Agenda Item	**16**
Report No	**HC/4/21**

HIGHLAND COUNCIL

Committee: **Highland Council**

Date: 25 March 2021

Report Title: **Prototype Fusion Reactor opportunity for Caithness and North Sutherland**

Report By: Executive Chief Officer Infrastructure and Environment

1. Purpose/Executive Summary

1.1 The UK Atomic Energy Authority has announced an ambitious programme to design and construct a prototype fusion power plant. In the first instance they have announced an open competition for a community to host this prototype. The purpose of this report is to highlight the Spherical Tokamak for Energy Production (STEP) opportunity and to seek Council agreement that the Dounreay site in Caithness is supported as the site being proposed by The Caithness and North Sutherland Partnership.

2. Recommendations

2.1 Members are asked to agree to the submission of the Dounreay site as a potential site for the STEP prototype Fusion power plant.

3. Implications

3.1 Resource – there are no resource implications arising from the bid process at this stage, other than officer time to support the drawing together of supporting information.

3.2 Legal – there are no legal implications at this time. The submission of a bid in no way prejudices other procedures that will have to be gone through from a consenting and licensing perspective.

3.3 Community (Equality, Poverty and Rural) – The opportunity presented has the potential to have a very positive impact on addressing issues relating to repopulation of the region, sustaining communities in the north and delivering improved educational outcomes.

3.4 Climate Change / Carbon Clever – The fusion prototype is designed to produce a clean form of energy and will deliver positive benefits in respect of climate change and low carbon ambitions.

3.5 Risk – All of the regulatory, planning and licensing implications will be considered in separate applications should the site at Dounreay be selected. These will be comprehensive and involve significant levels of consultation. No decisions taken at this Council meeting will prejudge or prejudice the role the Council will have in determining such applications.

3.6 Gaelic – There are no Gaelic implications at this time.

4. Background

4.1 UK Atomic Energy Authority (UKAEA) (**Appendix 1**) has announced an open competition for a community to host the site to house the construction of a prototype fusion power plant. (STEP). The site assessment process occurs in three phases and the initial phase has three critical elements:

1. An applicant organisation with local jurisdiction capable (in personnel and funding) of bidding and engaging with UKAEA on the process.
2. A site identified with an owner willing to discuss potential commercial arrangements.
3. Confirmation that local policy (Devolved Governments and relevant Local authorities) are in favour of a development.

The bid deadline is 31 March 2021.

4.2 UKAEA will make a recommendation to the Secretary of State for Business, Energy and Industrial Strategy (BEIS) on the most suitable possible locations for STEP. This recommendation will be defined through a structured assessment process, broadly based on three key things:

- Technical and operational suitability;
- Alignment with STEP's socio-economic and community benefit principles; and
- Support for the commercial progress of the project

To arrive at this recommendation the UKAEA will assess each nominated site against five assessment pools. Assessment will take place in several stages, with each one requiring increasingly detailed information.

4.3 Discussions with local partners have identified the potential to submit a bid for the Dounreay site in Caithness as a site that UKAEA should consider for the siting of the STEP reactor. The Caithness and North Sutherland Regeneration Partnership has agreed to take the lead with the initial bid, and it is considered essential that the Council also support the bid in principle at this stage given the significant long-term economic benefits that could arise from the opportunity. A Members' Seminar was held on 10 March 2021, where the elements of the bid process were set out and the intention to submit a bid was discussed.

5. The STEP Opportunity

5.1 STEP is a publicly funded Programme and is committed to delivering a full range of social benefits. The aim is to deliver not only a clean energy future but also a lasting and significant boost to the host community. The project will have a significant operational life and will employ many staff. Estimates are that there would be hundreds of jobs in the latter stages of planning and design, thousands in construction and a few hundred in operations. The opportunity fits with the timing of the anticipated reduction of jobs from the decommissioning of Dounreay. The highly technical process of Fusion suggests that ready transferability of existing staff skills would be likely and that roles would be well paid. Initial investigations indicate that Dounreay would be a good match against the site criteria set by UKAEA.

5.2 It is important to note the fact that this opportunity relates to a prototype fusion technology. This is very different from the nuclear fission process. Fusion technology would be one of the world's cleanest and lowest carbon forms of energy. It seeks to replicate the energy production process of the sun by fusing hydrogen into helium, producing huge amounts of clean energy. **Appendix 2** sets out more background on the differences between the two technologies.

5.3 Not only would the attraction of such a significant investment (funding of £222m has been identified for the concept design stage alone) be a major boost to the north economy, it could lead to significant supply chain, innovation and educational opportunities for generations to come. As well as having broad support from many Members during the recent seminar, the Members of the Caithness Area Committee have submitted a letter of support and this is attached at **Appendix 3**.

5.4 The benefits of attracting the UKAEA to invest in the Dounreay site can be summarised as follows:

1. It will have a significant operational life and could employ significant numbers of staff. Although job numbers that would be created are not identified in the current documentation, we could assume jobs of up to several hundred based on other nuclear research and power generation plants.
2. The jobs created would be highly skilled technical roles and therefore would be well paid.
3. The timeline of the project would be a good fit with the reduction of jobs at Dounreay.
4. The skills of Dounreay staff would be in the large readily transferrable to fusion.
5. As this is a prototype it will develop technology and expertise that could be exported around the world. There is the potential for a significant supply chain being built up locally that could potentially export worldwide.
6. UKAEA have identified resources to support an apprentice training scheme in the area surrounding STEP and will work with local education and training providers at the earliest opportunity. There are existing and highly respected apprentice programmes in the Caithness and North Sutherland area which could be readily adapted to the fusion programme.
7. The attraction of such a major new development and its supply chain would add to the critical mass of highly technical jobs in the region the development of further opportunities and act as a catalyst for research, training and the attraction of other opportunities requiring similar skills.

8. This is likely to be a highly competitive bidding process, with numerous sites around Scotland and the UK bidding. The process of identifying and developing the bid in this situation would strengthen the cohesion of the partnership working and establish the basis to attract other inward investment propositions. A well-structured bid would further raise the area's profile and publicly demonstrate the ambition of the region to be the powerhouse of green energy production in the UK.

6. Next Steps

6.1 As set out above, the first stage of the bid process has a closing date of 31 March 2021. Detailed evaluation will follow through to mid-2022, when a recommendation will be made on suitable possible locations for STEP. The site decision is likely to be known around the end of 2022, with the work on the outline design programmed to be completed by end 2024. From 2024 onwards, detailed design would be undertaken, including all of the necessary planning, environmental and safety regulation and licensing processes. Clearly any decision by the Council to support the bid for the Dounreay site in principle, will not prejudice any later regulatory decisions made.

6.2 Given the scale of the opportunity and the long-term economic benefits this potential investment could bring, Members are asked to support the Caithness and North Sutherland Regeneration Partnership in making the bid.

Designation:	Executive Chief Officer Infrastructure and Environment
Date:	12 March 2021
Author:	Malcolm Macleod, ECO – Infrastructure and Environment
Background Papers:	Further information from UKAEA can be found here: www.step.ukaea.uk/

STEP

Spherical Tokamak for Energy Production

UK Atomic Energy Authority

What is STEP?

STEP (Spherical Tokamak for Energy Production) is an ambitious programme to design and build a prototype fusion power plant.

It is a UKAEA programme, currently with £222 million funding from the UK Government to produce a concept design by 2024.

As we move beyond 2024 into the engineering design and build phases of the programme we will work with a range of partners to deliver the prototype of a commercially viable fusion plant.

What are you planning to build?

The STEP prototype will demonstrate the commercial viability of fusion. The learning from this will enable the future development of a fleet of commercial fusion plants.

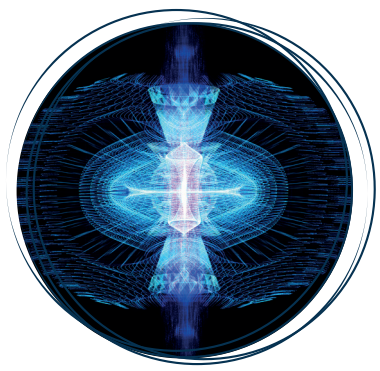
Once constructed, STEP will produce net energy and prove that electricity can be predictably and stably produced in a fusion power station.

Phase 1

The aim for this first phase of work is to produce a ‘concept design’ by 2024. This means an outline of the power plant, with a clear view on how we will design each of the major systems.

Phase 2

Through phase 2 the design will be developed through detailed engineering design, while all consents and permissions to build the plant will be sought.



Phase 3

Construction of the prototype power plant will begin in phase 3, targeting completion around 2040

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Finding a site for STEP

UK Atomic Energy Authority

In Autumn 2020, there will be an open call to communities across the UK to host the prototype. UKAEA will make a recommendation to the Secretary of State for BEIS on the most suitable locations for STEP following a rigorous process of assessment using a defined set of key criteria.

More information on the siting process can be found on the website:
step.ukaea.uk

What will the site requirements be?

With the plant still in the design phase, it's not possible to be too precise about exactly what buildings and facilities will be needed on site. This will become increasingly clear in the coming years as the design develops and a site is established.

STEP will have many of the features of a fully operational power station, including infrastructure and associated research and development facilities. It is likely to be of a comparable scale and value as any major power station.

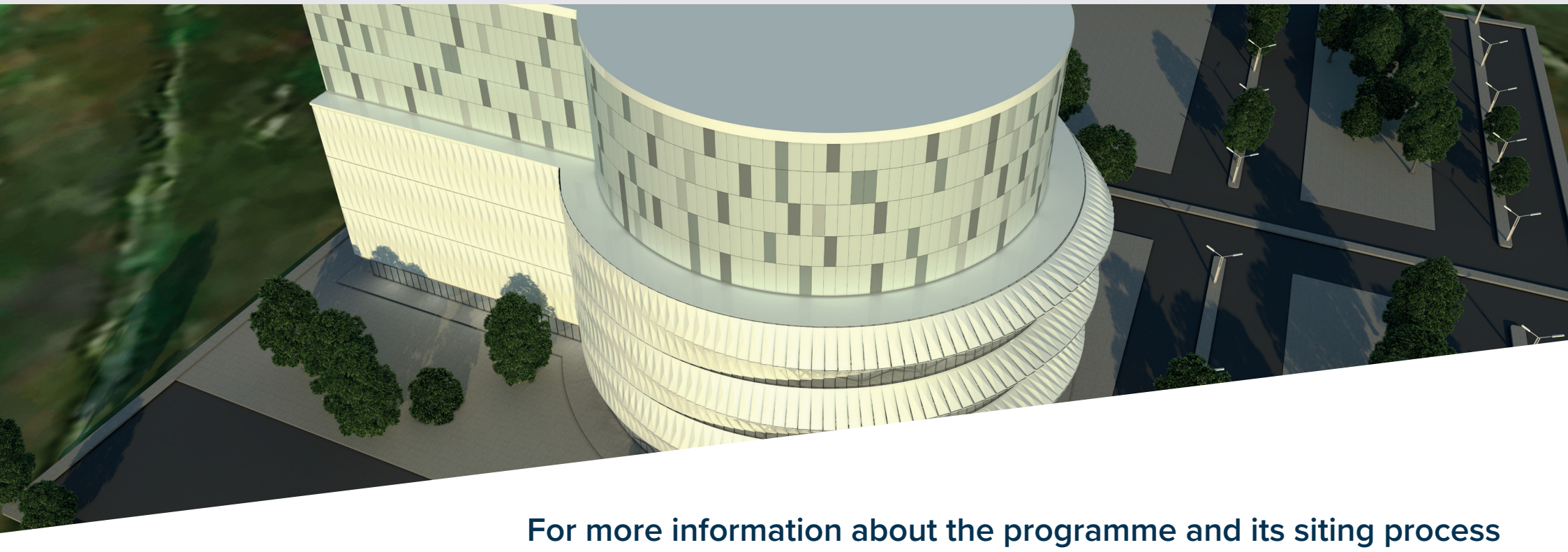
What benefits are there for the community?

There will be long-term and enduring economic benefits to the host community. STEP will be a project at the international forefront of the clean energy revolution, bringing visibility to the community on a global stage.

STEP will create opportunities for growth across the UK, with jobs at all levels created in the region. The programme will also have a focus on skills development.

The skills needed will mostly be in science, technology, engineering and maths although there will be opportunities across a wide range of roles and skills.

UKAEA has already allocated resources to support an apprentice training scheme in the local area and will work with local education and training providers at the earliest opportunity.



For more information about the programme and its siting process please visit: step.ukaea.uk where you can sign up for regular updates.

To discuss any aspect of the STEP programme further please contact: siting@step.ukaea.uk

Appendix 2

Fusion and power generation

Q: “What world-changing idea, small or big, would you like to see implemented by humanity?”

A: “This is easy. I would like to see the development of fusion power to give an unlimited supply of clean energy.”

Prof Stephen Hawking ‘Brief Answers to the Big Questions’ [i](2018)

What is Fusion[ii]?

Fusion is the energy source of the Sun and stars. In the tremendous heat and gravity at the core of these stellar bodies, hydrogen nuclei collide, fuse into heavier helium atoms and release tremendous amounts of energy in the process.

Twentieth-century fusion science identified the most efficient fusion reaction in the laboratory setting to be the reaction between two hydrogen isotopes, deuterium (D) and tritium (T). The DT fusion reaction produces the highest energy gain at the "lowest" temperatures.

Three conditions must be fulfilled to achieve fusion in a laboratory: very high temperature (on the order of 150,000,000° Celsius); sufficient plasma particle density (to increase the likelihood that collisions do occur); and sufficient confinement time (to hold the plasma, which has a propensity to expand, within a defined volume).

At extreme temperatures, electrons are separated from nuclei and a gas becomes a plasma—often referred to as the fourth state of matter. Fusion plasmas provide the environment in which light elements can fuse and yield energy.

In a tokamak device, powerful magnetic fields are used to confine and control the plasma.

What are the effects of fusion on the environment?[iii]

Fusion is among the most environmentally friendly sources of energy. There are no CO_2 or other harmful atmospheric emissions from the fusion process, which means that fusion does not contribute to greenhouse gas emissions or global warming. Its two sources of fuel, hydrogen and lithium, are widely available in many parts of the Earth.

What’s the difference between nuclear fission and fusion?

Both are nuclear processes; in that they involve nuclear forces to change the nucleus of atoms. Chemical processes on the other hand involve mainly electromagnetic force to change only the electronic structure of atoms. Fission splits a heavy element (with a high atomic mass number) into fragments; while fusion joins two light elements (with a low atomic mass number), forming a heavier element. In both cases, energy is freed because the mass of the remaining nucleus is smaller than the mass of the reacting nuclei. The reason why opposite processes release energy can be understood by examining the binding energy per nucleon curve. Both fusion and fission reactions shift the size of the reactant nuclei towards higher bounded nuclei.

Does Fusion produce radioactive nuclear waste the same way fission does?

Nuclear fission power plants have the disadvantage of generating unstable nuclei; some of these are radioactive for millions of years. Fusion on the other hand does not create any

long-lived radioactive nuclear waste. A fusion reactor produces helium, which is an inert gas. It also produces and consumes tritium within the plant in a closed circuit. Tritium[iv] is radioactive (a beta emitter) but its half life is short (12.3 years). The beta particle that is emitted by tritium has a very low energy. As a result, these particular beta particles can only travel about 6 millimetres (mm) in air. It is only used in low amounts so, unlike long-lived radioactive nuclei, it cannot produce any serious danger. The activation of the reactor's structural material by intense neutron fluxes is another issue. This strongly depends on what solution for blanket and other structures has been adopted, and its reduction is an important challenge for future fusion experiments.

Can fusion cause a nuclear accident?

No, because fusion energy production is not based on a chain reaction, as is fission. Plasma must be kept at very high temperatures with the support of external heating systems and confined by an external magnetic field. Every shift or change of the working configuration in the reactor causes the cooling of plasma or the loss of its containment; in such a case, the reactor would automatically come to a halt within a few seconds, since the process of energy production is arrested, with no effects taking place on the outside. For this reason, fusion reactors are considered to be inherently safe.

Can fusion reactors be used to produce weapons?

No. Although hydrogen bombs do use fusion reactions, they require an additional fission bomb to detonate. Working conditions of a magnetically confined fusion reactor require a limited amount of fuel in the reactor. This fuel is continuously injected and consumed; therefore, there is never a sufficient amount of fuel to produce the instantaneous power required for a weapon.

When is electricity generated through fusion expected to be available?

At present, fusion devices produce more than ten megawatts of fusion power. ITER will be capable of producing 500 megawatts of fusion power. Although this will be on the scale needed for a power station, there are still some technological issues to address before a commercial power plant can operate. The STEP prototype of a fusion reactor is expected to be built by 2040. Electricity generation and exploitation developed through these and other approaches is also expected to take place in the second half of the century, depending on funding and technical advancement.

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[i] Brief Answers to the Big Questions is a popular-science book written by physicist Stephen Hawking, and published by Hodder & Stoughton (Hardcover) and Bantam Books (Paperback) on 16 October 2018.
[ii] ITER project https://www.iter.org/proj/inafewlines
[iii]International Atomic Energy Agency – Fusion FAQs https://www.iaea.org/topics/energy/fusion/faqs
[iv] https://hps.org/documents/tritium_fact_sheet.pdf

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Tuesday 9 March 2021

STEP FUSION PROTOTYPE REACTOR – CAITHNESS

Dear

As Chair of Caithness Area Committee, I am writing on behalf of all eight Caithness councillors to state our unanimous, cross-party support for the bid to site the STEP Prototype Fusion Reactor in Caithness and North Sutherland.

We believe that Caithness is ideally positioned to develop this technology, having hosted prototypical reactors for the UK Atomic Energy Authority and the Ministry of Defence for six decades. Both licensed sites support a highly skilled local workforce and a diverse supply chain across the Far North that is unlike any other in the United Kingdom.

Fusion technology has the advantage of creating abundant energy with no long-life radioactive waste and inherent safety benefits over conventional nuclear development. The specialist skills developed at both the Dounreay and Vulcan sits are readily transferable to fusion. This expertise and technology can be exported globally, as well as acting as a catalyst for further R&D and inward investment.

Long-term, the STEP programme is a natural successor to the Dounreay site, with the potential to create hundreds of highly skilled jobs and support an extensive apprenticeship programme. A whole new generation could benefit from the spin-off businesses and innovation that will inevitably flow from this project, and the education and employment opportunities will last for decades to come.

Beyond Caithness, the bid will strengthen opportunities for Highland in its drive towards net zero, and build on the reputation of our region as the energy centre of the whole country.

In short, the STEP Prototype Fusion Reactor is a critical opportunity to diversify the Caithness economy and present a positive, long-term vision for the prosperity of our county.

As elected members we fully endorse the bid and are committed to working with key regional and national stakeholders to bring it to fruition.

Signed

Cllr Nicola Sinclair, Cllr Struan Mackie, Cllr Karl Rosie, Cllr Raymond Bremner, Cllr Matthew Reiss, Cllr Andrew Sinclair, Cllr Willie Mackay, Cllr Donnie Mackay