Fusion energy: is it the answer to all our woes, or a solution that will never arrive?

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The common quote often stated when fusion energy is mentioned is that it is 30 years away from commercial viability, and always will be.

If we can harness fusion energy, the same process that powers our sun and thus all life on earth, then we could potentially have almost limitless clean energy. Because of the huge changes that this technology could provide to our world, particularly as we stumble ever more quickly towards a climate disaster, research into this technology is being carried out by over 80 institutions and 35 private companies across the globe with billions of dollars being thrown at the problem. And the problems are huge.

Some of those problems include creating a vacuum chamber on a massive scale, whilst heating plasma to 150 million degrees Celsius. If that's not enough, we then need to cool equipment mere metres away from this super-hot plasma to minus 269 degrees Celsius and use a substance (tritium) that costs $30,000 per gram (yes per GRAM) with total global stocks that amount to 20 kg. Yet as with almost any new technology, some of the biggest hurdles to overcome are not technical, or even economic, but political and this is where the International Thermonuclear Experimental Reactor (ITER)[1] can give us hope in an ever more fragmented world.

ITER is a multibillion-dollar project to see if the concept of fusion is a possibility. The experiment that is costing in excess of $20 billion (with some quoting ten times that figure as the true amount) will never generate any usable electricity. It's not even connected to the French electricity grid, this is purely to see if the theory that the scientists are hypothesising will actually work.

Based in the South of France, ITER is a collaboration of 7 main member countries that are sharing the cost, research and production of the first large scale tokamak fusion reactor. First developed by the Russians during the Cold War[2], "Toroidal Magnetic Confinement" reactors (tokamak for short) are an attempt to simulate conditions at the centre of the sun here on Earth with magnets keeping the superheated plasma confined so that hydrogen atoms can be forced together thus creating helium and a lot of excess energy that we can then harness. The theory seems to be clear, it should work: applying that theory in the real world is the problem.

Member states of the ITER consortium are each producing key components, then shipping them to the site in France so that knowledge, research and product development can be disseminated across the globe. This also has the added benefit on a practical level that it helps the member states offset their financial commitment to the project by investing in their own economies. Crucially though, all members then have open access to the discoveries and techniques developed by their partners. So, these production developments and technical innovations – such as technical advances in India where the cryogenic systems are being produced, or China's work in producing some of the largest magnetics ever made – are then shared throughout the other member states.

Tokamak reactors like that at ITER aren't the only avenue of research though, and research in the USA[3] has demonstrated that Magnetised Targeted Fusion (MTF) may be a quicker, cheaper and more modular approach to commercial fusion energy. This research is so promising that the Biden administration (US Energy Secretary Jennifer Granholm) announced in December 2022 that the USA aimed "to get to a commercial fusion reactor within 10 years"[4]. A bold claim, but one that the USA has backed by over $1 billion of investment this year[5] (2023). This is on top of $3 billion of private investment in the USA in 2022 alone.

The potential returns on this technological breakthrough would be huge with energy production costs being reduced by anything up 75%[6] or more, and the societal impacts cannot be overstated. In a world where clean energy is so cheap, suddenly water scarcity would be a thing of the past as desalination plants could become commonplace, and carbon capture systems become viable allowing a truly net zero emissions future to become a possibility. Heating and cooling homes would have little cost with no greenhouse gas emissions and the move to electrifying our transport system or producing green hydrogen all become possible. Could we eradicate energy poverty? With clean plentiful energy providing a base load to our electricity grids, could the cost of living dramatically reduce, and thus disproportionately help those on lower incomes? Could staples like heat and light become so cheap that costs are negligible, and reduced manufacturing costs invigorate stagnating consumerist volumes? There are so many possibilities.

But this then raises the ugly truth of developmental growth, and as with the ITER project and almost all other fusion research, it is the global North that has invested in the development of this technology and thus controlled the discoveries and expertise created[7]. Whilst the ITER project may well demonstrate cross border collaboration the question must be asked how readily that knowledge will be shared with others? If we manage to attain commercial fusion energy production, will it solve the world's energy problems, or will it merely exacerbate the "haves" from the "have not's"? Only time will tell.

More than the eye-watering costs, or ground-breaking technical strides that fusion research is taking, it is the cross border collaboration that ITER is championing that sets it apart in a world that is becoming more and more insular and isolationist. If Russia, the European Union, the USA, India, South Korea, China, and Japan can set aside their differences to try and show that fusion is possible then perhaps there is hope for us all.

Insights into the ITER project came about as I was a recipient of a grant from the Association of British Science Writers (ABSW) which allowed me to attend the World Conference of Science Journalists in Colombia. This amazing opportunity allowed

me to travel to a marvellous country and be taken out of my comfortable Euro-centric world and be exposed to cultural, economic and environmental norms very different to my everyday.

I travelled to the conference expecting to be surrounded by egocentric ‘hacks’ that were either too timid to challenge the status quo or too comfortable to upset their funding streams. What I found were people determined to make a difference to the world they lived in through their writing. Collaboration was evident in almost all of the workshops and discussions during the conference, with industry, NGO’s (non-governmental organisations) universities, communities, and governments all having a role to play. The writers and journalists I met often had to supplement their income with secondary careers in order to be able to write, but they did it because they were determined to make a difference.

Thank you to the ABSW for this opportunity, and to the science journalists of the world; keep up the great work, you are needed more than ever.

1. https://www.iter.org/
2. http://www-fusion-magnetique.cea.fr/gb/fusion/histoire/site_historique.htm
3. https://www.theguardian.com/environment/2022/dec/13/us-scientists-confirm-major-breakthrough-in-nuclear-fusion
4. https://www.bloomberg.com/news/articles/2022-12-13/biden-wants-fusion-power-by-2032-it-s-likely-to-take-far-longer?leadSource=uverify%20wall
5. https://www.fusionindustryassociation.org/post/congress-provides-record-funding-for-fusion-energy
6. https://www.prnewswire.com/news-releases/fusion-energy-can-be-the-most-cost-competitive-source-of-baseload-power-at-the-same-level-as-renewables-301150014.html
7. https://www.iaea.org/bulletin/uniting-countries-through-fusion-research-and-cooperation