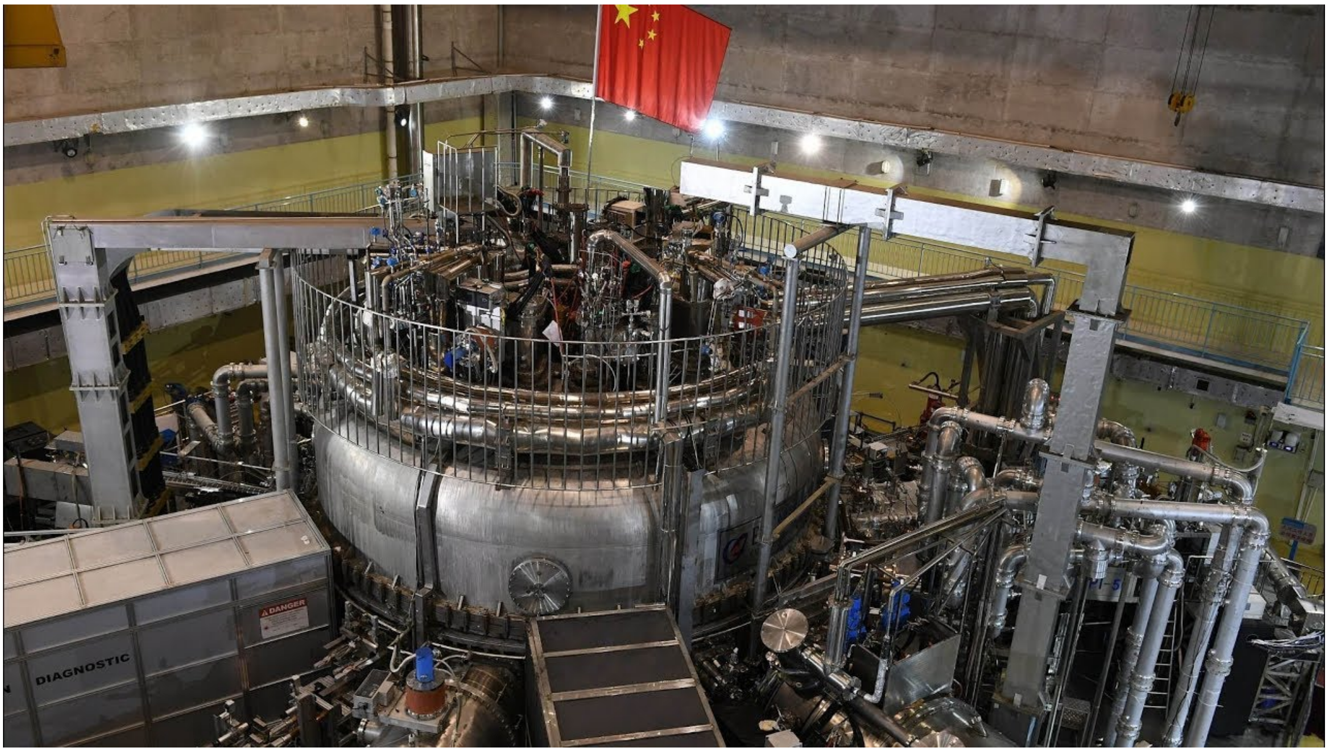
Humanity’s Rays of Hope—China’s Artificial Sun

The human race has been overly dependent on fossil fuels for its energy requirements for centuries. Over the years, newer and cleaner sources of fuels have been developed, but even today, many countries rely on coal for access to cheap and easily accessible power. Although renewable energy sources like solar and wind energy have made their presence felt in a lot of regions, they are still a long way away from replacing fossil fuels as the primary source of energy for our power-hungry species. With multiple energy crises crippling various economies since the turn of this century and global demands for cleaner, renewable power rising in order to curb the effects of global warming, it was high time a serious investment was made into clean, nuclear power.



Construction of China’s EAST Tokamak reactor within the site [Image Credits: Chinese Academy of Sciences]

Although nuclear fission power plants have been operational since the 1950s, they are not the answer to the ultimate energy crisis, given the amount of nuclear waste they generate on top of the high risk of nuclear disasters.

Nevertheless, nuclear energy remains the most reliable clean source of energy the human race could dream of harnessing. Given the spotty safety record of nuclear fission plants, nuclear fusion seems like the perfect alternative to it. Not only is fusion much more potent than fission, but it also carries zero risks for an accident like that in Chernobyl.

Achieving sustainable nuclear fusion has been one of the longest-running endeavours of the global scientific community. The International Thermonuclear Experimental Reactor (ITER) was founded in 1979 with the goal of achieving sustainable nuclear fusion by the second half of the 21st century.

Why Is This Energy Required?

As of 2019, 27% of the world's energy demands were met by coal, one of the most polluting energy sources in existence. Despite legitimate concerns about air pollution and greenhouse gas emissions, coal use is likely to continue to be significant in the absence of concerted government policies. Overall, fossil fuels contributed to about 84% of the world's primary energy consumption in 2019 in spite of revolutionary advances made in various renewable power sources like solar, wind, and hydro energy. They simply aren't efficient enough to fulfil the power needs of seven billion humans.

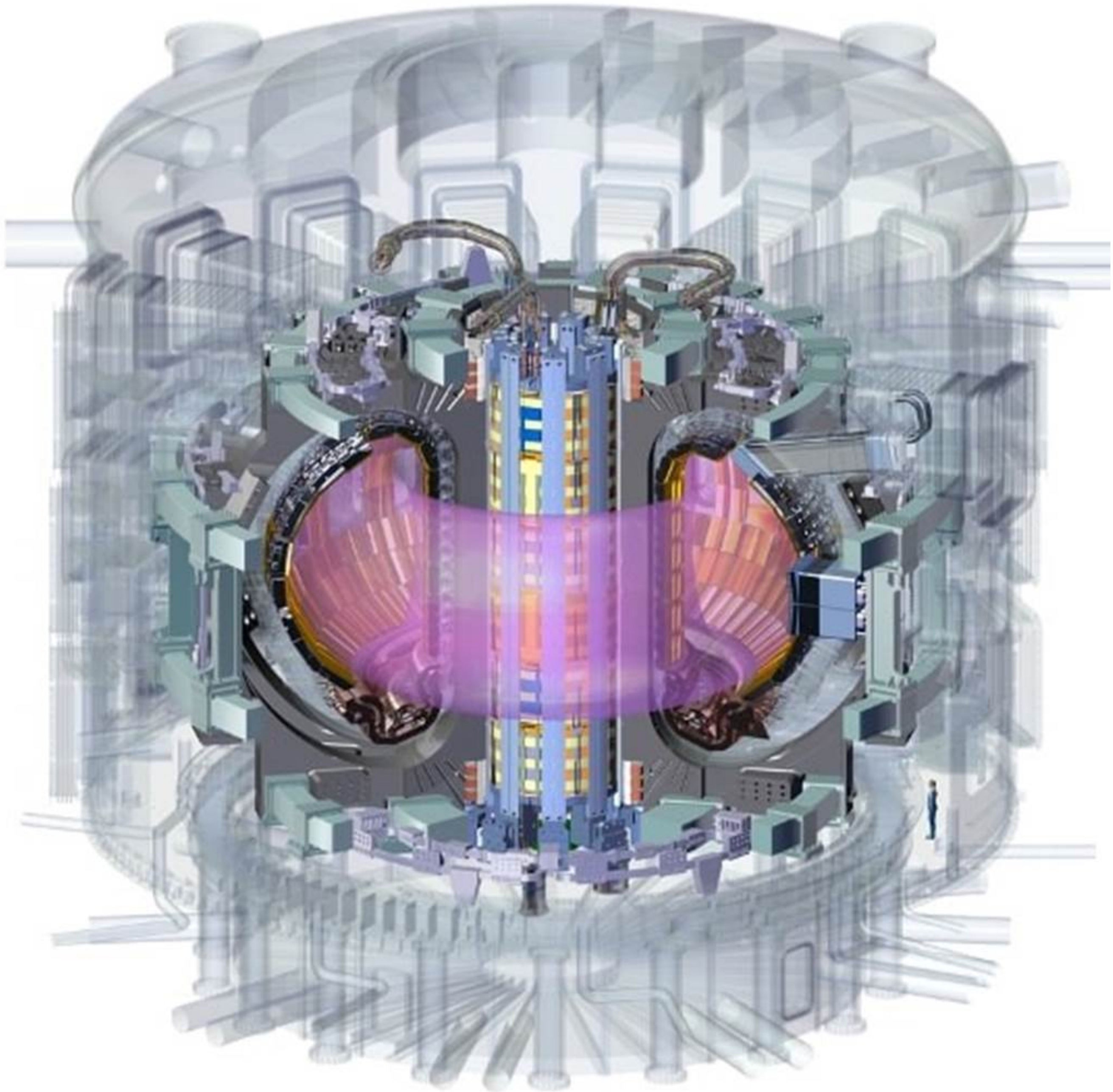
Although relatively cleaner and much more efficient than fossil fuels, the fission reaction has its own issues. In this process, the nucleus of atoms of heavy metals such as Uranium is split into two or more smaller nuclei which releases a lot of energy, along with radioactive byproducts. The amount of free energy contained in nuclear fuel is millions of times the amount of free energy contained in a similar mass of chemical fuel such as gasoline, making nuclear fission a very dense and yet inadequate source of energy.

The 444 nuclear power plants currently in existence provide about 10% of the world's energy. In order to meet current and future energy needs, the nuclear sector would need to scale up to around 14,500 plants, which is beyond unfeasible given the high cost of this process and low availability of enriching the uranium these reactors use as fuel.

The Process Behind It

Nuclear fusion is the process of combining two or more atomic nuclei to form one or more different atomic nuclei and subatomic particles. The difference in the masses of the reactants and the products is manifested as an enormous amount of energy. Our Sun turns 600 million tonnes of Hydrogen into Helium through nuclear fusion every second, releasing the energy that gave birth to life on Earth.

The most efficient fusion reaction in a laboratory setting has been identified to be the reaction between two Hydrogen isotopes: Deuterium and Tritium. This fusion reaction produces the highest energy gain at the "lowest"(about 150,000,000°C) temperatures. ITER aims to achieve a sustainable fusion reaction with the help of a tokamak, an experimental machine designed to harness the energy of fusion. Inside this doughnut-shaped vacuum chamber, under the influence of extreme heat and pressure, gaseous Hydrogen becomes plasma—a hot, electrically charged gas. Plasma provides the environment in which light elements can fuse and yield energy.



Central solenoid placed in the heart of the reactor to initiate and drive the plasma during operation [Image Credits: ITER]

The energy produced is absorbed as heat in the walls of the vessels. Just like a conventional power plant, a fusion power plant will use this heat to produce steam and then electricity by way of turbines and generators. Not only is this process much more efficient than fission, but it doesn't produce any radioactive waste either. In addition to that, the fuels required for this process are Deuterium and Tritium, which are much easier to obtain when compared to the enriched Uranium that fission requires. In terms of sheer scale, the energy potential of the fusion reaction is superior to all other energy sources discovered so far. A controlled, ideal fusion reaction would yield four million times more energy than a chemical reaction such as the burning of coal, oil or natural gas and four times more than nuclear fission.

Demerits

The fundamental principle on which the reactor works is nuclear fusion. As opposed to the widely used fission of particles, fusion requires an inexplicably large amount of initial temperature to take place. This is by no means easy to achieve, especially considering the work environment of a laboratory.

It is equally important to maintain the plasma at a very high temperature, which happens to be extremely challenging given the fickle nature of particles vibrating with high energy in their plasma state. Since plasma is being contained in a controlled environment, any slight miscalculation or error can prove to be fatal. The hot plasma formed by nuclear fusion is capable of laying waste to entire buildings and melting human tissue on contact. As such, there is an undoubtedly high risk that comes with working in a laboratory with such conditions.

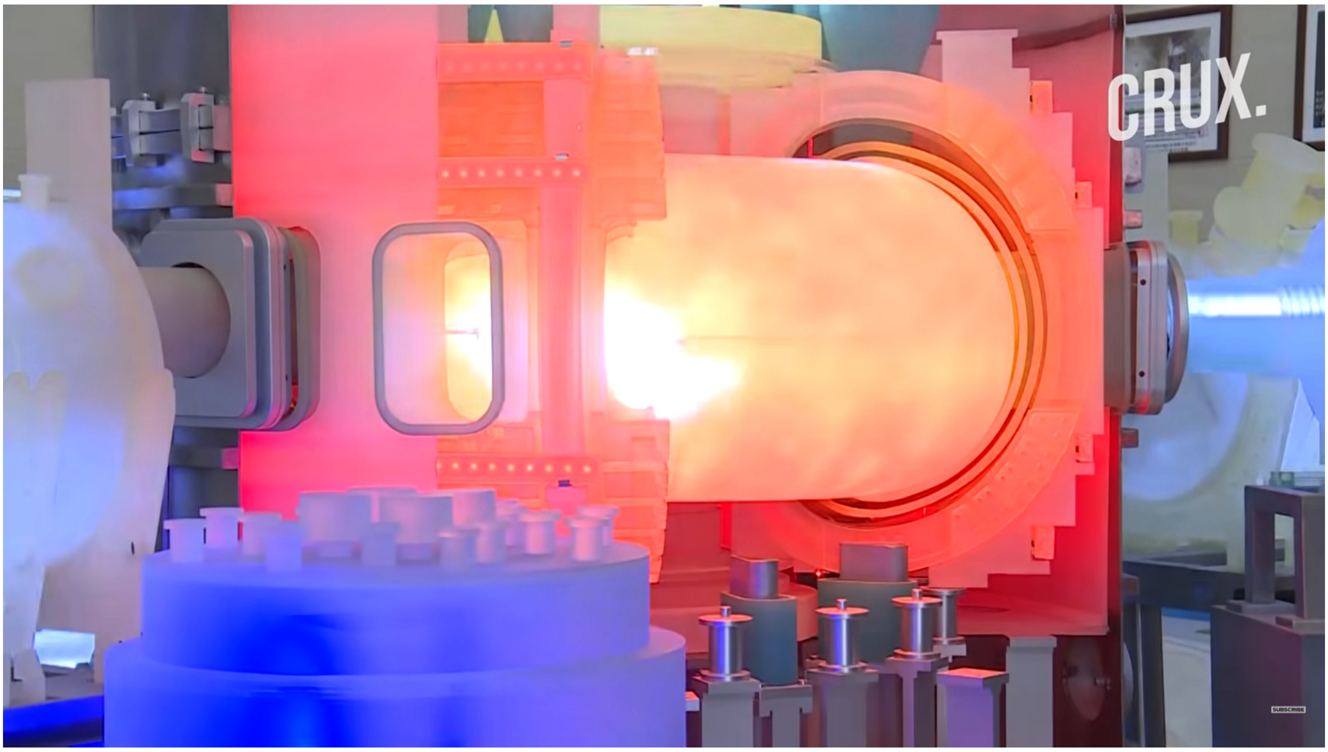
Another important aspect to consider, as with anything that has to do with a developing civilisation, is the ever-changing political climate. It is unpredictable as to how the Chinese government may choose to distribute their new-found energy resource, should it come to fruition. Solid diplomatic relations with other countries would ensure that the world progresses as one. However, such overwhelming power in the wrong hands or with the wrong political connections at any point in the future might lead to a completely polar outcome.

Hindrances To Its Development

The most crucial step of harnessing this energy source is containing it first. In order to do so, a material must be found or fabricated to withstand the high temperature and prevent any leaks or that may arise, causing explosions and unprecedented disasters. Wang Yugang, a professor of nuclear physics at Peking University in Beijing, stated that some radioactive particles produced by fusion reactions could not be contained by HL-2M's magnetic field. *"It is fine only for short-term operation,"* Wang said, also insinuating that no man-made material could withstand the cumulative damage over a long time period. Furthermore, Wang adjudged that finding the right material may take several years.

Scientists are currently uncertain as to how they can go about keeping the reactor burning. A commercial reactor would need to run for years or even decades, and Chinese researchers are trying to find a solution at the Tokamak (EAST) in Hefei, which was built to make the fusion reaction last several minutes or longer. Another concerning uncertainty is the amount of heat required. The Tokamak is the only facility in the world with the capacity of simulating a heat ten times the temperature of the sun's surface.

Moreover, in its current progression, the scientists have successfully managed to maintain a steady temperature of 120 million degrees Celsius for a grand total of 101 seconds, which is no way near the required amount of time for it to be a sustainable energy resource. It additionally attained a peak temperature of 150 million degrees Celsius for 20 seconds. The heavy funding from government grants to further experiments is something to keep in mind, considering that the long-term plan of the project spans literal decades in the making.



The Tokamak reactor breaking the world record by successfully maintaining a high temperature for nearly two minutes [Image Credits: CRUX]

What's In Store For The Future?

Despite the challenges, the Chinese government is primed to proceed with building the China Fusion Engineering Test Reactor (CFETR) as soon as next year. The experimental reactor, which could take about a decade to build, would use extremely powerful magnetic fields to contain the hot plasma.

Apart from EAST, China is operating the HL-2A reactor as well as J-TEXT at the time. This experimental reactor is a milestone in the growth of China's nuclear power research capacities. This project includes the contribution of various other countries such as India, South Korea, Japan, Russia and the USA.

China aims to achieve the commercial production of fusion energy by the year 2050, and it is suggestive that this country would believe in the idea even when others abandon it considering it a costly, risky and potentially hopeless cause.

ITER has also been working on its own reactor in France. It is expected to be completed in 2025.

While the thought of the reactor being completed in a couple of decades seems like a distant pipe dream, one must keep in mind the giant leap in modern civilisation it will bring in. The project has received copious amounts of criticism with respect to its production, along with scepticism from the media as well as distinguished professors and scientists. Nevertheless, the news of China’s Artificial Sun provides a sliver of hope and respite in light of real-world issues such as global warming and toxic pollution. As Rome was not built overnight, it will undoubtedly take an immense amount of time and effort to usher in the new age of clean energy.

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