NFLA New Nuclear Monitor Policy Briefing

Nuclear Free Local Authorities
Councils working for a renewable, safe and peaceful future

Edition Number 62, September 2020

NFLA Response to the UKAEA call for potential sites to host a nuclear fusion reactor in England

i. Overview of Policy Briefing

This edition of the NFLA New Nuclear Monitor arises from a request of a NFLA member authority to develop a model response letter and a wider policy briefing to a UK Atomic Energy Authority (UKAEA) letter. UKAEA are ascertaining local authority interest in potentially hosting a site for a nuclear fusion reactor. The UKAEA and the UK Government have initiated considerable funding in the STEP (Spherical Tokamak for Energy Production) programme, promising 'billions' of pounds seeking to accelerate progress towards commercially viable fusion power, through design and construction of a prototype fusion reactor by around 2040 / 50. This briefing and a model response letter to it has been developed by the NFLA Secretariat and member authorities are encouraged to use it.

Nuclear fusion has been a long-held ambition of the nuclear industry and governments who support nuclear power for decades, since nuclear fission came into being prior to the Second World War and the creation of thee nuclear weapons used on Hiroshima and Nagasaki. It has always been 'close' to development, and many billions has been spent over the past 7 decades on what has often been called by its critics an 'energy pipedream'. Whilst the development of new nuclear fission reactors in the UK are struggling to find the required finance for their construction, the UK Government is potentially planning to put billions into nuclear fusion. It appears a popular concept for the Prime Minister Boris Johnson and his special advisor, Dominic Cummings. A copy of the letter to English local authorities from the UKAEA is attached as Appendix 1. The NFLA's model response letter is attached as Appendix 2. The formal launch of this process is in the autumn, though local authorities are being encouraged to indicate early interest in supporting the project.

NFLA has rarely commented on nuclear fusion, given such energy projects have yet to be commercially realised. All have foundered around complex challenges in developing such technology. NFLA believe it is important to comment on this matter given the UK Government's letter to English Councils (but strangely not to Scottish or Welsh Councils).

NFLA's five key concerns with nuclear fusion technology is as follows:

- Nuclear fusion, like nuclear fission, still produces significant quantities of radioactive waste.
- Radioactive tritium emissions would be released as part of the fusion process.
- A large water source for cooling would be required.
- It costs huge sums of money that the public exchequer cannot afford.
- Any delivery of it will come too late to seriously tackle the effects of climate change.

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1. Introduction – the ‘dream’ of nuclear fusion

The idea of creating nuclear fusion reactions to supply huge amounts of ‘waste free’ energy has been an ongoing endeavour for many scientists, the nuclear industry and pro-nuclear governments for decades. Indeed, 2020 is the centenary of scientist Arthur Eddington theorising that hydrogen-helium fusion could be the primary source of stellar energy. Replicating the process of the sun, a main sequence star that generates its energy by nuclear fusion of hydrogen nuclei into helium (in its core, the sun generates 500 million tons of hydrogen each second) within a smaller, controlled industrial setting has been undertaken since the 1940s, but it still remains elusive to the nuclear industry to make it a commercially successful venture.

The theory around nuclear fusion was developed from the early experiments in nuclear transmutation by Ernest Rutherford, and laboratory fusion of hydrogen isotopes was accomplished by Mark Oliphant in 1932. Hans Bethe worked out the theory of the main cycle of nuclear fusion in stars in the late 1930’s. Research into nuclear fusion was carried out for military purposes beginning in the early 1940’s as part of the Manhattan Project, which went on to produce the first atomic bombs. Following on from the weapons programme was the creation of nuclear fission reactors in the 1950s (nuclear fission is a process in which the nucleus of an atom splits into two or more smaller nuclei as fission products generating energy, and usually creates some by-product particles leading to radioactive waste). Nuclear fusion was accomplished in 1951 and 1952 in US nuclear weapon tests. Converting such tests into a controlled environment for commercial purposes, through a nuclear fusion reactor, has been tested for decades, but it has not proven possible due to the complexity in creating the level of energy to force a nuclear fusion reaction. (1)

A number of states with large nuclear power programmes have spent vast sums of money for over seven decades to try and create a commercial nuclear fusion reactor. It always seems to be around 5 - 10 years from completion. It has been stymied by complex scientific and technological difficulties, but as some progress has been made that continues to keep the funding going. (2) At present, the two most advanced approaches for nuclear fusion reactor design are around magnetic confinement (what are called toroid designs) and inertial confinement (or otherwise laser designs), and each has been pursued to varying degrees.

2. Existing nuclear fusion projects

Presently, the International Thermonuclear Experimental Reactor (or ITER), a toroidal tokamak reactor, is the main nuclear fusion reactor in development. The project began in 2007, moving on from a solely EU funded project, JET. It is aimed to deliver as much as ten times more fusion energy than the amount needed to heat plasma to the required temperatures. The ITER facility in Provence, southern France is expected to finish its construction phase around 2025. It will then start commissioning the reactor that same year and initiate plasma experiments in 2025, but is not now expected to begin full deuterium-tritium fusion until at least 2035. ITER is funded by the European Union, China, India, Japan, Russia, South Korea and the United States. (3)

Other nuclear fusion reactors being developed include one by Canadian-based General Fusion, which is developing a magnetized target fusion nuclear energy system, aims to build its demonstration plant by 2025; and another by the US National Ignition Facility, which uses laser-driven inertial confinement fusion, was designed with a goal of break-even fusion; the first large-scale laser target experiments were performed in June 2009 and ignition experiments began in early 2011.

To date, none of these reactors have produced more energy than was put into them.

The new UK concept coincides with plans for it to leave the European Union, and was announced in November 2019 with an initial £200 million investment from the UK Government.

The design and the proposed timeline for the UK programme is amongst the more ambitious around. Over the next four years, scientists at the Culham Centre for Fusion Energy (near

Oxford) will produce a detailed design for the Spherical Tokamak for Energy Production (STEP), a plant it is hoped that could be capable of generating hundreds of megawatts of net electrical energy that would be up and running by the early 2040s. If the decision is made to go ahead and build the facility, the bill would need to increase significantly to around £10 billion and upwards. (4)

Unlike the ITER project, the STEP project's goal is seeking to go a stage further by creating a plant that will harness electricity from fusion. However, ITER needs to succeed for nuclear scientists to understand whether such a prototype commercial plant as STEP is really viable.

The planned UK STEP project, like ITER and its predecessors, will be based on a 'tokamak' design. These reactors use magnetic fields to confine a plasma of heavy isotopes of hydrogen, tritium and deuterium, which fuse under extreme heat and pressure. A core difference with ITER though is that STEP uses a method trialled in the UK since the 1990s by holding the superheated gas in a more compact, cored-apple shape (rather than a doughnut like shape) reactor. By developing a smaller facility – measuring about 10 metres diameter – it could potentially be produced cheaper. However, this could create other issues, such as how to manage the plasma's extreme heat.

This could be a risky project that may fail, as Anne White, a plasma physicist from MIT has told the periodical Nature. For spherical tokamak designs there are many unknowns, she says. "That means there is more risk, but on the flip side, it could also mean there is more to discover and perhaps more to optimise."

The UK Government's initial funding will commence and start the development of the STEP reactor until 2024, when it will then require both public and private investment.

The move to develop STEP may arise from an uncertain future for the UK's involvement in ITER, as its membership of that project comes through the European Atomic Energy Community (Euratom), which the UK government plans to leave when the country exits the European Union at the end of 2020. The facility in Culham has hosted the EU-funded Joint European Torus (JET) for over three decades, which is testing fuel technologies for ITER. The UK Government has publicly stated it hopes to find a way to remain part of ITER, but that STEP investment helps to maintain its involvement in nuclear fusion development. All of the core partners in ITER are seeing it as a vehicle to eventually develop commercial fusion reactors, supply chains and what they would hope is a profitable energy source in the 2040s or 2050s.

3. Core weaknesses of nuclear fusion

Given work on nuclear fusion is over seven decades old and, despite much finance and scientific research, it is useful to consider what are the core challenges of such technology.

Professor Daniel Jassby, a former principal research physicist at the Princeton Plasma Physics Lab with 25 years of experience in areas of plasma physics and neutron production related to fusion energy research and development, has analysed the current state of nuclear fusion development for the Bulletin of Atomic Scientists. (5)

Whilst Professor Jassby notes the proponents of nuclear fusion see it as a 'perfect' energy source – creating vast sources of energy with smaller amounts of radioactive waste and little or no plutonium by-products that could be used for nuclear weapons production – it has a serious, if not critical hitch:
"While it is, relatively speaking, rather straightforward to split an atom to produce energy (which is what happens in fission), it is a "grand scientific challenge" to fuse two hydrogen nuclei together to create helium isotopes (as occurs in fusion). Our sun constantly does fusion reactions all the time, burning ordinary hydrogen at enormous densities and temperatures. But to replicate that process of fusion here on Earth—where we don't have the intense pressure created by the gravity of the sun's core—we would need a temperature of at least 100 million degrees Celsius, or about six times hotter than the sun. In experiments to date,

the energy input required to produce the temperatures and pressures that enable significant fusion reactions in hydrogen isotopes has far exceeded the fusion energy generated."

Professor Jassby says some of the new reactors are 'promising' and bringing the possibility of commercial nuclear fusion closer, but that it may not be the 'perfect' energy source for the following reasons:

a) **Scaling down the sun**. The sun creates fusion reactors by burning hydrogen at enormous density and temperature creating benign helium isotopes. "Artificial (terrestrial) fusion schemes, on the other hand, are restricted to much lower particle densities and much more fleeting energy confinement, and are therefore compelled to use the heavier neutron-rich isotopes of hydrogen known as deuterium and tritium—which are 24 orders of magnitude more reactive than ordinary hydrogen."

The burning of such neutron-rich isotopes produces harmful byproducts such as:
- radiation damage to structures;
- radioactive waste;
- the need for biological shielding;
- and the potential for the production of weapons-grade plutonium 239, adding to the threat of nuclear weapons proliferation.

Furthermore they also share some of the serious problems that affect nuclear fission reactors, such as:
- radioactive tritium release;
- daunting coolant demands;
- high operating costs.

Additional drawbacks unique to fusion devices include:
- the use of a fuel (tritium) that is not found in nature and must be replenished by the reactor itself (and currently only supplied by fission nuclear reactors);
- unavoidable on-site power drains that drastically reduce the electric power available for sale.

The tritium consumed in fusion can theoretically be fully regenerated in order to sustain the nuclear reactions. To do this, a lithium-containing "blanket" must be placed around the reacting medium—an extremely hot, fully ionized gas called a plasma. The neutrons produced by the fusion reaction will irradiate the lithium, "breeding" tritium.

However, the lithium blanket can only partly surround the reactor, because of the need for gaps for vacuum pumping, beam and fuel injection in magnetic confinement fusion reactors, and for driver beams and removal of target debris in inertial confinement reactors. Nevertheless, the most comprehensive analyses indicate that there can be up to a 15% surplus in regenerating tritium. However, in practice, any surplus will be needed to accommodate the incomplete extraction and processing of the tritium bred in the blanket.

Jassby notes: "Replacing the burned-up tritium in a fusion reactor, however, addresses only a minor part of the all-important issue of replenishing the tritium fuel supply. Less than 10% of the injected fuel will actually be burned in a magnetic confinement fusion device before it escapes the reacting region. The vast majority of injected tritium must therefore be scavenged from the surfaces and interiors of the reactor's myriad sub-systems and re-injected 10-to-20 times before it is completely burned. If only one percent of the unburned tritium is not recovered and re-injected, even the largest surplus in the lithium-blanket regeneration process cannot make up for the lost tritium. By way of comparison, in the two magnetic confinement fusion facilities where tritium has been used (Princeton's Tokamak Fusion Test Reactor, and the Joint European Torus), approximately 10 percent of the injected tritium was never recovered."

As a result, to make up for the inevitable shortfalls in recovering unburned tritium for use as fuel in a fusion reactor, fission reactors must continue to be used to produce sufficient supplies of tritium—a situation which implies a perpetual dependence on fission reactors, with all their safety and nuclear proliferation problems.

b) **Huge parasitic power consumption.** A further core problem for fusion reactors is that they consume a large part of the power that they produce, on a scale unknown to any other source of electrical power. Fusion reactors must accommodate two classes of parasitic power drain:

- First, a large amount of essential auxiliary systems external to the reactor must be maintained continuously even when the fusion plasma is dormant such as liquid-helium refrigerators; water pumping; vacuum pumping; heating, ventilating and air conditioning for numerous buildings; tritium processing; and so on, which all consume energy. As a result, when the fusion output is interrupted for any reason, this power must be purchased from the regional grid at retail prices.
- Secondly, the power needed to control the fusion plasma in magnetic confinement fusion systems (and to ignite fuel capsules in pulsed inertial confinement fusion systems). The total electric power drain for this purpose amounts to at least 6% of the fusion power generated, and the electric power required to pump the blanket coolant is typically 2% of fusion power. The gross electric power output can be 40% of the fusion power, so the circulating power amounts to about 20% of the electric power output.

To have any chance of economic operation that must repay capital and operational costs, the fusion power must be raised to thousands of megawatts so that the total parasitic power drain is relatively small. As a result, below a certain size (about 1,000 MWe) parasitic power drain makes it uneconomic to run a fusion power plant.

c) **Radiation damage and radioactive waste.** Jassby notes that to produce usable heat, the neutron streams carrying 80% of the energy from deuterium-tritium fusion must be decelerated and cooled by the reactor structure, its surrounding lithium-containing blanket, and the coolant. The neutron radiation damage in the solid vessel wall is expected to be worse than in fission reactors because of the higher neutron energies. Fusion neutrons knock atoms out of their usual lattice positions, causing swelling and fracturing of the structure. Also, neutron-induced reactions generate large amounts of interstitial helium and hydrogen, forming gas pockets that lead to additional swelling, embrittlement, and fatigue. ***These phenomena put the integrity of the reactor vessel in peril.***

In reactors with deuterium-only fuelling (which is much more difficult to ignite than a deuterium-tritium mix), the neutron reaction product has five times lower energy and the neutron streams are substantially less damaging to structures. But the deleterious effects will still be ruinous on a longer time scale.

The problem of neutron-degraded structures may be alleviated in fusion reactor concepts where the fusion fuel capsule is enclosed in a one-meter thick liquid lithium sphere or cylinder. However, the fuel assemblies themselves will be transformed into ***tons of radioactive waste to be removed annually from each reactor.*** Molten lithium also presents a fire and explosion hazard, introducing a drawback common to liquid-metal cooled fission reactors.

Bombardment by fusion neutrons knocks atoms out of their structural positions while making them radioactive and weakening the structure, which must be replaced periodically. ***This results in huge masses of highly radioactive material that must eventually be transported offsite for burial. Many non-structural components inside the reaction vessel and in the blanket will also become highly radioactive by neutron activation. While the radioactivity level per kilogram of waste would be much smaller than for fission-reactor wastes, the volume and mass of wastes would be many times larger.*** What's more, some of the radiation damage and production of radioactive waste is incurred to no end, because a proportion of the fusion power is generated solely to offset the irreducible on-site power drains.

Jassby also notes that: "To reduce the radiation exposure of plant workers, biological shielding is needed even when the reactor is not operating. In the intensely radioactive environment, remote handling equipment and robots would be required for all maintenance work on reactor components as well as for their replacement because of radiation damage, particle erosion, or melting. These constraints will cause prolonged downtimes even for minor repairs."

d) **Nuclear weapons proliferation.** The open or clandestine production of plutonium 239 is possible in a fusion reactor simply by placing natural or depleted uranium oxide at any location where neutrons of any energy are flying about. The ocean of slowing-down neutrons that results from scattering of the streaming fusion neutrons on the reaction vessel permeates every nook and cranny of the reactor interior, including appendages to the reaction vessel. Slower neutrons will be readily soaked up by uranium 238, whose cross section for neutron absorption increases with decreasing neutron energy. Uranium 238 can be converted to Plutonium 239, a core element of a nuclear weapon.

A reactor fuelled with deuterium-tritium or deuterium-only will have an inventory of many kilograms of tritium, providing potential opportunities for diversion for use in nuclear weapons. Just as for fission reactors, IAEA safeguards would be needed to prevent plutonium production or tritium diversion.

e) Additional disadvantages shared with fission reactors.

- Tritium will be dispersed on the surfaces of the reaction vessel, particle injectors, pumping ducts, and other appendages.
- Corrosion in the heat exchange system, or a breach in the reactor vacuum ducts could result in the release of radioactive tritium into the atmosphere or local water resources. Tritium exchanges with hydrogen to produce tritiated water, which is biologically hazardous.
- The release of even tiny amounts of radioactive tritium from fission reactors into groundwater causes public concern.
- In addition, there are the problems of coolant demands and poor water efficiency.

All of the above means that any fusion reactor will face outsized operating costs.

Commercial fusion reactor operation will require skilled nuclear regulatory staff, security experts for monitoring safeguard issues and skilled personnel for radioactive waste management. Additional skilled personnel will be required to operate a fusion reactor's more complex subsystems including cryogenics, tritium processing, plasma heating equipment, and elaborate diagnostics.

Jassby notes:
"Fission reactors in the United States typically require at least 500 permanent employees over four weekly shifts, and fusion reactors will require closer to 1,000. In contrast, only a handful of people are required to operate hydroelectric plants, natural-gas burning plants, wind turbines, solar power plants, and other power sources."

Other operating expenses include:

- 75-to-100 megawatts of parasitic electric power consumed continuously by on-site supporting facilities that must be purchased from the regional grid when the fusion source is not operating.
- The replacement of radiation-damaged and plasma-eroded components in magnetic confinement fusion, and the fabrication of millions of fuel capsules for each inertial confinement fusion reactor annually.
- Allocated funding for end-of-life decommissioning as well as the periodic disposal of radioactive wastes.

Jassby concludes: “It is inconceivable that the total operating costs of a fusion reactor would be less than that of a fission reactor, and therefore the capital cost of a viable fusion reactor must be close to zero (or heavily subsidized) in places where the operating costs alone of fission reactors are not competitive with the cost of electricity produced by non-nuclear power, and have resulted in the shutdown of nuclear power plants.

These impediments—together with the colossal capital outlay and several additional disadvantages shared with fission reactors—will make fusion reactors more demanding to construct and operate, or reach economic practicality, than any other type of electrical energy generator.”

In reference to the potential huge costs of nuclear fusion, in a recent 2019 analysis of the ITER by Dr Michael Dittmar for the Green Group in the German Parliament, he noted that:

- Cost estimates for ITER have been wrong and increased fourfold in budget. This is despite the experimental program, including the tritium breeding tests, of the ITER project being significantly decreased during the last few years.
- The original 2007 estimates claimed that plasma experimentation would begin around the year 2018, but they have now been delayed by around a decade due to technical difficulties.
- Despite working on this project since 2005, ITER scientists predict that commercial fusion plants could start to come on line as soon as 2040. The exact timing, according to fusion experts, will depend on the level of public urgency and political will that translates to financial investment.
- Proponents of such reactors suggest the initial capital cost of a 2,000-megawatt fusion plant (supplying 2 million homes) will be in the range of $10 billion. They argue capital costs will be offset by extremely low operating costs, negligible fuel costs, and infrequent component replacement costs over the 60-year-plus life of the plant. Such an argument has been made for many decades.

The report concludes: “Sufficient information about the design and construction of large Tokamaks has been obtained during the last 20 years, those data allow to conclude that this technology will not lead to electricity producing fusion power during the first half of the 21s century. In addition, it is difficult to avoid the conclusion that the highly praised “scientific expertise” to control DT nuclear fusion and the related estimated monetary costs, which formed the basis to design the ITER project during the years 1995-2007, were based at best only on gigantic miscalculations.” (6)

Why would the UK Government going alone from this international project find all of these huge technical barriers any easier to overcome than the ITER project, which has been so well funded by a wide range of states?

5. Tackling the climate emergency

With the UK budget deficit, due to Covid-19, at the highest in recorded history, how could a UK Government fund such an expensive project, whilst also fully funding many other critical spending and infrastructure projects, including the billions lost by local government in the past year?

Furthermore, hundreds of Councils and over 10,000 cities worldwide have declared a climate emergency in the past couple of years, and are developing ambitious projects and policies to seek to become zero carbon in the next 10 – 20 years. There are some fantastic ideas out there in local government, as the NFLA have outlined in detail (7), but they need both local and central government finance urgently to realise them. To do so will ensure that decentralised, renewable energy, as well as energy efficiency and energy storage projects will positively contribute to the essential endeavour of getting to a zero carbon world as quickly possible. Diverting billions of pounds rather into a nuclear fusion project that has not delivered in 70 years, and is unlikely to deliver before climate catastrophe has already started to take place is a foolhardy and unnecessary adventure.

The UK needs around £18bn in the next 10 years to fund fuel poverty-busting energy efficiency measures and get heating decarbonised by 2050 - measures which can reduce carbon emissions ***immediately***. Yet the Prime Minister's Chief Advisor Dominic Cummings has been reported as describing this as "boring old housing insulation", preferring to waste money on the STEP project not expected to produce any energy for ***at least twenty years***.

The UK Atomic Energy Authority and the UK Government should focus its nuclear policy on dealing up the huge nuclear legacy created by 70 years of nuclear fission and bring the costs down of this programme, which runs at over £3 billion a year, and is estimated to require further budget of over £210 billion by the end of clean-up.

6. Conclusions

The current UK Government, like its predecessors, has been a strong proponent of nuclear fusion technology as it sees the potential final product in its eyes – vast amounts of cheap low carbon output energy with relatively lower amounts of radioactive waste, as eminently preferable in comparison with building large amounts of renewable energy facilities across the country to fill a perceived future energy gap. Despite the aspiration, 70 years of nuclear fusion research is still at least 15 – 30 years away from some kind of technical solution.

This Policy Briefing has also shown that there are serious and quite likely insurmountable problems that nuclear fusion proponents face. These include the creation of a harmful amount of dangerous byproducts including radiation damage to structures, radioactive waste, the need for biological shielding, and the potential for the production of weapons-grade plutonium 239, adding to the threat of nuclear weapons proliferation. They also share some of the serious problems that affect nuclear fission reactors, such as radioactive tritium release, daunting coolant demands and high operating costs.

NFLA believes the £200 million being spent on the STEP programme and the billions already spent for decades has been a colossal waste of money. With the climate emergency now so urgent and pressing over the next two decades, the UK should not be wasting such scarce resource on a technology that may never be commercially viable. As on our views with overly expensive new nuclear fission reactors, which are also taking much longer to realise than their proponents suggest, NFLA believes they divert attention from the sensible energy direction – creating a cheaper, cleaner, radioactive waste free and more realisable renewable energy programme allied with energy efficiency, energy storage and smart energy solutions.

NFLA encourage English local authorities to reject the UK carrot of site investment as part of the STEP programme, and rather call instead for a diversion of resources into renewable energy alternatives.

7. References

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Appendix 1

Letter from UK Atomic Energy Agency to English Local Authorities

UK Atomic Energy Authority

Mr Tristram Denton
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Chief Executive Officers
Local Authorities in England
Care of: Ministry of Housing, Communities & Local Government

Site Selection: Spherical Tokamak for Energy Production (STEP)

Dear Colleagues,

I trust you and your team are staying well, amid the current global challenge of Covid-19.

I am writing to introduce the STEP programme - a UKAEA and UK Government initiative to accelerate progress towards commercially viable fusion power, through design and construction of a prototype fusion reactor by 2040.

Fusion power provides scope for almost limitless low carbon energy. Whilst Fusion has previously been seen as something of a future prospect, technology advances in recent years now show a clear viability for commercial operations around the middle of this century.

STEP (Spherical Tokamak for Energy Production) is an innovative programme which draws on the UK's world-leadership in compact fusion technology, and aims to transition from a research-led sector to industrial-design and delivery.

The programme is expected to represent an ultimate investment of multiple £billions, and to further enhance UK leadership in the field. This is expected to bring immediate and enduring economic benefit - construction of the prototype represents a major infrastructure project in-and-of-itself; whilst the success of the programme will further establish the UK as a global hub of the fusion industry.

This prototype plant is not necessarily expected to be based on the current UK fusion research campus, which is near Culham in Oxfordshire. Whilst the campus is a vital and world-class research hub which will support the sector for many decades to come, the STEP plant is expected to have requirements much more closely aligned to those of a generating power station. As such we will shortly begin the process of looking for a suitable site on which to construct the STEP prototype.

The site ultimately selected will not only host a major construction programme, but will also become fertile ground for a flourishing, modern, low-carbon, high-skill and high-value supply chain. Consideration of necessary skills and training initiatives are already underway, and long-term workforce development will be a priority consideration as the programme proceeds.

To establish the most effective enduring relationship with the ultimate host community, UKAEA intends to issue an open call for site nominations – based on collaborative proposals from landowners, local authorities, LEPS and local communities. Commercial terms of site access would naturally be subject to associated engagement between the landowner and UKAEA.

Nominations would be welcomed from a broad range of entities – and UKAEA will simply ask that those who nominate sites provide basic information in line with a set of site assessment criteria to be published alongside the call for sites. Needless to say; size, land profile, current use, access to cooling water, grid connectivity and industrial base are significant amongst those criteria.

We wanted to give you foresight of this coming process; both so you can consider any potential opportunities associated with your area, and so you could be prepared for any questions this may raise for you. We expect to launch the process this Autumn, via a bespoke website and media announcement.

If you have any questions and would like to discuss STEP, please feel free to contact shelley.vaisey@ukaea.uk to arrange a meeting with me or a member of my team.

Yours Sincerely

Tristram Denton
STEP Head of Commercial and Programme Development

Appendix 2

Model response letter to the UKAEA

Local authority name and address

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Dear Mr Denton,

Site Selection: Spherical Tokamak for Energy Production (STEP)

Thank you for your letter seeking interest from English Local Authorities to potentially be involved in site selection for a new nuclear fusion reactor - called the spherical tokamak for energy production or STEP.

We are interested to know why this offer has only been made to English Local Authorities, and not also to those in Scotland and Wales, whose policy would not prevent them showing interest.

We have consulted on this response with the UK & Ireland Nuclear Free Local Authorities, and have received a detailed briefing on them on the prospects for nuclear fusion. (The full briefing can be found on the NFLA website https://www.nuclearpolicy.info).

In summary they note five key concerns with nuclear fusion:

- Nuclear fusion, like nuclear fission, still produces significant quantities of radioactive waste.
- Radioactive tritium emissions would be released as part of the fusion process.
- A large water source for cooling would be required.
- It costs huge sums of money that the public exchequer cannot afford.
- Any delivery of it will come too late to tackle climate change.

We share those concerns. We do not want to see more radioactive waste generated in the UK when there still remains no solution for dealing with the 70 years of existing nuclear legacy materials.

We note in your letter that the UKAEA hopes a commercially operating nuclear fusion reactor will be up and running by the middle of the century. However, almost 300 Councils have now declared a climate emergency and see a critical need for a full transition to zero carbon emissions by 2040 at the latest. Nuclear fusion will not bring any positive impact to such a deadline, but will require billions of pounds of investment at a time when the Covid-19 outbreak has raised the public debt by record levels, and where all local authorities are under severe financial pressure. We think the billions being suggested for this project would be better used to fund low carbon renewable energy, energy efficiency, smart energy and energy storage alternatives instead.

States like the UK have been chasing the dream of nuclear fusion for over 70 years, and it is always just ‘around the corner’ in achieving it, despite vast levels of investment being thrown at it. A detailed outline of the huge technical problems in developing nuclear fusion has been provided by Professor Daniel Jassby, a former principal research physicist at the Princeton Plasma Physics Lab with 25 years of experience in areas of plasma physics and neutron production related to fusion energy research and development, who has analysed the current state of nuclear fusion development for the Bulletin of Atomic Scientists. (1) His core concerns can be found in detail in the NFLA briefing and provide considerable evidence of the huge technical challenges and unpleasant externalities with developing nuclear fusion power.

Professor Jassby concludes:
“It is inconceivable that the total operating costs of a fusion reactor would be less than that of a fission reactor, and therefore the capital cost of a viable fusion reactor must be close to zero (or heavily subsidized) in places where the operating costs alone of fission reactors are not competitive with the cost of electricity produced by non-nuclear power, and have resulted in the shutdown of nuclear power plants.

These impediments—together with the colossal capital outlay and several additional disadvantages shared with fission reactors—will make fusion reactors more demanding to construct and operate, or reach economic practicality, than any other type of electrical energy generator.”

Furthermore, the planned UK STEP project, like the planned ITER site in Provence and its predecessors, will be based on a ‘tokamak’ design. These reactors use magnetic fields to confine a plasma of heavy isotopes of hydrogen, tritium and deuterium, which fuse under extreme heat and pressure. A core difference with ITER though is that STEP uses a method trialled in the UK since the 1990s by holding the superheated gas in a more compact, cored-apple shape (rather than a doughnut like shape) reactor. By developing a smaller facility – measuring about 10 metres diameter – it could potentially be produced cheaper. However, this could also create other serious issues, such as how to manage the plasma’s extreme heat.

This could be a risky project that may fail, as Anne White, a plasma physicist from MIT has told the periodical Nature. For spherical tokamak designs there are many unknowns, she says. “That means there is more risk, but on the flip side, it could also mean there is more to discover and perhaps more to optimise.” (2)

Given this information, we respectively decline the offer to consider hosting such a reactor.

Yours sincerely,
Local authority Chief Executive / Leader of Council (as appropriate)

(1) Professor Daniel Jassby, ‘Fusion reactors: not what they are cracked up to be’, Bulletin of the Atomic Scientists, April 19th, 2017 https://thebulletin.org/2017/04/fusion-reactors-not-what-theyre-cracked-up-to-be/
(2) Nature, 11th October 2019 https://www.nature.com/articles/d41586-019-03039-9