

Science, Innovation and Technology Committee

Oral evidence: Innovation showcase, HC 523

Tuesday 8 April 2025

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Members present: Chi Onwurah (Chair); George Freeman; Dr Allison Gardner; Kit Malthouse; Jon Pearce; Steve Race; Adam Thompson.

Question 13

Witness

I: Itxaso Ariza, Chief Technology Officer, Tokamak Energy.

Examination of witness

Witness: Itxaso Ariza.

Chair: Good morning and welcome to this morning's session of the Science, Innovation and Technology Committee. The Committee wants to understand how the UK supports innovators and what more can be done. Every week, we start our session with our innovation showcase. To inform our work, each Committee member takes turns to select an innovator to share their story before our main evidence session. This week's innovator is Itxaso Ariza of Tokamak Energy. Jon Pearce will introduce her.

Q13 **Jon Pearce:** Thank you, Chair. This week's innovator Tokamak Energy is a world-leading fusion technology company. They are driving progress towards commercial fusion, which has the potential to deliver clean, safe, limitless and secure energy.

I chose them for my showcase because fusion is set to be a \$10 trillion global industry by 2050. Their work places the UK firmly at the centre of the global race to develop and deploy the technology. Also, they have an east midlands connection: they have been shortlisted, as part of the Celestial consortium, as the engineering partner for the Government's STEP programme, which will develop a prototype fusion plant at West Burton in the east midlands by 2040. I will now hand over to Itxaso to deliver the showcase.

Itxaso Ariza: Good morning, everyone. Thank you for having me. I may speak a bit fast because I get really excited when I talk about fusion. I am chief technology officer for Tokamak Energy. I am going to talk about fusion to start with, and then superconductivity. I am not sure how much you know about fusion, so I will start by saying what fusion is.

Fusion is where two light atoms, or the nuclei of two atoms, bind together or fuse to produce energy. They release a lot of energy when they do that. Fission, which is the nuclear reaction that we use in nuclear plants today, is the opposite: you take one big atom of enriched plutonium, normally, or uranium, and split it into two to release energy. The interesting thing about fusion is that the fusion reaction, where two atoms bind, is 10 million times more energy emitting than fission is. It is a lot more powerful, but it is not used in nuclear reactions today because it is really hard to achieve.

The conditions required for fusion are very specific with regard to temperatures and pressures. It is the energy that powers the stars and the sun, but on Earth it is hard to achieve. That is difficult for us but also a benefit, because it makes it inherently safe. You need to maintain those conditions for fusion to continue. If the conditions were lost, the reactor would shut down, so there is no concern about runaway reactions like in fission.



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Fusion does not require any enriched fuel to operate and does not leave any radioactive waste in its wake. It uses abundant fuel: sea water or hydrogen atoms in water can be used as fuel. As Jon said, it is clean, limitless and safe. We believe it will be part of the energy security of the future—a very good complement to renewables, providing a reliable source of energy and perhaps requiring a lot less space than solar and wind.

How do you achieve fusion on Earth? A lot of different types of fusion reactors have been operated around the world. When it comes to commercial fusion, a tokamak, which is a chamber that has the shape of a ring, is the one that has the most promising results to date, leading to commercial fusion. The conventional tokamak—this is where it will become more understandable—is shaped like a doughnut. I was trying to find a doughnut-shaped thing that I could bring to show you. The Joint European Torus was shaped like a ring doughnut. ITER, in the south of France, will be shaped like a ring doughnut.

However, some research in the UK about 15 years ago suggested that a spherical tokamak—a spherical chamber—would be a much more promising type of device to achieve fusion. How do they compare? The spherical tokamak is like an apple—we say it is like a cored apple. I have a couple of props here. This is what a spherical tokamak looks like. It really looks like a cored apple. The plasma is contained in the central chamber. I have a smaller version to circulate.

Fifteen years ago, our founders spun off out of UKAEA to develop the spherical tokamak as a fusion device. More recently, the UKAEA and UKIFS selected a spherical tokamak as the device of choice for STEP, to be built at West Burton in north Nottinghamshire in the next decade. We have not quite been selected to be an engineering partner in STEP yet; we hope, by the end of the year, as part of Celestial, that we will be selected to do that.

Since its foundation, Tokamak Energy has been building ever more complicated and bigger devices—spherical tokamaks—culminating with ST40, which is the device we have in operation today. The “40” in ST40 refers to 40 cm being the distance between the centre of the device and the centre of the plasma. It is actually not a very big device. With all the ancillary support of the heating systems, control systems and diagnostic systems, and the power supply it needs, because we cannot take the power from the grid directly, it occupies a volume of about 8,000 cubic metres in a building in Oxford.

ST40 is really impressive because, although it is small, it has achieved results comparable with devices that are 80 times bigger, and probably 1,000 times more expensive. It was built in record timescales in Oxford. In 2022, it achieved the record temperature of 100,000,000°C. That temperature is what you need to achieve fusion. It also happens to be six times hotter than the core of the sun, and it is just down in Oxfordshire.



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The team operates plasma on a daily basis. They continue to advance the science. ST40 is the reason why many people like me joined Tokamak Energy. There are many fusion companies around the world but not many companies that have a functioning device, and an impressive one at that. More recently, it is the centre of the first ever UK-US Government fusion collaboration, in the LEAPS programme that was announced in December last year. It has a really good record on fusion.

Now I will talk about superconductivity. I said that to achieve fusion on Earth you need high temperatures and high pressures. You achieve the high pressures with very powerful magnets. The kind of pressures you need to achieve fusion are not achievable with conventional magnets made of copper material. The currents you need have to be conducted with other materials. That is where superconductivity and high-temperature superconducting materials come into play. They are materials that, when you cool them down, can carry almost any current because they become resistanceless.

To bring it into context—I will pass these around as well—this is a copper tape. It is very thin, similar to the wires you have in your house. It is limited to about 1 ampere at room temperature. The wiring in your house will probably be about the same. You have probably seen fuses around 13 amperes. This other one is HTS tape, which is thinner. You will feel it when you pass it around. It can carry 1,000 amperes—1,000 times more current than copper cable—when it is cooled to 20°C.

Since its inception, Tokamak Energy has been developing high-temperature superconducting technologies. We have become world-leading in superconductivity. We have mastered the tape itself and the physics in the tape. The tape is about 60 or 70 microns thick, but there is only one micron of superconducting material in it. It is a very rare earth material, ReBCO. There is a bit of an art in manipulating the tape but, through investing in its development for the last 10 years, we have become world-leading in superconductivity and in HTS magnets themselves.

We have mastered the tape and we have also mastered the manufacturing methods. We are able to make very compact and very simple modular magnets. This is basically a magnet made of the tape. It is just wound around. Each of the magnets can produce 3 or 4 tesla. You can actually stack them up to operate stronger magnets. The competition has tried to do this, but using different manufacturing methods. The cleverness in the invention here is the modularity and the simplicity in the manufacturing process. We can pass the magnets round.

Through that innovation, we realised that although the HTS magnet technology was developed for fusion, it has applications in all sorts of other fields. We are currently developing magnet coils for transport. We are collaborating with one of the big aircraft manufacturers around the world to develop a magnet for hybrid flights. We are collaborating with



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another international company on magnetic levitation train propulsion. We are collaborating with some Governments on sub-water saline propulsion for defence applications. That is transport.

Beyond that, medical imaging is another very important application for us. MRI machines use a predecessor to HTS technology, which was a low-temperature superconducting magnet. It has its limitations. There are potentially new markets to be opened by using HTS technology in medical research, in medical innovation, in mineral separation and in mining operations.

Because of serving all those applications, and realising that we had a way to manufacture magnets for those applications, in July last year we created TE Magnetics—Tokamak Energy Magnetics. It is a semi-independent division within Tokamak Energy that operates by trying to take superconductivity and the magnet technology into the adjacent markets.

Chair: We need to come to a close.

Itxaso Ariza: I am just about to finish. Half of the company is working in fusion; the other half of the company works in superconductivity. The next exciting development in superconductivity is not in magnets, but in superconductivity itself. Data centres and AI will require ever increasing energy transmission. The energy transmission required for data centres is not achievable with copper magnets or with copper transmission, so you should see HTS technology as the enabler for the future of AI.

Chair: Brilliant—a great line on which to close. I am sorry to have hurried you towards the end; we could have listened for hours. As someone who has long followed both fusion and fission, I felt I learned quite a lot from your presentation. Thank you, Jon, for introducing Tokamak. We do not generally encourage our innovation showcasers to bring food to the Committee, but I have to say that that illustration of the difference was very effective. Whenever I see an apple now, I shall think about fission. Thank you very much.