to FPPs.

In the context of engagement the current UK nuclear site licensing regime enable regulators to engage with licence applicants at the early stages of a project and the preliminary safety report (PSR) stage is an example of how initial design concepts can be reviewed at an early stage to identify any "show stoppers".

It is vitally important to understand the dangers of too much engagement at the design stage and experience and robust regulatory processes are needed to prevent not only regulatory capture but also preventing the regulator dictating design solutions so that at a later date they are not "marking their own homework".

On what evidence does the Government believes that there is no need for regulatory hold points prior to commissioning? This is madness. It goes against all the lessons learned from the regulation of the UK's nuclear industry and is contrary to the permissioning principle as set out in the IAEA Handbook on Nuclear Law that apply to ALL nuclear and radiation facilities.

Surely, duplicating the capabilities that exist within ONR in EA/HSE it is not in line with the Government's desire for effective and efficient regulation. There is a limited supply of engineers and scientists and given that ONR is a well-established nuclear safety regulator it would be better for the fusion industry to make use of the countries engineering and scientific resources.

The current nuclear site licensing regime enables engagement between regulators, the industry and the public, a good example being the operation of local liaison committee.

Why try to reinvent the wheel!

Page 55 Defining fusion facilities in scope

Care needs to be exercised here. A 50MW fusion reactor is generating a lot of heat that needs to be removed. We should distinguish between FPP size for planning controls and FPP size for safety requirements. The nuclear licensing regime has been successfully used to regulate the safety of small research reactors with power outputs much lower than 50 MW.

Regarding FPP definition, the IAEA is currently working on how to define fusion installations which include FPPs and the regulatory approach that should be applied to the different types of Fusion Installation.

If the Government accepted the application of the nuclear site licensing regime to FPPs there would be no need to adopt the proposes approach which appears to be solely driven by their desire the use the HSE/EA regulatory approach that has no formal or legal power to enable early engagement in the design process.

Page 56 Increased developer engagement

There are real dangers with this. It is vitally important to understand the dangers of too much engagement at the design stage and experience and robust regulatory processes are needed to prevent not only regulatory capture but also preventing the regulator dictating design solutions so that at a later date they are not “marking their own homework”.

Under UK law it is not the developer that is held responsible for safety, it is the operator / licensee. The way this is usually handled is for developers / licence applicants / licensees to have access to design safety guidelines and design safety standards that are recognised by the safety regulator. It is usually the industry that develops these safety guidelines an example being the European Utilities Requirements for LWRs.

The use of the AMR competition approach is not a suitable analogy for the regulation of an FPP project where legally based decisions are required and where there are criminal sanctions for non-compliance. In the AMR competition regulators were assisting in a technical capacity rather that a legal capacity. The NII in 1976 were used by the then Government to assess the suitability of the introduction of PWR technology into the UK. NII’s advice had no bearing on the subsequent application of the nuclear site licensing process to the Sizewell B project.

Page 57 Guidance

As pointed out above, the regulation of the safety of such a complex machine as an FPP requires more that the IRRs. There would be no need for additional guidance as proposed if the UK's nuclear site licensing regime was used to regulate FPPs.

As discussed above, the Regulatory Horizon Council's report is fundamentally flawed for many reasons, therefore its findings and recommendations in general lack credibility. If the nuclear site licensing regime was adopted there would be no necessity to clarify the ONR regulatory approach. It is only because a less than fit for purpose regulatory approach is being proposed that addition guidance to sell what is a second-best solution is deemed to be necessary.

It is vital to understand that the Government Department that is responsible for the promotion of the fusion industry should not be determining how regulatory policy should be enforced or operated. Independence between the regulator and the industry must be observed.

Pages 59-62 Proposed Framework for Fusion Power Plants

As shown by my previous comments and question responses, I don't believe Government's proposed safety regulatory framework is the right one for the UK. The existing nuclear site licensing framework is more than capable of providing a proportionate safety regulatory framework for FPPS that covers all the required bases.

Table 6 Fusion and the definition of a nuclear installation

It is not true to say that the definition of a nuclear installation was not developed with fusion in mind. Section 1 paragraph 3 (a) of the NI Act clearly states that an installation producing or using atomic energy may be prescribed. The definition of Atomic Energy in the NI Act comes from the definition used in the 1946 Atomic Energy Act and fusion falls within this definition. The Original 1965 NI Act allowed the UKAEA to build and operate nuclear installations (including fusion installations) on its sites outside the control of the statutory nuclear safety regulator.

Regarding the last column, this statement is subjective as the EU and the IAEA (from which the international nuclear community takes its lead) have not yet decided on what would constitute an appropriate regulatory framework for FPPs.

Table 6 Regulatory Engagement

See my response to question 17

Table 6 Public Engagement

This is incorrect, see my response to question 20

Table 6 Cyber security

See my response to questions 14 and 15

Table 6 Nuclear safeguards (preventing state diversion of source or special fissionable material for military purposes)

See my response to question 27

Table 6 Radioactive Waste Management and Decommissioning for Fusion

See my response to Q 23 and Q24

Table 6 Export controls

See my response to Q 28

Page 76 International engagement

If the UK wants to positively influence the international community it should adopt a proportionate nuclear site licensing regime for FPPs. The current proposal for safety regulation is not likely to be consistent with the way other countries are going or have gone. FPPs are not radiation facilities or chemical plants.

I agree it is important for the UK to be able to influence and contribute to the development of internationally agreed safety standards for FPP.

It is misleading to say that in the UK's lower hazard radiological sites are regulated by HSE. There are low hazard nuclear sites that are effectively regulated under the site licensing regime by ONR.

In goal setting regimes design safety standards are developed by the industry not the regulators. The important factor is the extent to which regulator has the competence to assess the adequacy of the standards.

Page 78 Conclusions

It is not accurate to say that this is the first time for a government to set out its regulatory intentions for fusion energy regulation. The French regulatory system is clear, ITER is regulated as a nuclear installation as will subsequent FPPs. As shown in my comments on this consultation paper and my responses to the questions, I disagree with the road the Government has chosen to go down. I believe it is ill conceived and potentially dangerous to the deployment of FPPs in the UK. I hope the compelling arguments I have made will hasten a change of direction before it is too late.

This publication is available from:
www.gov.uk/government/consultations/towards-fusion-energy-proposals-for-a-regulatory-framework

If you need a version of this document in a more accessible format, please email enquiries@beis.gov.uk. Please tell us what format you need. It will help us if you say what assistive technology you use.