Japan Equity Strategy – Fiery Rings.

Nuclear fusion in Japan, and why we should now start to pay attention.

29th August 2024

KEY TAKEAWAYS

- Recreating the sun's energy on Earth has been tougher than anyone imagined, but as the need for clean energy grows, investors' pockets get deeper.
- A cascade of scientific breakthroughs and records, with public and private funding expanding, suggests useful reactors may not be far off.
- Within six years, there could be a profound change in Japan's energy planning with "new nuclear", decarbonization plans and perhaps even a future for electric cars.

Japan / EQUITY STRATEGY RECOMMENDATION

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The long-standing joke

The long-standing joke within and outside scientific circles has been that nuclear fusion as an energy source is 30 years away and always will be. I have been of the same opinion: it seems just too hard to pull it off.

But my mind was changed after a conversation last week with a young post-graduate, a friend's nephew who, armed with his freshly minted mechanical engineering degree, has landed a job in the private nuclear power sector. He will be spending a third of his time working on upcoming fusion systems – and the rest on fission reactors, maintenance, and long-term decommissioning. He is not a wild-eyed scientist, but a down-to-earth mechanical engineer. Hearing this persuaded me to take a fresh look at what has been going on recently to see what I may have missed.

What makes fusion advances particularly relevant for me is that Japan has been craving new energy sources for over a decade, and as the yen plummeted the energy bill rose to a hefty 6% of GDP. For Japan to import 94% of the fuel to generate its base load of electricity is incredibly expensive. And with no native oil supplies worth mentioning, all of the petrol and diesel for transport is also imported.

Recreating the sun is challenging.

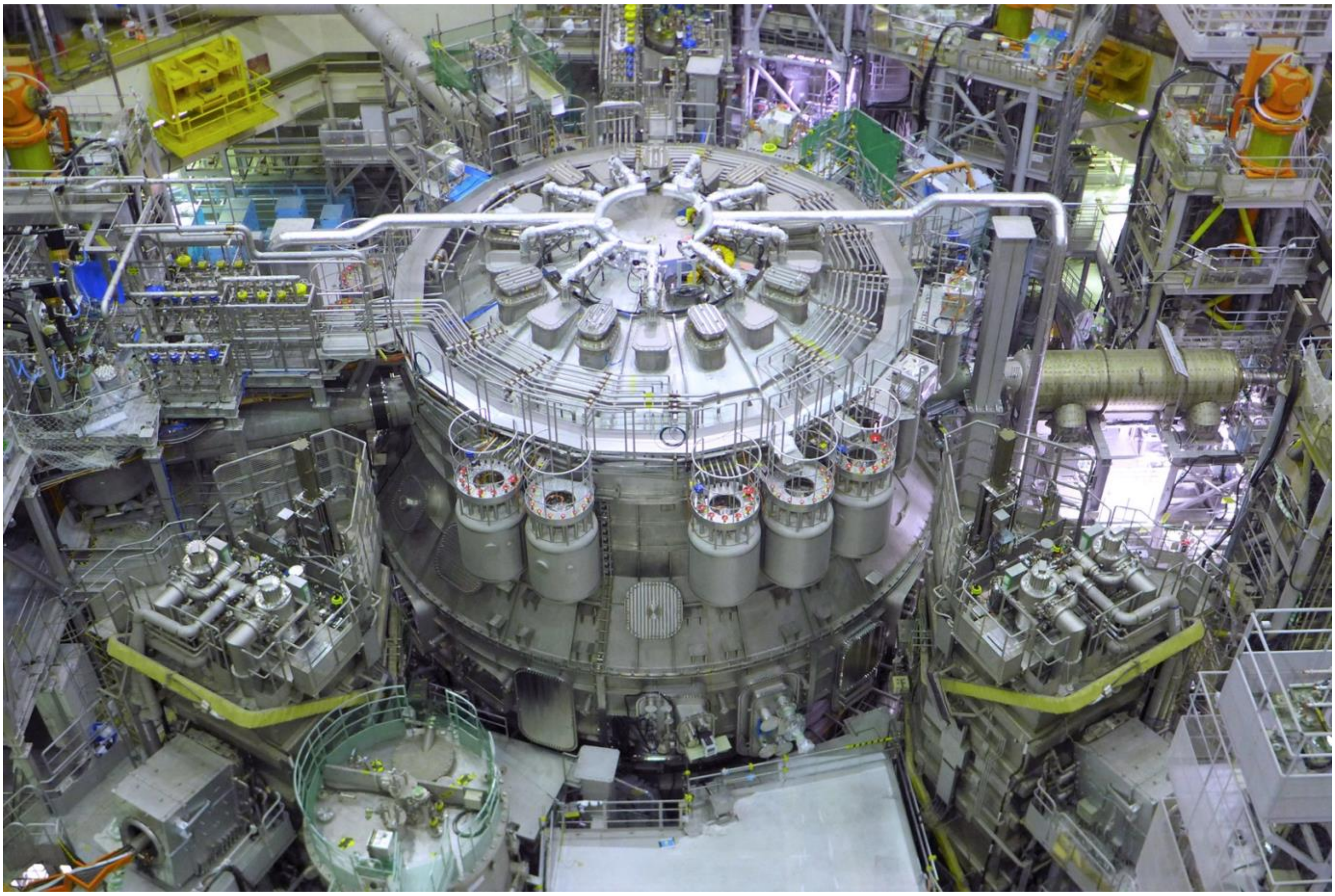
Source: JAPANMACRO

Japan has not been idle.

Today, there is little hope of squeezing more efficiency out of Japan's electricity usage as the country has been very stingy since the 2011 tsunami that took the nuclear power plants offline, most of which will never restart. And with no slack in the power supply at peak times, if electric cars are ever to become a reality, then a "new nuclear" alternative is the only option.

Japan currently has the world's largest operational fusion reactor, a superconducting tokamak in Naka, Ibaraki Prefecture. The JT-60SA (a.k.a. Japan Torus-60) achieved its first plasma in November 2023, after 15 years of construction, and is jointly operated by Japan and the European Union. Nevertheless, the news flow around Japanese fusion has been relatively low-key, and fusion isn't being meaningfully promoted at energy trade shows.

Japan's JT-60SA is the most powerful Tokamak in the world, located in Naka, Ibaraki.



Source: Fusion for Energy (F4E)/ Japan's National Institutes for Quantum Science and Technology (QST)

But this year has been big for fusion achievements globally, with both new records and research breakthroughs helped by a few jars of Hellmann's Real Mayonnaise. It seems to me the research has both breadth and momentum, and is becoming too important to ignore. As Japan plays a key role, it is time to pay attention to which companies are active and investing in the technology that will knock burning coal to generate electricity, with or without ammonia, into a cocked hat.

But first, please let me indulge in a little theory. My A-level certificates have yellowed with age, but I think I can still get to grips with the basics.

$E = mc^2$ is the key

Albert Einstein's most famous work, in which he theorised that the energy (E) of an object is equal to its mass (m) multiplied by by the speed of light (c) squared comes into play here as nuclear fusion taps into this equation.

When two light atomic nuclei are forced to combine and form a heavier atom, a tiny amount of their mass is converted to energy. But how much energy is that? Well, it's the mass that gets converted multiplied by the speed of light squared. The technical term to describe the amount of energy is "a lot".

If the energy you manage to capture from the reaction is greater than the amount of energy required to create and sustain it, then you have cracked the problem.

The most common fusion reactors in development use as their fuel two close relatives of hydrogen, the isotopes deuterium and tritium. When they are fused they become helium, release a spare neutron, and generate 8 to 10 million times more heat than burning the same weight of heating oil. And no carbon is produced.

Efforts to harness the potential of this physics marvel have been ongoing since the 1950s, but the reaction is very difficult to start and even harder to maintain. Research has been mired by a lack of progress and ballooning costs until now.

Latest attempts

The latest attempts at the fusion reaction take place in a donut-shaped loop, where the hydrogen isotopes are heated to 100 million °C, the necessary temperature to turn them into plasma, an ionized gas.

The plasma then sits in a doughnut-shaped vessel, known as a tokamak, that uses intense magnetic containment fields to keep it comfy and snug. But the fiery ring is notoriously unstable and quickly collapses after firing out a burst of heat, helium, and neutrons.

Some mechanical engineers describe plasma as having the physical state and flow characteristics of mayonnaise; not solid, liquid, or gas, just tricky.

In the past few months, an experiment at the University of Wisconsin-Madison broke the record for the strongest steady magnetic field to contain a plasma in its HTS Asymetric Mirror reactor (WHAM); a 17-year-old student built for his A-levels a fusion reactor that achieved plasma; and mechanical engineers at Lehigh University in Pennsylvania used Hellman's Real Mayonnaise (yes, they name the brand) as a substitute plasma, whipping it to study a plasma type flow at kitchen temperatures to help with the complex containment of the real stuff at 100 million degrees C.

As bizarre as this all might sound – and a mini fusion reactor is way beyond my A-level physics class – the takeaway here is that there is a lot of diverse research going on, and not just in heavily funded government labs. The news is littered with a seemingly endless stream of new records, new scientists and engineers getting involved, and fresh discoveries. When artificial intelligence gets thrown into the mix, especially in superconductor research, we may see even shorter development times and faster breakthroughs.

The Koreans currently hold the record for a sustained reaction, lasting 48 seconds. A major multinational project, the International Thermonuclear Experimental Reactor (ITER), is aiming for a long duration plasma of 600 seconds of 500 MW worth of heat from 50 MW of input power – but they might not be the first now having been delayed to 2034 and while so many other countries involved in national and international projects are aiming for stable plasmas by 2030.

Superconducting magnets, superconducting cables and Japan

One of the key advances in fusion technology over the past 10 years has been the development of high-temperature superconducting magnets. An article in The Telegraph in March cited a poll at the International Atomic Agencies forum in London where 65% of "insiders" thought nuclear fusion will be connected to the UK grid at a viable cost by 2035, and 90% by 2040, largely because of this research.

High-temperature superconducting magnets and cables are a Japanese specialty. Mass deployment will occur with the construction of the 285km (177 mile) Tokyo-Nagoya section of the Tokyo-Osaka maglev bullet train, where this new technology will bring power losses close to zero.

Arguably, Japan is well positioned to build several essential components for fusion reactors: containment vessels, where it has had a significant presence in the fusion power plant construction historically, and superconducting coil magnets where research is intense.

Japan and nuclear fusion

Japan has decided to accelerate the development of nuclear fusion technology to bring it up to a similar target timeframe as other countries and is making strategic alliances to speed the whole thing up where possible. On July 10th, the revision in strategy started under the auspices of the newly formed Japan Fusion Energy Council (J-Fusion) which aims to leverage off Japan's participation in the ITER project and support public, private and scientific national projects by bringing them together. Japan's national project targets will be aligned with the 2030 targets of other international participants in ITER.

Fusion reactors can potentially be very compact, taking up little land, using virtually no water, and can be immediately switched off without the risk of a meltdown, making them particularly attractive for seismically active parts of the world – unlike nuclear fission. The introduction of fusion technology would completely upend the policies on nuclear energy and the future energy mix. And because they have no useful purpose in nuclear weapons manufacture, many places that would have trouble getting funding for fission reactors would have better luck with fusion.

The only byproduct of fusion is inert helium – which in itself is a strategic resource. Helium is used in superconductors for cooling, as its boiling point is close to absolute zero. It is also used in medicine, airships, rockets, spacecraft, and breathable artificial atmospheres.

Getting there

It has taken 70 years for nuclear fusion to get to this point. And some will argue it's still in its very early stages, with commercial applications still decades off. But the cascade of new advances in the area, and the breadth of research around the world that's reported in the media, would suggest otherwise. I'd argue it is the time to put the long-standing joke aside and research investment opportunities.

Chuo Shinkansen, 177 miles of superconducting magnets, and that is just the beginning.

Source: Wikopedia

Pre-IPO companies and investors in Japan

Blue Laser Fusion

Blue Laser Fusion is a nuclear fusion startup based in Palo Alto, California. It is developing its technology in the US and Japan in collaboration with research institutions such as Osaka University. It was founded by 2014 Nobel Prize winner Shuji Nakamura who developed the very first blue LEDs. Softbank and Itochu are two high-profile investors.

Kyoto Fusioneering

Kyoto Fusioneering is a privately funded energy engineering company tackling the difficult engineering aspects of generating power through fusion. It is headquartered in Tokyo, with branches in the UK and US, and R&D in Kyoto. High-profile investors include J-Power, Fujikura, Inpex, JAFCO, Mitsubishi Corp., Mitsui & Co, and Mitsui Fudosan.

Helical Fusion

Helical Fusion is a startup that aims to develop the world's first steady-state fusion reactor. The company was the winner of the grand prize in the pitch contest at SusHi Tech Tokyo, a networking event held for investors from Japan and abroad. High-profile investors include Sony, Nikon, KDDI, and SBI.

EX-Fusion

EX-Fusion is a startup that is developing the first laser-powered commercial nuclear fusion reactor. It is a spin-out from Osaka University that aims to sell to the space and semiconductor manufacturing industries, and contribute to global energy security. It is in the very early stages of venture-capital investment.

Commercial superconducting magnets and cables

Mitsui Mining and Smelting, SWCC Showa Holdings, and Japan Superconductor Technology (JASTEC), owned by Kobe Steel.

Important Information

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Neutral – shares will perform in-line +/- 10%
Sell – shares will lag the market index by more than 10 percentage points.

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