UK Atomic Energy Authority

United Kingdom Atomic Energy Authority

Corporate Plan 2013

Overview

1 Executive Summary

The United Kingdom Atomic Energy Authority (the Authority) has as its principal mission 'to position the UK as a leader in a future, sustainable energy economy by advancing fusion science & technology and related technologies to the point of commercialisation'. This mission covers both fusion and research relevant to the resurgence of UK fission and other spin-off and growth technologies.

Fusion is the process that heats the Sun and other stars, and harnessing its immense power capabilities is a major challenge for mankind and is one of the most promising options for generating large amounts of carbon-free energy in the future. We manage the UK Fusion Programme (part of the UK Research Council's Energy Programme), with the aim of delivering sustainable energy by the middle of the century.

This work is carried out at the Culham Centre for Fusion Energy (CCFE), and is integral to the roadmap to the realisation of fusion electricity[1], which has been recently updated and published by the European Fusion Development Agreement (EFDA). The next steps in fusion are the internationally funded ITER project currently under construction in the south of France, and a demonstration reactor, DEMO, expected to come on line in the late 2030s.

We support these at Culham both in the operation of JET, currently the world's largest fusion machine, which we carry out on behalf of EFDA; in the operation of our own machine MAST; and in other internationally renowned areas of research and development. The fusion programme at CCFE is highly leveraged by European funds, and has strong input from many universities and collaborations with all the major international industrial and academic players in fusion and fission.

We are supporting our physics research by moving into technology-based research, with the aim of progressing the key technology issues for the next steps in fusion and fission new-build. One of our key aims over the next few years is to ensure that CCFE is ready for these new technology challenges, and indeed is in a position to lead work on the design of DEMO, which is expected to start during the next EU framework programme, Horizon 2020.

Thus, over the next three to five years, the Authority has seven strategic objectives, which are driving this plan:

- Maintain and exploit our world class scientific and operational capability to ensure the success of ITER and our role in it;
- Deliver JET as a world class fusion facility for the benefit of the international fusion programme and maximise the benefits for us beyond 2016;
- Complete the full upgrade of MAST to deliver novel solutions to DEMO and component test facilities, in addition to its wider research role;
- Secure significant additional technology facilities including the European DEMO Design centre;
- Work with UK industry and university partners to help them engage and profit from the fusion economy and associated spin-offs;
- Develop a sustainable, balanced Business Development programme to help the resilience of the organisation, including exploiting fusion/fission synergies to develop world class advanced fission research capability, and;
- Attract, retain, develop and recognise the required skills and expertise for future success.

[1] See http://www.efda.org/2013/01/bringing-fusion-electricity-to-the-grid/

This plan describes this work over the next five years and beyond. In this period, we are carrying out a major upgrade to MAST to enable it to make further critical steps towards understanding reactor relevant operations. JET will carry out experiments using tritium to demonstrate the enhanced performance now available using the ITER like materials and operational scenarios, breaking its own world records and reinvigorating the public perception of fusion, as well as providing invaluable support to the ITER project. We are currently anticipating the end of JET operations in 2016, although it is increasingly likely that operations will be extended further, involving international support. The operation of JET to 2016 and extensions beyond this date are subject to the agreement of the Horizon 2020 Research Programme (2014-2020) and Euratom programme (2014-2018).

During this period we will be building a new Materials Research Facility (MRF) as part of the National Nuclear User Facility which includes sister facilities at NNL and the Dalton Cumbrian Facility, part of the University of Manchester. This will provide unique facilities for researchers across the UK to investigate advanced materials for fusion and fission. We are also planning other facilities for remote handling, tritium handling and other areas to support our Technology programme, and UK academia and industry. We are also in the middle of a programme to build up related areas of research and development, including increasing business development income from sources outside of our current funding.

We support the Government's growth agenda through a number of initiatives including the training and development of the new generation of scientists and engineers and the support of industry. UK industry has already won over €200 million of contracts for ITER support and we have a key role in promoting ITER and fusion / fission technologies to industry, as well as increasing public support and outreach. Our apprentice, graduate training schemes, PhD and research fellowship opportunities are supporting the younger generation, and encouraging them into engineering and R&D professional careers.

We also have a property portfolio based around our Culham and Harwell sites in Oxfordshire, and manage the UK Atomic Energy Authority Pension Schemes, as well as legacy items from historical responsibilities, on behalf of our sponsor department, BIS.

2 Introduction

We are responsible for the UK magnetic confinement fusion research programme, the operation of JET and associated programmes, and present here a strategy for these going forward, optimising the UK's position in the future fusion power economy.

Nuclear fusion offers the promise of a nearly perfect energy source: fusion fuel in the oceans could power the world for millions of years; fusion reactors will have a low accident potential, minimal environmental impact and low land use. The world record demonstration of 16 MW[2] of fusion power in 1997 in JET showed that fusion works. The central issue is therefore to make it work reliably and economically on the scale of a power station.

The principal mission of the United Kingdom Atomic Energy Authority (the Authority) is to position the UK as a leader in a future, sustainable energy economy by advancing fusion science and technology and related technologies to the point of commercialisation.

We manage the UK's magnetic confinement fusion research programme carried out at the Culham Centre for Fusion Energy (CCFE), which is part of the UK Research Councils (RCUK) Energy Programme. We operate JET, Europe's flagship fusion research facility, under contract to the European Commission[3].

Fusion research and technology are contributing to the UK Government's plan for growth. UK companies have so far won over €200 million worth of construction and support work at the international ITER device currently under construction in the south of France. We have won over €6 million of additional grant and contract work ourselves on this project – leading to direct increases in employment and opportunities for training going forward. We are supporting UK Trade and Investment (UKTI) and others in publicising such opportunities to other UK organisations who may not have previously entered fusion research.

The Authority is an executive non-departmental public body, sponsored by the Department for Business, Innovation and Skills (BIS). In addition to our main mission, we manage our property portfolio at the Culham and Harwell sites in Oxfordshire and a number of other responsibilities that arise from historical civil nuclear programmes[4].

2.1 Fusion Roadmap

The fast track to fusion power plan adopted by the European Commission and RCUK following an independent review in 2010 lays a roadmap for the delivery of the first fusion electricity before the middle of the century. CCFE is one of the world's leading fusion research laboratories and we are working with partners around the globe to develop fusion and meet the fast track schedule.

The key elements of the fast track are outlined in Figure 2.1:

(a) First commercial reactors before 2050;

(b) the first fusion electricity producing demonstration plant, commonly known as DEMO (construction to begin ~2030, operation to begin 2040);

(c) the demonstration of self-sustained fusion burn on the international device ITER, starting in 2020 (see below)

(d) the demonstration of fusion conditions on JET and alternative scenarios on MAST (these are on-going at Culham);

[2] The total input power was 24MW. Experiments planned in JET later this decade will aim to improve on this performance.
[3] The JET Operation Contract (JOC) is managed under the European Fusion Development Agreement (EFDA) and funded by Euratom.
[4] The Authority was originally set up in 1954 to carry out research into atomic energy, amongst other duties (Atomic Energy Authority Act 1954). We have gone through a number of reorganisations in subsequent years.

This central route is supported by a concept improvement programme to bring down the cost and scale of the future reactor and a technology and materials development programme including the construction of a component test facility (CTF) that would complete the demonstration of the technology for DEMO and commercial power plants.

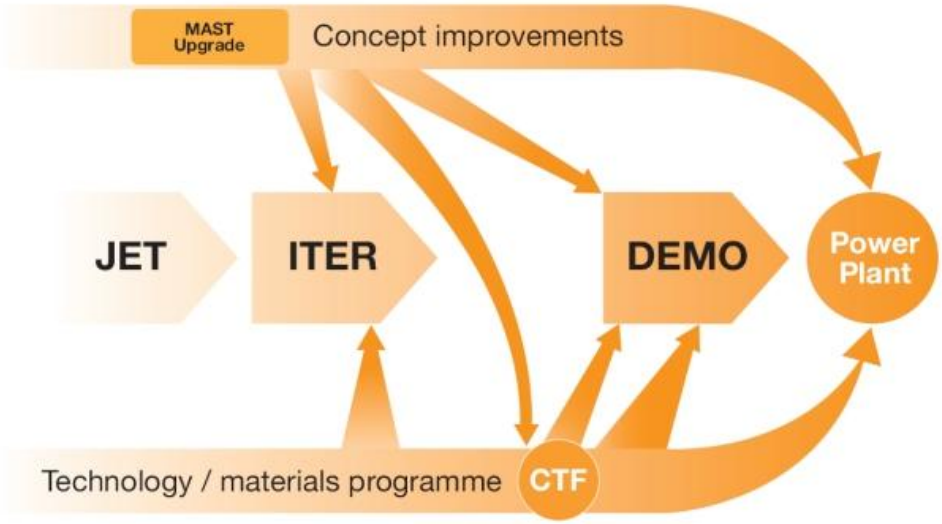

Figure 2.1: Key elements of the fast track roadmap for fusion.

We are at the forefront of world fusion development in operations, technology and our theory and modelling programmes. We operate two world-class facilities at Culham that are key elements of the fusion roadmap:

- **JET** (Joint European Torus) is the only device currently capable of generating significant fusion reactions in the world. First operated in 1983, JET operations restarted in 2011 following the successful installation of the new ITER-like wall (which surrounds the plasma) and other major enhancements that will make important contributions to the development of ITER operating scenarios. Our current plan assumes JET operation until the end of 2016, with a final phase of operation using the hydrogen isotopes deuterium and tritium as fuel[5], when JET is expected to break its own fusion power records achieved when tritium was last used on the machine. Operation beyond this date is becoming increasingly likely as explained below.
- **MAST** (Mega Amp Spherical Tokamak) is an innovative compact device (designed at Culham) that promises to reach fusion conditions at reduced scale and cost. It has been operating at Culham with considerable input from UK universities and overseas collaborators since 2000, and has shown this scientific promise at sub fusion conditions. A programme of upgrades to MAST has started, to take this concept to the threshold of fusion conditions. Operation after the first stage of this upgrade programme is due to begin in 2015.

Both the JET and MAST programmes are highly geared towards supporting ITER, the international collaboration between Europe, China, India, Japan, South Korea, Russia and the United States that is in the early stages of construction at Cadarache in the South of France. First experiments are scheduled for 2020 and ITER is expected to achieve fusion power of around 500MW with less than 50MW input power for hundreds (perhaps thousands) of seconds at a time in the late 2020's – the scientific demonstration of the feasibility of fusion power. The European domestic agency for ITER, 'Fusion for Energy' (F4E) is based in Barcelona.

[5] Normal operations use a Deuterium – Deuterium mix of fuel. Adding Tritium produces significantly more energy from the fusion reactions, but tritium is a radioactive fuel, so used sparingly on JET.

3 Summary Plan

During the next decade, given the fast track to fusion power outlined above, we must transition our own programmes from one heavily focussed on the science of fusion to a programme developing the technology and design of future power plants. However, we must do so without losing key scientific expertise. Our plan has five main themes to deliver this transition:

- An updated **Technology Roadmap** has been produced to drive our expansion into the next phase of Power Plant development work, with the aim of setting up the lead DEMO design team at Culham. This will include the construction of relevant technology facilities (or adaptation of existing facilities). Euratom and EFDA have initiated work in this area and we intend to increase our participation to provide a base programme after the closure of JET.
- Our work for **ITER** will expand though our contract work for ITER and F4E, with industrial partners. We are supporting ITER through both our scientific programme and developing key ITER components. Because of their considerable experience of operating fusion devices (JET and MAST), our scientists are expected to play a leading role in future ITER operation. We will also continue to help UK industry obtain contracts with the ITER organisation and F4E for ITER construction.
- **JET** operation until the end of 2016 (under currently agreed plans), with a final phase of full power deuterium/tritium operations to show that recent advances translate into record fusion performance. Operations at JET provide an ideal stepping-stone to ITER, and we expect to be heavily involved in ITER operations and physics studies. During 2011, an independent expert panel appointed by the Commission confirmed the significant benefits derived from JET operations for ITER, and recommended a number of steps to be taken including possible operations beyond 2016. The EFDA Fusion Roadmap published in November 2012 envisages JET operation until 2019, with additional international collaboration to support ITER. It should be noted that the operation of JET to 2016 and extensions beyond this date are subject to the agreement of the Horizon 2020 Research Programme (2014-2020) and Euratom programme (2014-2018).
- **MAST** operation until late summer 2013, followed by an 18-month shutdown to install the first major upgrade. MAST will then resume operations in 2015 for a decade of physics experiments exploring fusion at compact scale and developing reactor and compact CTF concepts, initially focusing on power exhaust solutions. The other projects needed to complete the upgrade programme will be implemented as and when additional funds can be secured.
- The above programmes will be supported by expanding our work into non-fusion areas (based on fusion capabilities and skills.) This is a new **Business Development** programme, and will build up during 2013/14 and beyond. In particular, we expect to increase our links with the advanced fission research community where there are a number of related research themes.

We carry out a number of other duties, which remain from our previous corporate responsibilities. These are funded and monitored under the '**Shareholder Programme Agreement**'. The main part of this is the '**Property Programme**', which is responsible for the management of our property portfolio at the Culham Science Centre and 'Harwell Oxford' science, innovation and business campus (where we retain the freehold).

We also manage the Atomic Energy **Authority Pension Schemes**, with 2,800 active members, 22,200 pensioners or dependants and 20,400 deferred pensioners.

3.1 Funding

Our fusion programme is funded around two thirds by the European Atomic Energy Community, Euratom (mainly via the JET Operation Contract, JOC) and one third by the RCUK energy programme by an EPSRC grant.

In addition, we receive funding from the Commission under a Contract of Association (CoA) between Euratom and us for specific fusion research carried out on their behalf. In 2014 and beyond this arrangement will be changed, with the emphasis moving from delivery of individual Association programmes to delivery of the overall Euratom programme priorities, centred around ITER. The final arrangements will be confirmed by the Commission during 2013.

EPSRC awarded us a six-year grant in 2010 to the end of March 2016. The grant provides a funding platform and an additional £20 million funding for the MAST Upgrade project. This grant was a significant demonstration of Government support for our fusion programme. Work will begin during the coming years on proposals for the period following March 2016.

The EU funding beyond the end of 2013 is not confirmed at March 2013. Both the Horizon 2020 research framework programme (2014-2020) and the Euratom fusion funding (2014-2018) are subject to agreement between the Commission, Council of Ministers and European Parliament. This agreement may not occur until late in 2013 / early 2014 so we will be keeping in close dialogue with the Commission and BIS to ensure that JOC funding is secured.

We are supplementing EPSRC and EU funding in specialist technology areas through grants and contracts for research and development awarded by the ITER Organisation (IO) direct or by the European Domestic Agency for ITER, Fusion for Energy (F4E), and will increase this further through contracts in the new Business Development programme.

BIS provide separate funding for the Shareholder Programme Agreement, which funds our legacy and governance work.

Funding for the Authority Pensions Schemes is provided outside of our main funding by a separate Parliamentary vote.

3.2 Staff

We have a highly skilled workforce. We need to grow this to deliver our commitments to external organisations, especially the JET Operations Contract, and to further our future Business Development plans and work on building up our capabilities for power plant and DEMO opportunities. However, we have seen a gradual rise in the total number of vacancies over the last few years, as staff have left or retired and we have found it difficult to replace them in competitive, highly paid, and skilled areas. The Government has agreed to our proposal to increase recruitment and retention in scarcity areas.

We are encouraging the younger generation into fusion research, as well as addressing the national need for a more technically skilled workforce, through our apprentice and graduate training schemes (in addition to our support of post doctorate studies). The apprentice scheme trains young engineering technicians in a four-year programme based at Culham and a local college. The scheme is designed to develop both technical and academic abilities and personal qualities. Completing the programme results in a certificate of Advanced Apprenticeship. A number of the apprentices were shortlisted and won national awards during the last year, recognising the quality of their work.

Our graduate training scheme takes around ten students per year and trains them over 2 years to become fusion engineers. Part of the scheme includes joining our Monitored Professional Development Scheme, which is approved by IMechE, IET and the Institute of Physics, and results in graduate entrants achieving chartered status in about 5 years.

3.3 External Overview of the Authority Programmes

The UK fusion programme is reviewed regularly (at least twice a year) by the Fusion Advisory Board (FAB) set up by EPSRC and RCUK to advise them on the UK magnetic and inertial confinement fusion programmes. In addition, a mid-term review of our present EPSRC grant took place in February 2013. The results of this review, expected in early 203/14, will be used to steer the programme during the remaining three years and beyond.

BIS will review the present role and management arrangements of the Authority in 2014. This is in line with the Cabinet Office expectation of regular review of all public bodies, and is timed so that the review will take place when the future of JET operations beyond 2016 is clearer, the plans described in this document should be well advanced towards successful implementation, and the implementation of the EPSRC mid-term review is complete.