

Defence Operational Energy Strategy

Foreword by CDLS and DCDS MilCap

Throughout history, militaries have gained decisive operational advantages by exploiting new energy types or the technologies they enable. Gunpowder, the internal combustion engine, flight and nuclear fission are just a few such examples of battlewinning capabilities driven by the novel application of energy. A strategic competition exists between all nations to be the first to capture the military benefits of new energy types and technologies.

However, the pace of this competition is changing. A rapid global energy transition is taking place, driven by the undeniable impacts of human-caused climate change. Fossil fuels are being phased out to reduce carbon emissions and meet net zero targets, resulting in a seismic shift in the energy landscape. This shift brings an unprecedented period of technological innovation, with the MOD potentially facing its biggest step change in energy since the industrial revolution.

The MOD must act to respond to the energy transition. However, the transition remains highly uncertain – we do not know what new energy types might cost, what new operational effects they can deliver, or where the energy or raw materials will be supplied from. The pace of change requires a different operating model, a new approach to managing energy and a cultural shift in how the MOD makes its decisions.

This Strategy creates a compelling case for change – that the MOD must respond to the energy transition in such a way as to maintain or extend operational advantage over its adversaries; and it sets out the immediate actions the MOD can take to secure the opportunities the accelerating energy transition will create. Our allies and adversaries are positioning themselves for this competition. The UK must act now to ensure its Armed Forces are equipped and empowered to Protect the Nation and Help it Prosper.



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Glossary

Term	Definition
BNEF	Bloomberg New Energy Finance
CC&S	Climate Change & Sustainability
CDLS	Chief of Defence Logistics and Support
CO ₂	Carbon dioxide
CSA	Chief Scientific Adviser
DCDS MilCap	Deputy Chief of the Defence Staff Military Capability
DEES	Defence Estate Energy Strategy
DESNZ	Department for Energy Security and Net Zero
DLOD	Defence Line of Development
DOES	Defence Operational Energy Strategy
DOM	Defence Operating Model
EU	European Union
FLC	Front Line Command
GHG	Greenhouse gas
IEA	International Energy Agency
IMO	International Maritime Organisation
ЮрС	Integrated Operating Concept
IRE	Innovation, Research and Experimentation
MOD	Ministry of Defence
ΝΑΤΟ	North Atlantic Treaty Organisation
OEA	Operational Energy Authority
OODA	Observe, Orient, Decide, Act
RAF	Royal Air Force
R&D	Research and development
SAF	Sustainable aviation fuel
TWh	Terawatt hour

Executive summary

Energy is a critical resource and capability for the Armed Forces, enabling the Ministry of Defence (MOD) to deliver its priorities of protecting the UK, projecting the UK's global influence and promoting UK prosperity. The execution of these priorities relies on the MOD's ability to access energy globally, providing its forces with equipment that gives them an operational advantage over the UK's adversaries and brings its allies and industrial base along with them.

However, a complex global energy transition is under way in response to human-caused climate change. This transition is driving a technology revolution of unprecedented magnitude and has the potential to change fundamentally how militaries use energy and carry out operations.

The MOD must engage head-on with this revolution and in doing so maximise the potential opportunities it brings, while planning for some significant new risks. The disruption caused by the energy transition will affect the way that the MOD takes decisions on a critical component of military capability – operational energy. That is the energy required to train, deploy, operate and sustain UK forces across missions and operations.

The Defence Operational Energy Strategy (DOES) sets out how the MOD can approach its decisions related to operational energy. It does not provide guidance on energy choices related to fixed infrastructure, which will be set out in the Defence Estate Energy Strategy (DEES). Though the significant potential interactions between operational and estate energy are clear and will be factored in as the two strategies evolve.

The MOD will seek to maximise operational advantage through its energy choices

Over the coming years, the MOD, its allies and its adversaries will seek to harness new energy technologies in a way that enhances military capability. These include new forms of energy production that:

- reduce the need for, or extent of, operational logistics chains
- enhance equipment performance from platforms that are powered by alternative energy types
- increase resilience as greater energy efficiency reduces energy demand.

The MOD also has the opportunity to secure advantage by enhancing its energy interoperability with allies and energy integration with its industrial base. And by exploring opportunities to reduce the through-life cost of energy and cost of supplying energy to operations.

If the MOD does not develop a strategic response, it exposes itself to a series of potential risks. These include:

- reduced access to operational energy supplies by relying on energy types that become less available or more expensive
- creating dependencies on adversaries for energy or related technologies
- making energy choices that reduce the MOD's licence to operate

These opportunities and risks give the MOD a compelling case to assess strategically the value of adopting new energy sources and equipment against the benefits of fossil fuels. And to consider adopting related energy technologies that enhance energy efficiency.

The MOD also acknowledges that its freedom to respond to the energy transition is constrained. Factors to consider include:

- the need to maintain interoperability with allies and alignment with its trusted industrial base
- legacy equipment decisions that have set a reliance on fossil fuels for decades
- a complex MOD energy system that is reliant on fossil fuels
- processes that do not account for the strategic nature of energy choices in capability decisions
- a risk-aversion to increasing operational complexity

The MOD will develop a response that recognises its constraints, whilst responding effectively to opportunities and risks. This will enable the MOD to achieve advantage through three strategic outcomes:

- 1. Advantage through energy. The MOD will innovate and deploy energy sources and technologies that provide it with battle-winning advantages over its adversaries.
- 2. Advantage through coherence. The MOD will work with its allies and industrial base to enhance energy interoperability and interchangeability across domains and joint forces, and its integration with its trusted industrial base.
- 3. Advantage through organisational agility. The MOD will minimise the long-term, evolving risks of the energy transition and maximise the speed at which it harnesses new opportunities. It will do this by systematically identifying, assessing and adapting to evolving energy trends faster and more effectively than its adversaries.

In addition to these strategic outcomes, the MOD's response is also expected to deliver decarbonisation benefits, enhancing UK prosperity and enabling UK global leadership.

The MOD's response will be delivered through three phases

The uncertainties around the energy transition mean that the MOD does not yet have sufficient information to make fully informed operational energy choices into the future. This uncertainty relates to factors such as the global availability and cost of energy types, the energy types that will achieve wide-scale adoption in key sectors and the operational energy choices of key allies.

The DOES therefore does not provide firm direction on the energy types and technologies that should be adopted by the MOD. Instead, the DOES will embed an energy decision-making cycle within the MOD operating model to incrementally reduce and respond to these uncertainties. The MOD will continuously transition through an analytical cycle that requires it to gather evidence, assess the implications, take energy-informed decisions and review and learn from its choices.

The practical application of the energy decision cycle means the MOD must change the way that it operates and makes strategic decisions. Delivering these changes will be achieved through three 'response phases':

- Now-2025 Laying the foundations: The MOD will conduct analysis to develop energy insights and update relevant components of its operating model to ensure energy is considered in strategic decisions.
- **2025-2030 Making bold and informed decisions:** The MOD will fully embed energy options into decisions and make bold and informed energy choices in procurements.
- **2030 onwards Advantage:** The MOD will fully achieve the DOES vision, delivering consistent advantage through its energy choices and its continuing response to the energy transition.

The MOD's near-term focus is to deliver the first response through six priority actions

Six priority actions will be delivered by 2025. These will enable the MOD to deliver the outcomes required in the first response phase (laying the foundations) and enable energy-conscious decisions making to commence. These are:

- 1. Establish energy leadership and oversight within the MOD. The MOD will enable a coherent approach to operational energy by establishing a ministerial lead and a senior energy sponsor. They will be responsible for enabling coherence in MOD operational energy decisions and overseeing the performance of the operational energy system.
- 2. **Develop and distribute operational energy insights**. The MOD will develop an integrated and strategic understanding of operational energy opportunities and risks. This will be done by gathering insights from across MOD, industry, academia and allies.
- 3. **Embed energy considerations into equipment acquisition and management.** The MOD will embed operational energy considerations throughout the key decision-making processes related to equipment acquisition and management. This will include their pan-Defence Line of Development (DLOD) implications.
- 4. **Optimise energy management.** The MOD will manage its operational energy needs to drive efficient energy use, make strategic decisions about energy production, storage and transportation. And to ensure it has the infrastructure to meet future operational energy needs.
- 5. **Conduct innovation, research and experimentation to inform future energy choices.** The MOD will act now to progress its understanding of most promising energy choices, building on existing programmes.
- 6. **Manage the interdependency between operational and estate energy**. The MOD will understand the likely interdependencies and interfaces between operational energy and estate energy. It will set the direction for how these can be managed.

The DOES must be periodically updated to reflect the evolution of the energy transition

The complexity and uncertainty of the energy transition means that the action generated through the DOES is deliberately focused on near-term, systemic changes that enable informed energy choices. The MOD's continued success in navigating the opportunities and the risks associated with the global energy transition require a regular reassessment of the energy transition and how this might affect the MOD's response. As such, this initial iteration of the DOES must be periodically reviewed and updated to ensure that the MOD's response is optimised.

Overall, the DOES sets a clear vision for the future and a set of actions for delivering that vision. It will put the MOD on a strong footing to anticipate and engage with changes to the energy system, enabling the UK to work confidently with allies and harness the opportunities that the energy transition brings.

Figure 1: Overview of the DOES



Context

Future operating environment

The world is becoming more complex, **uncertain and volatile** due to multiple concurrent trends¹. These includes increasing geopolitical tensions, demographic changes, climate change and rapid technological development. These trends will change the future operating environment, meaning the MOD must adapt to assure the future delivery of Defence tasks and outputs.

The 2023 Integrated Review Refresh recognises the transition to clean energy and net zero as a key geostrategic issue, with energy security being a priority focus to address the UK's vulnerabilities.² These challenges are framed in the context of strategic competition and an evolving character of warfare, as set out in the Defence Strategy, the Defence Command Paper and the Integrated Operating Concept (IOpC).

Therefore, the MOD must clarify how it will respond to the global energy transition and mitigate potential risks to the delivery of operational outputs. The Defence Operational Energy Strategy (DOES) sets out its intended approach.

The uncertainty of the global energy transition

Human-caused climate change is creating negative impacts on nature and people, and this will intensify in the coming decades. In response, countries and organisations are setting and implementing net zero targets, initiating a global energy transition to adopt alternative forms of primary energy production, storage and use. In parallel there is increased scrutiny of material selection and the use of critical raw materials and resources due to the social and environmental impact their extraction and production can have.

The direction and pace of the energy transition is expected to vary geographically. It will be influenced by local industrial opportunities, trade and energy security strategies, and geopolitical developments. And the availability and affordability of natural resources, workforce capabilities and energy infrastructure.

The diversity of energy pathways means there is a **high degree of uncertainty about the future mix of energy sources that will replace fossil fuels.** And about the scale and pace of adoption in different regions globally.

Nevertheless, it is clear that **fossil fuels will play a continuing but decreasing role in the global energy mix**. Sectors such as aviation and shipping are more difficult to decarbonise due to the energy intensity required. They will continue to use fossil fuels to some extent for the foreseeable future.

As a result, the energy transition will create a **more complex and diverse energy system** globally, nationally and within economic sectors.

¹ MOD, 2018: <u>Global Strategic Trends</u> – a new version of this report is currently being developed

² HMG, 2023: Integrated Review Refresh 2023

The MOD's response

The energy transition will move the MOD from operating within a stable and uniform energy system to a future system of unprecedented complexity, diversity and uncertainty. While organisations of all sizes and characteristics will be affected, the complexity of the challenge is magnified for militaries. This is because their operational activities are dynamic, span multiple domains and are often conducted in extreme, high-risk environments.

The MOD must assess the opportunities and risks that the energy transition presents and develop a response. In doing so, the MOD has the imperative to continue to deliver on its core responsibilities, with a primary focus on maintaining or increasing the UK's operational advantage.

The DOES identifies the opportunities and risks created by the MOD's operational energy choices and sets out how the MOD will navigate the complexity of the energy transition to make informed and bold decisions in the future.

Scope

Operational energy

A definition for operational energy has been adapted from the current working definition used by the North Atlantic Treaty Organisation (NATO).³

'Operational energy' is the energy required to train, deploy, operate and sustain UK forces across missions and operations.

In practice, this definition means that operational energy comprises energy used to power all types of military equipment across all domains. This includes platforms, weapons, other systems such as communications equipment and deployed energy production for operational bases. Operational energy also includes the energy required to power fixed operational infrastructure.

Scope of the DOES

The scope of the DOES is narrower than the full definition of 'operational energy'. The DOES addresses how the MOD will consider its future operational energy choices for military equipment. As shown by Figure 2, the DOES also considers the implications for the full energy system required to support those operational energy choices. This includes the production, procurement, supply and management of operational energy.

The report does not consider energy choices and systems for nuclear weapons or powerplants for submarines. These are managed separately through the Defence Nuclear Enterprise.

The DOES also does not consider energy for fixed operational infrastructure. The MOD will consider its strategic response to the future of energy for fixed infrastructure ('estate energy') separately. This reflects the current broad distinction in the Defence Operating Model (DOM) between the management of energy systems for liquid fuels, typically employed by platforms and mobile equipment, and those for the supply of electricity and gas, as used by the estate. The DOES has been developed ahead of the estate strategy. This reflects that the energy choices we make start by considering the operational effect required and the energy needed to deliver it. It's only then that we can look at where that energy comes from. This includes sources such as the estate. The relationship between the DOES and the estate energy strategy will be closely managed.

Finally, the DOES provides recommendations for embedding energy considerations into strategic and operational decisions. In some cases this will drive further interactions between estates and operational energy. In the coming years, a single Defence Energy Strategy will be developed to provide overall energy coherence.

³ NATO, 2023: <u>Joint force development experimentation and wargaming – NATO operational energy concept</u>

Figure 2: Scope of operational energy and of the DOES



Diagnosis

Summary

Energy security and resilience are important factors in the era of persistent strategic competition. In which the UK, its allies and partners, and its adversaries are all exploring how they can most effectively harness energy as a strategic asset and enabler.

The MOD must respond to the energy transition in a way that maximises its operational advantage. It has opportunities to do so by harnessing sustainable energy technologies that deliver improvements to military effectiveness. This includes enhancing energy interoperability with allies and partners and drawing on innovation in the industrial base. There are also opportunities to improve energy efficiency to provide greater sustainment of deployed forces and reduce the through-life cost of energy and the cost of supplying energy to operations, especially those in contested environments.

The MOD also cannot ignore the risks that might be created by the energy transition. **If the MOD does not develop a strategic response, it exposes itself to a series of potential risks.** These include reducing the security and cost of supply of its operational energy, creating dependencies on adversaries for energy or related technologies and reducing its licence to operate.

These opportunities and risks give the MOD a compelling case to assess strategically the potential benefits of adopting new energy types, beyond fossil fuels.

In addition to the significant uncertainty around the future pathways of the energy transition, the MOD will face **inherent constraints** when selecting and adopting the appropriate course of action. For example, the MOD will need to make energy choices which maintain interoperability with key allies. It will be reliant on the capabilities of its industrial base, and it will have to manage the energy provision for legacy equipment that is likely to rely on hydrocarbons for decades.

The MOD's current energy system is optimised for fossil fuels and is underpinned by processes that do not account for the strategic nature of energy in capability decisions. There is also an aversion to increasing operational complexity which is perceived as a risk inherent in any move away from fossil fuels.

In summary, the MOD must maximise its operational advantage by carefully assessing the value of alternative energy technologies compared with fossil fuels, whilst mitigating key risks from the energy transition that could compromise its ability to deliver operational outputs.

This section provides further context and detail for this diagnosis.

The UK is engaged in a global strategic competition for advantage

All nations and militaries are engaged in a strategic competition for operational advantage over their adversaries, and to maximise their influence within any alliances. Energy can contribute to advantage in several ways – for example, a more secure energy supply enables a military to carry out unconstrained operations and faster exploitation of new energy technologies enables deployment of more advanced but energy-intensive platforms or weapons that offer battle-winning capabilities.

The energy transition is driving rapid change in the global energy system, creating opportunities for operational advantage and risks if adversaries secure these opportunities first. While specific advantages are time-bound and will diminish as other militaries catch up and level the playing field, the constantly evolving nature of the energy transition means that new opportunities will emerge. This offers the chance for regular innovation to maintain advantage.

Operational energy strategies are being developed and implemented by prominent militaries and institutions, including NATO and the US, Australian and French defence establishments. Russia and China have also both sought to gain geopolitical advantages through their national responses to the energy transition.

The MOD cannot afford to adopt a reactive stance. It needs a proactive strategy to ensure it can respond better than its adversaries to the energy transition. This will also allow the MOD to maximise the strategic and operational advantage from this period of rapid change and innovation.

The MOD must prioritise advantage through its energy choices

The MOD's priorities are to protect the UK, enhance its prosperity and project its influence.⁴ This is reflected in the MOD's Climate Change & Sustainability (CC&S) Strategic Approach. This states that the MOD must preserve capabilities despite the implications of climate change. It must take opportunities to enhance capabilities and resilience with new options while never compromising capability solely for a sustainable solution.⁵

Reflecting this strategic ambition, the primary focus of the MOD's response to the energy transition is to preserve and, where possible, enhance its operational advantage. It will do this through better energy choices and innovative use of new technologies or approaches. This objective has primacy over all other ambitions and comprises the key focus of the DOES.

Opportunities

Step changes in operational effectiveness

Alternative energy options potentially offer a range of military benefits that can enable the future force envisaged by the IOpC. A force which will require greater autonomy from its strategic base to generate greater agility, responsiveness, precision and resilience in a persistently engaged posture defined by constant competition.⁶

The potential benefits derive from energy technologies that might

- increase battle-winning capabilities
- increase the power available on deployment through local energy production
- increase stealth, enhance operational agility
- reduce the logistical, force protection, or engineering support burden

Some examples are set out below and summarised in Figure 3.

⁴ MOD: <u>MOD priorities</u> as set out on the <u>organisation profile</u>

⁵ MOD, 2021: <u>CC&S Strategic Approach</u>

⁶ MOD, 2020: <u>Integrated Operating Concept</u>

• Freedom of manoeuvre, self-sufficiency and reduced logistics requirements in contested environments

Emerging energy production, storage and transmission technologies have the potential to change the way that energy is supplied to operations and if fully harnessed could radically improve supply chain advantage and reduce risk.

For example, it is possible that electricity could be generated on deployment by using micro nuclear reactors or renewable energy technologies. This electricity can be used to power platforms and equipment or converted into other forms of operational energy, for example by producing hydrogen through water electrolysis. Hydrogen can be used as a fuel or combined with carbon dioxide captured from the atmosphere to produce e-fuel which is generally compatible with ships, aircraft and vehicles in service today.

Unlocking this opportunity will require significant amounts of carbon dioxide and hydrogen to generate e-fuel in the quantities needed for operational activity. It will also depend on the proven feasibility of employing micro nuclear technology in a combat setting. However, if deployed production of electricity, e-fuel or hydrogen fuel can be achieved, it could eliminate the logistical and force protection burden. A burden which is currently associated with supplying fossil fuels into theatre for use in platforms and generators. This has the potential to enhance the freedom of manoeuvre available to operational commanders, increase operational endurance and reduce resource-intensive and high-risk logistics tasks. This is especially important for forces operating in contested environments, characterised by proliferating kinetic and non-kinetic threats.

Increased battlefield power

The introduction of more sophisticated and powerful systems into military equipment is expected to increase future operational energy requirements. This trend is likely to be accelerated further by the advent of next-generation intelligence, surveillance, reconnaissance and strike capabilities. This includes directed energy weapons or large numbers and variations of robotic and autonomous systems. New energy technologies that can deliver greater energy in the deployed space, such as micro-nuclear energy production, could enable these advanced platforms and weapons and in some contexts provide a battle-winning advantage.

Increased stealth

The electrification of military capabilities enables silent running and improves silent watch capability. For vehicles, forward operating bases and deployed headquarters this will reduce noise and thermal signature and increase tactical survivability.⁷ At the operational level, improved in-theatre energy production and storage should lead to a reduction in logistics support requirements. These present new opportunities for UK forces to operate in a more dispersed and covert manner, further helping with deception, camouflage and survivability.

Increased resilience

Diversification of the energy sources used across military capability would provide the MOD with the choice to field forces that can operate more effectively in the context of diverse regional energy systems. Also, the use of more efficient powertrains, equipment

⁷ MOD, 2021: British Army Approach to Battlefield Electrification

designs and new approaches to conducting operations (such as more efficient routing) can enhance resilience by reducing the amount of fuel required on operations.

• Enhanced equipment performance

New energy types and technologies may deliver improved performance of platforms and weapons. For example, electric vehicle powertrains are recognised as being easier to drive, delivering faster acceleration and requiring fewer moving parts.^{8,9} This could enhance performance and reduce maintenance needs with fewer replacement parts. More fuel-efficient engines could also enable a greater range of operations.



Figure 3: Potential military benefits from energy technologies

Coherence with allies, within the MOD and with industry

The energy transition will disrupt established relationships for all militaries, potentially affecting interoperability, internal coherence between domains and the ability to rely on an industrial base to deliver energy and capabilities. If the MOD can navigate this disruption more effectively than its adversaries, it can enhance its relative operational effectiveness during the energy transition.

• Interoperability

Energy forms a key component of interoperability, as demonstrated by the intent of the NATO Single Fuel Concept. But its delivery has not always maximised the potential benefits. For example, the current NATO single fuel recommendation has resulted in reduced efficiency of some platforms not designed for its use, lower performance in certain

⁸ Energy Saving Trust, 2023: <u>What you need to know about electric vehicles</u>

⁹ Peugeot: <u>The advantages of electric cars</u>

conditions and a mixed application of relevant environmental standards for fuels.¹⁰ The MOD has an opportunity to enhance interoperability by shaping emerging allied joint concepts and doctrine. It can also contribute to the development of new energy standards and platforms to guide a more coherent approach to the energy transition among key allies, especially within NATO.

• Intra-operability

The energy choices made by different parts of the MOD must be coherent to maximise the capabilities of the combined force and for the MOD operational energy system to effectively supply operational energy needs. All militaries will experience some disruption to their energy supply chains from increased complexity as they adopt new energy technologies, providing the MOD with potential advantage if it can manage this disruption effectively.

• Coherence with industry and civil sectors

Civil industries that the MOD rely upon – such as the aviation, shipping and automotive sectors – are increasingly subject to legislative, shareholder and customer pressure to decarbonise. Many MOD suppliers operate across both civil and defence markets and are not immune to these requirements. The MOD has limited commercial influence to direct the choices that these suppliers and industries make in relation to energy given the size of its budget, but these choices may have a significant impact on its capability.

For example, the International Maritime Organisation (IMO) has set targets to decarbonise the shipping sector.¹¹ The energy types that are adopted will have widespread implications for global maritime energy availability and cost, whilst also influencing future ship design.

If the MOD can better understand and align with the energy choices made by this and other key sectors, it will access benefits in terms of the cost and supportability of its equipment and security of its energy supplies, including greater supply chain control.

There is also an opportunity for the UK to take a leading role within NATO and other frameworks to promote energy interoperability and coherence across defence, industry and civil sectors. The MOD can play a major role in shaping the standards, investment priorities and joint policies or concepts. This will also create export opportunities for UK industry and indirect operational benefits by increasing the size, competitiveness, and resilience of the UK supply chain.

Potential reduction in operational energy costs

The cost of energy is likely to increase over the coming decades, as new energy types are expected to cost more than cheap primary energy sources today (such as coal and gas) and as governments implement carbon pricing mechanisms on fossil fuels. For example, the MOD would be exposed to an additional cost of £2bn from carbon pricing in the 2030s to operate its current equipment, nearly a 60% increase in fuel cost when comparing the price of fuel today to 2030.¹²

¹⁰ Further details on the current state of interoperability and NATO's current Single Fuel Concept can be found in the accompanying RAND report, *International comparison of approaches to defence operational energy.* ¹¹ IMO, 2018 IMO STRATEGY ON REDUCTION OF GHG EMISSIONS FROM SHIPS

¹² Based on 2021-2022 fuel consumption from Aviation, Ground and Maritime equipment reported in the Ministry of Defence Annual Report and Accounts 2021 to 2022. Conversion factors from litres of fuel to kg Carbon dioxide (CO₂)were taken from CBS - Statistics Netherlands, IATA, Michelin and ICCT. These were multiplied by Bloomberg

This increase would be in addition to any increase in fuel costs due to decreasing availability of fossil fuels or other factors.

Alternative energy technologies and increasingly efficient energy systems will require upfront investment to deploy, but once in use have the potential to **reduce the through-life cost and logistical supply costs** of operational energy. Further analysis is required to assess and confirm these opportunities.

• Energy efficiency

The use of more efficient powertrains, more efficient equipment designs and new approaches to delivering operations can reduce the amount of fuel needed by a capability and therefore reduce through-life costs. Introduction of such technology and designs should be considered for new procurements and mid-life upgrades. For instance, the UltraFan engine that Rolls-Royce is currently developing is expected to reduce fuel burn by up to 25% compared to the first generation of Trent engines utilised by the Royal Air Force (RAF) Voyager fleet.¹³ Battery electric platforms use energy much more efficiently than internal combustion engines and also allow for smart grid applications at deployed bases.

According to the results of the Department for Energy Security and Net Zero (DESNZ) Industrial Energy Efficiency Accelerator programme, adopting the demonstrated technologies could lead to savings of up to 40.5 Terawatt hour (TWh) of energy by 2031. This translates into a cumulative reduction of 10 MtCO₂e in carbon emissions over the next decade. This is equivalent to powering 12% of the UK's electricity consumption in 2019, highlighting the importance of energy efficiency.¹⁴

Better energy management and equipment efficiency can also deliver operational energy cost savings. For example, prioritising fuel saving when planning operational routes could deliver immediate cost reductions. The provision of energy to forward locations is also a significant challenge for the MOD. Reducing the total amount of energy needed could reduce the burden of resource-intensive supply chains.

• Through-life operational energy costs

The future cost of fossil fuels is expected to increase over time as commercial availability of fossil fuels reduces¹⁵ and the price of carbon increases.¹⁶ Investment into new equipment and energy types, especially electrification, could deliver long-term savings despite higher upfront costs. This could be accelerated through the adoption of smart material choice and implementing circularity by design.

New Energy Finance's (BNEF) 2022 carbon price forecasts. Assumes carbon pricing is applied to all fuel types by 2030. The percentage increase was calculated by comparing IATAs jet fuel price 5 May 2023 with the additional cost of a carbon price in 2030.

¹³ Rolls-Royce, 2022: <u>Rolls-Royce Trent 700 engine helps power RAF military transporter flight</u>

¹⁴ Carbon Trust, 2021: <u>New wave of cutting-edge technologies supported by UK Government show potential to</u> significantly cut carbon and costs for industry | The Carbon Trust

¹⁵ Some analysts (including International Energy Agency (IEA)), 2022: <u>World Energy Outlook 2022</u> believe fossil fuel use has already either plateaued or peaked

¹⁶ Carbon pricing will increasingly impact the cost of fossil fuels as countries implement policy to drive decarbonisation. Carbon prices can be implemented in a number of ways and are expected to increase the cost of fossil fuels to reflect the impact of the carbon emissions they produce.

The MOD has a potential opportunity to minimise the through-life cost of operational energy by assessing the relative cost implications of different energy options in equipment procurement. Budgeting and procurement processes support this approach to equipment choices.

• Logistical costs of supplying energy

The full logistical cost of supplying operational energy to its point of use incorporates multiple components of cost such as storage, transport and protection. This makes the full 'cost to serve' higher than the actual cost per unit of energy purchased. If the MOD can produce electricity and fuels in deployed locations, using renewable energy or micro nuclear reactors, the logistical costs and cost to life from protecting supply chains associated with the supply of energy may decrease.

Risks

The energy transition presents potential risks to the delivery of the MOD's outputs.

Reduced security of supply

As the world moves to a more diverse energy system, the global availability and cost of operational energy may not be assured. This can reduce the MOD's certainty of accessing the energy types it requires, when it needs to and in the required quantity, sufficiently close to the location of use and at a price that is affordable. These considerations relate to both the continued use of fossil fuels and alternative energy types.

• Availability

The availability of operational energy is critical to delivering operational effect; but this may be compromised as the energy transition unfolds. For example, the electrification of road transport and switching to alternative aviation and shipping fuels is predicted to reduce global demand for conventional liquid transport fuels (and therefore widespread availability).

Regionally, the energy transition pathway is likely to be diverse depending on the local resources and geography. The MOD will face risks associated with energy availability to secure supplies of fossil fuel or alternative energy types, depending on which region UK forces are operating in. An adaptive and informed approach to energy availability is needed to ensure the MOD can maintain its ability to operate globally without encountering significant limitations.

• Cost

Carbon pricing is expected to be applied to fossil fuels and may increase to nearly £150/t CO₂e by 2050.¹⁷ This could make fossil fuels materially more expensive. In parallel, taxes, levies and policies are being introduced to make sustainable technologies more financially attractive or mandatory, such as the jet fuel kerosene tax under discussion in the European Union (EU)¹⁸ and the UK sustainable aviation fuel (SAF) mandate.¹⁹

Dependence on adversaries

¹⁷ BNEF, 2023: New Energy Outlook 2022, Net Zero Scenario

¹⁸ European Commission, 2021: <u>Revision of the Energy Taxation Directive</u>

¹⁹ <u>Mandating the use of sustainable aviation fuels in the UK - GOV.UK (www.gov.uk)</u>

Should the MOD adopt certain sustainable energy technologies, it could generate a dependence on key technologies or underlying components and raw materials produced by its adversaries. Even in the case of dependence on neutral parties, global supply chains may involve reliance on nations with fragile political and security situations or extensive corruption and human rights issues. In the same way hindering the UK's efforts to ensure reliable access. This could compromise the MOD's ability to secure the resources it needs to deliver operational outputs.

For example, electrolysers and batteries are in increasing demand by both the military and commercial sector. The manufacturing and mining of some of these components and key raw materials within them is currently highly dependent on Asia (three in four lithium-ion batteries are currently produced in China).²⁰ An understanding of these complex dependency risks must inform operational energy decisions, requiring a deep understanding of multiple layers of the current and proposed MOD supply chain.

Licence to operate

As emphasised by the IOpC, gaining information advantage and control of the narrative is an essential component of operational success, whether competing below the threshold of open conflict or in a warfighting scenario. The UK's adversaries have proven themselves willing and able to use a wide range of levers and tactics to promote misinformation and hostile narratives targeting UK forces and operations.

If the MOD is perceived to deliver an insufficient or inappropriate response to the energy transition, it may suffer a reduced licence to operate, negatively affecting its freedom and capability. For example:

• International access

In the same way that foreign nuclear-powered ships aiming to visit a UK port need to provide the port with a safety assessment a year in advance, there is potential for similar restrictions to be in place in relation to the operational energy the MOD uses. For example, there could be restrictions on the use of nuclear energy or burning fossil fuels in some jurisdictions, reducing the MOD's ability to transit, operate or train in those locations.

• Social and political

There is increasing public concern, both in the UK and overseas, about the effects of climate change and environmental degradation. There is a risk that any perceived failure to adapt to new green technologies and the energy transition could be weaponised against the MOD. And undermines support for UK operations among key audiences. This could reduce the MOD's social licence to operate, and its ability to retain and attract talent as both current and future generations seek to work for an employer that takes greater climate action.

Freedom of the MOD to respond to the energy transition

²⁰ "98% of rare earths that are supplied to Europe come from China, we should not replace one dependency with another" (Mircea Geonana, NATO Secretary General)

Several factors could constrain or slow down the MOD's response to the energy transition. The factors set out below and in Figure 4 will need to be considered carefully so the MOD can make optimal energy choices across its current and future equipment.





• Interoperability

The MOD's operational energy decisions are influenced by the need for coherence with allies. The scale of operations carried out by some key allies may require the MOD to follow their operational energy choices, even if not optimal for the UK.

• Supplier alignment

As with interoperability, the MOD may be constrained in its choices by the activities of its industrial partners and suppliers. The defence industry often forms only a part of a supplier's business activities. It may be influenced by external factors such as investor appetite to maintain production or supply of equipment that is no longer aligned with the civilian sector. This could be driven, for example, by environmental, social and governance commitments or the commercial viability of producing entirely different products for the defence and civil sectors.

• Equipment lifespans

Analysis of Front Line Command (FLC) equipment plans shows that some equipment types will be in-service for decades. For example, the F35 combat aircraft and *Queen Elizabeth*-class aircraft carriers are expected to be in-service until the 2070s. Most current equipment is configured for liquid hydrocarbons. This creates a requirement for the MOD to continue using either fossil fuels or a drop-in low carbon alternative for a significant period, regardless of risks related to the global availability or cost of those fuels.

The long in-service lifespan of platforms creates a risk for the MOD due to potential obsolescence as global energy supply transitions to other energy types. This could create stranded assets or create additional costs to retrofit or retire these platforms early.

Operational energy infrastructure and skills

The MOD's energy infrastructure comprises its supply chain, fuel storage and delivery systems and skilled workforce. This system is currently optimised for fossil fuels. Changing this system to support the requirements of alternative energy types is likely to be costly, lengthy and challenging. The MOD will need time to secure funding, physically replace infrastructure and retrain its workforce (or compete with the civil sector to bring onboard trained workforce).

Furthermore, making the case for updating the MOD's energy infrastructure to support new energy sources may require a critical mass of capabilities to commit to adopting that new energy type. Critical mass will help achieve economies of scale and increased buying power when deploying new infrastructure and help justify the costs involved. This may constrain MOD's operational energy decisions in the short-to-medium term.

Consideration of energy in procurement

MOD procurement has historically not considered operational energy choices as a critical component of capability decisions. Operational energy has been seen as a procurement and logistics matter given the predominance of liquid fossil fuels. As operational energy opportunities and risks have greater impact on capability effectiveness, the current capability development and acquisition processes will need to evolve to ensure operational energy considerations are considered and costed in strategic decisions. This will also need to pull through to drive clear supplier incentivisation.

• Culture

The MOD has a cultural aversion towards increasing the complexity of operational activity and supply chains. This is due to the potential of additional equipment, skillsets and cost that this normally drives, or a concern about any actions with perceived potential to reduce operational effectiveness. Stakeholder interviews have identified that the potential transition from fossil fuels to multiple operational energy types is perceived as adding complexity to MOD operations. This presents a cultural blocker to adopting alternative operational energy types.

Vision and strategic outcomes

If the DOES is implemented successfully, the MOD's response to the energy transition will deliver the DOES vision and strategic outcomes, supporting and delivering operational advantage throughout the energy transition.

Vision for the DOES

In responding successfully to the energy transition, the MOD will maximise the operational advantage gained through its energy choices

The MOD will seek to deliver this vision through the achievement of three strategic outcomes:

- 1. Advantage through **energy**
- 2. Advantage through **coherence**
- 3. Advantage through organisational agility

Strategic outcome 1: Advantage through energy

The MOD will deploy energy types and technologies that provide it with battle-winning advantages over its adversaries. This will be characterised by the MOD overmatching its adversaries in terms of its energy resilience and, where feasible, securing advantages from new energy technologies. Examples of operational advantage are provided in Figure 5.

Figure 5: Operational advantages delivered through energy

Energy resilience The MOD has secure access to the amount of energy it needs, where it is needed Freedom of manoeuvre The MOD can operate globally, untethered to specific energy providers and unburdened by logistics chain constraints Self-sufficiency The MOD operations are more self-sufficient due to localised energy production Reduced exposure to contested logistics The MOD operations are less exposed to threats across the Defence supply chain as energy is produced near to the point of use **Battlefield power** The MOD can access increased battlefield power to enable battle-winning capabilities such as directed energy weapons and more sophisticated military systems Stealth and equipment performance

The MOD platforms are less detectable during operational manoeuvres as a result of effective operational energy choices

Strategic outcome 2: Advantage through coherence

Interoperability is already an important factor for the MOD and its allies. New energy concepts, doctrine, standards and joint capability programmes will enable the MOD and its allies to further enhance interoperability and interchangeability. Thereby maximising the deployment of a broad range of capabilities across a range of environments.

The UK and its allies maximise energy security through aligning their energy requirements with the collective energy resources and technological and industrial capabilities held by allies. This unlocks the secure and resilient energy supply needed to deliver operational outputs.

The MOD will be **deeply integrated with its industrial base**. It will work collaboratively with trusted suppliers to harness innovation from the energy transition. It will align capability development with the production capabilities of its trusted industrial base and mitigate risks of any dependencies on adversaries. For example, the supply of energy, raw materials and components.

The MOD will make energy choices that enable a high degree of multi-domain integration, complementing the operational effect delivered by each domain. This will maximise the capabilities of combined forces while allowing the delivery of a range of operational energy options. Options that promote agility and resilience when operating across global regions that have a mixed adoption of energy types.

Strategic outcome 3: Advantage through organisational agility

The MOD will minimise the long-term, evolving risks of the energy transition by maximising its organisational agility. Agility in this context means that the MOD as an organisation is capable of rapid change to adapt to the energy transition and harness and exploit new energy opportunities. This can be achieved by systematically identifying, assessing and responding to evolving energy trends faster and more effectively than adversaries.

The need to understand and respond to operational energy opportunities and risks will be deeply embedded in how the MOD operates. This includes within strategy, policy, capability development, acquisition, skills, organisational structure and culture. New, high-quality energy insights and tools (for example, better energy demand management, intelligent procurement, circular economy and optimised energy use), will enable the MOD to better use its resources and take advantage of further opportunities from the energy transition.

The MOD will also act quickly on its energy insights through accelerated decision-making processes. New energy types and technologies and the infrastructure required to supply them, move from Innovation, Research and Experimentation (IRE) through to testing and training, and procurement at pace. This enables the MOD to deploy operationally advantageous energy choices faster than its adversaries.

Second-order benefits: decarbonisation, UK prosperity and global leadership

The DOES vision has a primary objective of enabling the MOD to enhance its operational advantage through its response to the energy transition. Whilst not being a primary driver for the DOES, the DOES vision and strategic outcomes will likely have a second-order effect of decarbonisation, enhancing UK prosperity and UK global leadership.

• Decarbonisation

Militaries comprise some of the largest emitters of carbon emissions. The MOD has a carbon emissions footprint of 3,341,000 tCO₂e. Direct emissions from fuel combustion for capability energy represent approximately 58% of this total for FY21/22.²¹ If the MOD adopts sustainable energy technologies to deliver enhanced operational effectiveness, this should also deliver a reduction in the carbon intensity of its operational activity and support the MOD's commitment to contribute to achieving the UK legal commitment to net zero emissions by 2050.²²

• UK prosperity.

If the MOD chooses to adopt sustainable energy technologies with the help of UK industry, it can support a thriving entrepreneurial ecosystem that is emerging. This ecosystem is supporting the delivery of the UK government's net zero target, fostering green growth and economic opportunities. MOD spending already secures over 200,000 direct and indirect jobs across the UK and the UK is the world's second largest exporter of defence products.²³ New energy technologies and supply chains can boost this further.

²¹ GOV.UK, 2022: Ministry of Defence Annual Report and Accounts 2021 to 2022

 ²² GOV.UK, 2021: <u>Ministry of Defence Climate Change and Sustainability Strategic Approach</u> (<u>publishing.service.gov.uk</u>)
²³ MOD, 2021: Defence and Security Industrial Strategy

• Global leadership

If the MOD can secure operational, environmental and economic benefits from its response to the energy transition, it will position the UK as a global leader. This has the potential to influence the strategies of other militaries and defence industry and send a clear signal regarding the capacity of the UK to drive innovation.

The DOES approach

The MOD must respond to the energy transition through a coordinated approach. This needs to account for both military and civil responses to the energy transition and enable the MOD to adapt as the technological and commercial maturity of energy types and technologies change.

The energy decision-making cycle

Emerging energy technologies already have the potential to deliver operational advantage for the MOD. Some of these, such as batteries or biofuels, are already being used in a wide range of civil applications. Other solutions are less commercially or technologically developed, such as hydrogen or micro nuclear reactors. The MOD is investigating these technologies through IRE to understand whether they could deliver operational advantage and how they could be operationalised

But, there is significant uncertainty regarding key factors that influence when these new technologies could and should be deployed. These factors provide high level categories to guide decision-making. And include the operational advantage delivered by new energy and technology, the costs of deploying equipment and its through-life costs including energy. As well as the supporting energy infrastructure and skills required, the future global availability of the energy needed to operate equipment and the resources to build and maintain it. And interoperability with allies.

These uncertainties mean it is not yet possible for the MOD to make a reasoned assessment of the optimal operational energy sources on which it should rely over the medium-to-long term. An energy decision-making cycle of analysis should be embedded to address this uncertainty.

Once a reasoned assessment is possible, the MOD should rapidly move forward with its energy choices where there is clear operational advantage and no negative impact on interoperability.

The process set out below has been developed through collective engagement across defence stakeholders and industry to illustrate how the MOD can continuously understand the energy transition and take decisions. The process forms a loop²⁴, allowing constant review and learning to adapt to an uncertain and evolving world.

As set out in Figure 6, the energy decision-making process provides an approach through which the MOD can iteratively understand and adapt to the uncertainty created by the energy transition.

²⁴ Decision making loops of this nature have been used in other defence contexts and considered in the development of this process. For example, the Observe, Orient, Decide, Act (OODA) loop concept.

Figure 6: The energy decision-making process



As the MOD's environment changes, by continuously iterating the energy decision-making cycle, the MOD will:

- 1. remain alert to emerging energy technologies, challenges and opportunities,
- 2. disseminate insights internally, within government and with allies to adequately inform and influence decision making,
- 3. test and make certain energy choices, including least regret options, drawing on the best available evidence. And, where data is particularly uncertain, guided by appropriate risk appetite, and
- 4. continue to monitor the effectiveness of its energy-related choices to constantly adapt its approach.

The quicker the MOD goes through this cycle, the quicker the organisation can adapt and respond to the energy transition effectively. Iterating this cycle over time will allow the MOD to develop an agile and adaptive response that can facilitate informed energy decision making in any future operational energy procurements. This can enable the MOD's ability to gain and retain competitive advantage when responding to the energy transition and ultimately deliver the DOES Vision.

Embedding the energy-decision making cycle into the MOD

The practical application of the energy decision cycle in the MOD requires parts of the Defence Operating Model (DOM) to be updated to embed the intent of the cycle in the way that the MOD develops insight and makes decisions. As set out in the Diagnosis, the DOM currently does not enable strategic decisions to account for operational energy considerations, with energy being viewed as primarily a procurement and logistics challenge. Embedding this energy decisionmaking cycle into the MOD will take time. As a result, the MOD's response to the energy transition is expected to develop in three progressive 'response phases', as set out below and in Figure 7:

• Now to 2025 – Laying the foundations: The MOD becomes energy conscious by laying the foundations for informed operational energy choices. This is achieved by updating relevant

components of its operating model to ensure energy is considered in strategic decisions and conducting analysis to develop energy insights. Within this response phase, the MOD will:

- Establish energy leadership and oversight within MOD through a senior energy sponsor and Ministerial lead. The sponsor will coordinate energy understanding, deliver change, and review progress
- Articulate the importance of responding to the energy transition at the most senior levels, emphasising energy in the MOD's strategies, plans and policy
- Gather evidence from across the MOD, industry and allies on operational energy and develop and distribute energy insights to inform decision-making
- Embed energy options in decision-making processes to routinely consider energy options in all procurements
- Continue focused IRE to test key energy opportunities and accelerate opportunities through testing and deployment where operational advantages are identified
- Set out how the FLCs will embed the direction set by the DOES and plan for their future energy needs
- 2025 to 2030 Making bold and informed energy choices: The MOD has embedded energy options into its decisions and makes bold and informed energy choices in its organisational approach to energy, procurement decisions and IRE. Within this response phase, the MOD will:
 - Secure first mover operational advantage from bold energy choices, identified and informed through evidence-based insights
 - Continue to adapt its decision-making processes to respond to lessons from decisions it has made, enhancing the quality of the decisions
 - Develop a strategy to effectively manage a future where the MOD is concurrently using and supporting multiple energy types across its capability portfolio
 - Bring the operational energy and estate energy strategies together to create a single and coherent energy strategy across the MOD
- **2030 onwards Advantage:** The MOD achieves the DOES vision, with its choices and continuing response to the energy transition delivering consistent advantage. Within this response phase the MOD will:
 - Optimise and integrate its energy choices to deliver operational advantage
 - Effectively manage an evolving energy mix across its capability portfolio
 - Deliver strong coherence with allies and industry, magnifying the effect of its energy choices

Each response phase builds on the previous phase and will be continuously reviewed and iterated to adapt as the wider environment evolves and in response to lessons identified from action.

Figure 7: The phases of MOD's response to the energy transition



Laying the foundations: priority actions

Six priority actions have been identified to initiate the approach set out in the previous section. These will support the MOD in achieving the DOES vision of maximising the operational advantage gained from energy opportunities. These actions should be implemented by 2025 as part of the first response phase, laying the foundations for subsequent energy decision-making.

The actions will deliver the first response phase of the DOES approach, establishing the foundations needed to embed energy decision-making into the MOD. The transition to the second response phase will utilise the energy decision-making cycle to make bold and informed energy choices, and assess whether the actions taken in the first phase have worked or further intervention is needed.

The successful implementation of these actions will require the MOD to consider the people, resources and skills needed to both deliver the organisational activities (such as energy management and renewable energy production specialists) and the new energy types and technologies that may emerge.

The resulting integrated governance system that will result from the changes is summarised in Figure 8.

Figure 8: Impact of priority actions



Priority actions

Action 1

Establish energy leadership and oversight within the MOD

The MOD enables a coherent approach to operational energy by establishing a ministerial lead and a senior energy sponsor who have responsibility for enabling coherence in MOD operational energy decisions and overseeing the performance of the operational energy system

It is essential that the MOD's operational energy choices are coherent. Coherence in this context means that operational energy sources or equipment used by the MOD enable continued or enhanced operational effectiveness without disruption to operational outputs. This comprises coherence of:

- The deployment of different energy types and technologies to deliver operational effect
- The timing of MOD operational energy decisions
- Operational energy demands, costs and the ability of the MOD to supply the required types and quantities of new or diversified operational energy types and technologies
- MOD operational decisions and insights regarding government energy policy, allies' operational energy choices and the energy direction adopted by the MOD's industrial base and
- Decisions related to operational energy and estates energy

To achieve this coherence, the MOD requires operational energy activity to be understood, overseen and guided. The MOD will:

- 1.1. Identify a **MOD Ministerial lead for energy** to ensure there is senior buy-in for the need to consider energy at a strategic level. The Ministerial lead will set an ambition for delivering enhanced operational effectiveness through a coherent response to the energy transition. They will also drive political engagement across Whitehall, support funding discussions with HM Treasury, and enable collaboration with other government departments (for example, DfT on sustainable aviation fuels or DESNZ on hydrogen).
- 1.2. Establish a **senior MOD energy sponsor** who can ensure energy is prioritised at the highest levels across the MOD. They will be accountable for:
 - Providing MOD energy guidance and, where appropriate, direction through the Defence Plan and energy policy
 - Leading ongoing reviews of operational energy decisions and decision-making processes. They will identify lessons learned to inform further changes needed to the short, medium and long-term plans

- Supporting the MOD to identify, understand and prioritise the energy opportunities and risks. Through sight of the bigger picture across the Enterprise, or where issues should be escalated for resolution
- Providing guidance to inform operational decisions and activity in the MOD, including in relation to IRE activity. This will be based on knowledge of the nature of industry, allies and pan-Government approaches to energy. And an understanding of the implications of these on MOD operational energy activity
- Directing issues to be resolved by identifying the appropriate party in the MOD and jointly agreeing mitigating actions
- Guiding the nature and pace of change in response to the MOD's energy choices. Through developing and overseeing a transition approach that enables coherent change in relation to equipment types
- Guiding the nature and pace of transition of the MOD's operational energy supply system (energy provision, production, procurement and management). Through developing and overseeing a transition approach that enables future operational energy demands to be supportable
- Enabling the development of key energy-related skills by working with key stakeholders across the MOD to develop and update a Training Needs Analysis related to energy skills. Reflecting the future energy types that the MOD uses and supports
- Championing the need for investment in operational energy IRE, procurement and energy supply chain, movement and storage capability. Through attendance at key governance forums and by providing recommendations to Chief Scientific Adviser (CSA) and FLCs
- Enabling coherence between operational energy and estate energy decisions by identifying dependency risks and working with relevant parties to agree a mitigation plan
- Owning and updating the DOES, and overseeing implementation of DOES actions by leading or supporting (as appropriate) implementation activity
- 1.3. Ensure the senior energy sponsor has an appropriate level of authority and influence in key decision-making forums. Through direct attendance or representation (expected to include but not limited to Joint Requirements Oversight Committee, Military Capability Board, Integrated Concepts Board and the Investment Approvals Committee), strong interfaces with relevant parties within the MOD and externally. And the right level of resources to deliver their role.
- 1.4. Set out in Defence direction (including Defence Strategy and the Defence Plan) a requirement for FLCs, Enabling Organisations (EO) and Functions to identify and address opportunities and risks related to operational energy coherence. This includes an initial requirement to set out how they intend to respond to the proposals and actions included in the DOES.
- 33 Defence Operational Energy Strategy

Action 2

Develop and distribute operational energy insights

The MOD develops an integrated and strategic understanding of operational energy opportunities and risks through insight gathered from across MOD, industry, academia and allies

Effective operational energy decisions will rely on insights synthesised from multiple sources. This includes developments within relevant industry sectors, operational energy decisions made by allies and adversaries, innovation by academia and industry, evolution in domestic and foreign energy policy, and lessons from MOD decisions and IRE activity.

This is a complex challenge due to the need to gather, understand and interpret a broad and evolving set of data sources. To deliver this action, the MOD will:

- 2.1. Create a pan-Defence Energy Insight Function to develop and distribute insights for the MOD on future operational energy and technologies. This will inform decision-making across the MOD by providing a common and current evidence base. Insights will be gathered through:
 - Extant international engagement forums and mechanisms
 - Collaborating closely with industry and academia to identify the latest technological developments in both civil and military energy technologies as well as circular economy considerations
 - Maintaining strong links across government departments to understand the intent for implementing extant UK energy policy or the development of new energy policy, supported by an understanding of the implications for the MOD.
 - Establishing and regularly updating an understanding of energy policy in key foreign jurisdictions, assessing implications for UK operational energy choices
- 2.2. Align with the Defence Supply Chain Strategy and wider government industrial strategies, developing mechanisms for understanding where the MOD's industrial partners draw on the global supply chain. Identifying areas where they potentially compete for critical raw materials that are needed to support energy technologies. Highlighting risks of dependencies on adversaries.
- 2.3. Work closely with relevant MOD domain or sector leads to synthesise these sources of information into periodic sector-based insights to inform operational energy analysis and decisions related to IRE and capability development. This must be underpinned by the energy insight function establishing processes to integrate insights into capability development, force development and decisions regarding allocating IRE funding.

Action 3

Embed energy considerations into equipment acquisition and management

The MOD embeds considerations of operational energy options and their pan-DLOD implications throughout key decision-making processes related to equipment acquisition and management

Energy must be recognised as a key input in decisions, with the choice of energy type having strategic implications for capability performance, impacts across DLODs and consequences for the through-life cost of investments.

To achieve this, operational energy considerations must be embedded within key decisionmaking processes. The MOD will:

- 3.1. Set the MOD direction to mitigate and manage risks from the energy transition in procurement decisions, considering the pan-DLOD and through-life implications of energy types.
- 3.2. Embed energy considerations into relevant acquisition processes to ensure a full range of energy options and their pan-DLOD implications are considered during equipment acquisition. These processes include capability development, force development and investment appraisal. To support this, incorporate the requirement to consider operational energy considerations within the DLODs, for example through an energy specific DLOD or integration into an existing DLOD.
- 3.3. Embed energy considerations into capability audits to enable the MOD to understand the energy-related risks it may hold in relation to in-service capabilities, informing decisions related to capability use, upgrades and risk mitigation.
- 3.4. Incentivise operational energy efficiency and better inform operational energy decisions. This will be done by factoring in through-life and logistical supply cost implications of alternative energy choices during equipment procurement, with lifecycle analysis including end of life costs and potential gains.
- 3.5. Ensure that the insights derived from IRE activities and the Energy Insight Function (see Action 2) are incorporated into capability development options analysis, informing operational energy choices.
- 3.6. Trial the impact of changes to the capability development and management process by piloting energy options analysis on selected upcoming procurement decisions, providing strong preparation for the 'energy conscious' response phase.

Action 4

Optimise energy management

The MOD manages its operational energy needs to drive efficient energy use, make strategic decisions about energy production, storage and transportation, and ensure it has the infrastructure to meet future operational energy needs

The MOD must transition from treating energy as an unconstrained resource to understanding it as a strategic enabler that requires careful management to protect energy availability, resilience and through-life affordability.

This requires the MOD to develop strong data and analytics about energy demand, use, cost and supply. Better information will enable strategic decisions about the adoption of energy types, how energy can be more effectively managed, and how the MOD energy system should evolve.

To deliver this action, the MOD will:25

- 4.1. Reinforce the Operational Energy Authority's (OEA) role as an operational energy management function for the MOD. In this role the OEA will continuously monitor and assess energy needs, drive efficiency and reduced consumption. It will inform decisions on development of the MOD operational energy system (infrastructure, storage, transport, production and procurement).
- 4.2. Develop and maintain the authoritative view of short, medium and long-term operational energy requirements to enable current capabilities and meet the needs of the future force. This information will be actively shared with FLCs to inform decisions regarding the energy types needed to support future equipment. It should also inform investments in the MOD's energy system.
- 4.3. Develop analytical approaches and datasets to enable the MOD to assess the through-life and logistical supply costs of existing and new energy types. This will allow the MOD to better understand future operational energy costs for in-service equipment and inform the potential cost benefits from procuring new platforms or equipment that use different energy types.
- 4.4. Develop new commercial models for energy procurement that allow the MOD to address potential global supply constraints for alternative fuels and which optimise the quantity of energy held in relation to demand.

²⁵ It should be noted that a transformation of the MOD fuels enterprise is under way through the Fuels Transformation Programme (FTP). FTP has existing plans to support changes in many of these areas.

Action 5

Conduct innovation, research and experimentation to inform future energy choices

The MOD acts now to progress its understanding of the most promising energy choices

The MOD has numerous initiatives under way to explore new energy technologies. These initiatives will continue and be expanded in the form of a focused and funded Operational Energy IRE programme, building on the existing IRE programmes currently in place.

To deliver this action, the MOD will:

- 5.1. Use its insights about priority operational energy opportunities, commercial sector energy investments and knowledge of the energy actions of allies and adversaries to set CSA and FLC operational energy IRE priorities. These priorities will be informed by recommendations from the Senior Energy Sponsor and Energy Insight Function.
- 5.2. Undertake a comprehensive assessment of the opportunities to collaborate with allies to explore common operational energy IRE priorities, led by the Senior Energy Sponsor. This can enable faster experimentation, greater allied collaboration and interoperability, provide opportunities to utilise the industrial bases of multiple allies and increase the relatively limited influence of military requirements in shaping the commercial sector's energy transition.
 - In exploring the potential for international IRE collaboration, the MOD will consider whether to adopt strategic partnerships with key allies to enable pace and secure future energy interoperability.
- 5.3. Secure funding to conduct selected IRE activities to trial high-potential energy opportunities and make the case for these to be incorporated into equipment design and procurement decisions. This could include trialling new energy types in selected equipment procurements to improve the MOD's understanding of the barriers to new technology deployment even after successful IRE programmes have completed. Within near-term IRE programmes, the MOD will prioritise energy technologies that offer significant potential for operational advantage, or which help to address key risks. Those that could be considered for priority investment include:
 - Energy efficiency improvements through operational changes, mid-life upgrades, and new equipment procurement Energy efficiency improvements deliver a tangible operational advantage in terms of greater range and endurance, reduced logistics needs and more cost-effective operations. It is likely that some energy efficiency improvements can be delivered through operational changes alone. New platforms and mid-life upgrades can also deliver efficiency improvements and exploring energy efficiency to inform procurements should be prioritised.

- Hybrid-electric and electric platforms: Electric vehicles are achieving significant penetration in the UK civilian market in line with a full phaseout of internal combustion engines in passenger cars from 2035. Existing IRE programmes have investigated the benefits of electric and hybrid powertrains for military use and demonstrated operational advantages,²⁶ as reflected in the British Army's Battlefield Electrification Approach.²⁷ Electric platforms are also expected to play a role for smaller boats and certain types of aircraft.
- Procurement and/or production of alternative fuels including hydrogen, sustainable aviation fuel and lower carbon maritime fuel: The MOD is at the forefront of SAF deployment, certifying blending limits into the aviation fuel pipeline and carrying out test flights to show the viability of SAF. Low carbon fuels for maritime use are behind SAF in terms of commercial development but in some cases could be coproduced at refineries, and merit consideration when looking at SAF production and supply. Hydrogen use in vehicles depends on changes to engine technology and infrastructure, and in general requires greater operational changes than "drop-in fuels" do for adoption, but also offers significant potential benefits.
- Explore micro nuclear reactors: Small and micro nuclear reactors provide potential for operational advantage by enabling significant deployed energy production, if the technology can be developed and demonstrated. Allies and adversaries are already putting resources into this technology, and the MOD has an opportunity to leverage its knowledge of nuclear through its existing nuclear enterprise to drive technology development in the UK, working with its industrial partners.

²⁶ As part of the Technical Demonstrator 6 programme, Jackal and Foxhound were upgraded with hybridised motors giving them four-wheel drive. This made them more manoeuvrable and for the Foxhound platform simplified the number of mechanical parts, reducing the need for maintenance. Electrification also allowed the powering of electric tools, enabling the vehicles to act as a mobile electricity supply.

²⁷ British Army approach to battlefield electrification