Israel and the Global Race for Artificial Sun

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Energy consumption on earth is expected to rise in the coming decades, due to the increase in the world population and the economic and industrial growth of developing countries. One of the most effective and green alternatives for creating energy is nuclear fusion. The ITER, the international project to study nuclear fusion, is one of the ambitious ventures to construct a research reactor, and there are other projects that in recent years have achieved international breakthroughs in a field that is expected to become critical to the struggle against global warming and a response to the growing need for energy security. Although there is still a long way to go before the technology matures, Israel should harness its government, academic, and private sectors to integrate and become a significant player in an enterprise that will also be a means of strengthening its scientific and economic ties worldwide.

Energy consumption on earth is expected to rise in the coming decades, due to the increase in the world population and the economic and industrial growth of developing countries, particularly India and China. In 2020, over 80 percent of the world's energy was produced by burning fossil fuels, but this method generates greenhouse gases, leading to global warming. Therefore, for a number of decades, experiments have been conducted worldwide to find alternative sources of energy that do not pollute and will be able to supply humanity's expanding energy demand and the growing need for energy security.

One of the options is to generate energy by nuclear fusion, where energy is produced by merging atomic nuclei with larger nuclei. For example, combining hydrogen atoms with helium is the process occurring naturally in the sun's core, thanks to its enormous gravitational force. This vast

energy is released as heat, creating the sunlight that reaches the earth. A significant benefit of nuclear fusion is its high degree of safety compared to other methods of producing energy. Unlike nuclear fission, that is, breaking a larger atom into smallter atoms, which is the process that takes place in the world's nuclear reactors, the fusion process produces far more energy and does not create radioactive waste. The drawback of this method is the difficulty of conducting it in controlled coditions. The very high temperatures required for the process means it cannot take place in a physical container, and it is therefore necessary to use vast magnetic fields to contain the heated fuel.

Researchers seek ways to effectively reproduce the nuclear fusion process, the mechanism by which energy is created in the sun's core, and thereby generate huge quantities of clean electricity. Until recently, efforts focused on two methods of performing nuclear fusion: using large powerful lasers to compress hydrogen; or using a device called a tokamak, which involves activating a strong magnetic field around the hydrogen fuel. This method is currently closer to reaching a positive energy balance – in other words, the total energy produced in the process is greater than the energy used. At the Geneva summit in 1985 US President Ronald Reagan and Soviet Union leader Mikhail Gorbachev decided that the issue demanded an international effort, and jointly announced the establishment of the nuclear fusion research venture, called the International Thermonuclear Fusion Experimental Reactor (ITER). Thirty-five countries, led by the United States, China, India, South Korea, Japan, Russia, and the European Union, participate in the project, which uses the tokamak method.

China joined the ITER venture in November 2006. While its contribution to the project's construction and operation is estimated at only 9 percent, it began working independently on nuclear fusion in the middle of the last century, when it established the Southwestern Institute of Physics (SWIP) in 1965. In 2020, the HL-2M Tokamak facility began operation, using hydrogen and deuterium gases to create an "artificial sun." Another facility to study nuclear fusion is Experimental Advanced Superconducting Tokamak (EAST), which has been operating since 2006 in the Chinese Academy of Sciences

(CAS). In May 2021 it was claimed that it had set a new world record by reacing a plasma temperature of 120 million degrees Celsius for 101 seconds. The facility broke a further world record in December 2021 when it reached a plasma teperture of 70 million degrees Celsius for 1956 seconds. In addition, China is currently building an innovative nuclear reactor called China Fusion Engineering Test Reactor (CFETR), which uses powerful magnetic fields to create plasma or hot gas. This venture has three phases; the first phase, building the reactor, will be completed by 2035. In the second phase the nuclear fusion tests will begin, and in the third stage, estimated to start in 2050, China expects to produce electricity from nuclear fusion.

The West too is working feverishly on breakthroughs in this field. In August 2021, scientists at the United States National Ignition Facility (NIF) in California managed to produce by fusion about 70 percent of the input energy. In Britain, where the Joint European Torus (JET) venture operates, scientists succeeded in producing 59 mega-joules of energy for 5 seconds in an experiment conducted in December 2021 – twice their previous record from 1997. Another British venture is STEP, which aims by 2040 to connect the nuclear reactor currently under development to the national electricity grid. In France the ITER experimental reactor is under construction with the help of all 35 partner countries, and it is expected to begin its first tests in December 2025.

There are also some innovative private ventures that are trying to achieve nuclear fusion by various methods, and are on a much smaller scale than the facilities. A 2022 report from the Fusion Industry Association found 33 companies worldwide with a total investment close to $4.86 billion – a rise of 139 percent since 2021. Some of these companies seek to achieve a net profit from energy by the middle of this decade. The number of private companies in the field is expected to incrase in the next few years. The report also mentions the N.T.TAO startup as the only Israeli representative on the list.

Population growth has not bypassed Israel, whose population is expected to reach about 17.5 million by 2050. In addition, as of 2020, the average annual emission of greenhouse gases per head in Israel was about 8.5 tons. In view of the growing importance of the fight against global warming, and with the approach of his participation in COP26 in Glasgow in November 2021, in October 2021 then-Israeli Prime Minister Naftali Bennett announced zero greenhouse gas emissions by 2050. Among the steps taken by Israel are the program to support climate innovation and the establishment of the Conference on Climate Innovation and Technology led by the Prime Minister. The Ministry of Energy has already issued a call to create a consortium of research institutes led by the Hebrew University, Tel Aviv University, and the Soreq Nuclear Center, and the next stage is to set up a national research institute in the field of nuclear fusion with an investment of about NIS 30 million.

Conclusion

Efficient production of energy from nuclear fusion and its actual implementation will take much more time. At COP26, China and the United States jointly declared they would cooperate on reducing their greenhouse gas emissions in the present decade. They have already cooperated in the past: in 2019 it was announced that joint China-US teams had conducted research in which they managed to trap plasma in a strong magnetic field in order to prevent it from spreading. In August 2022 China announced that it was suspending the cooperation with the United States on climate research, after criticism in Taiwan from Speaker of the House of Representatives Nancy Pelosi, which increased the growing tension between the powers. However, at their meeting in November 2022, President Biden and Chinese President Xi agreed to resume cooperation on the issue. Now it is necessary to examine the consequences of the war in Ukraine and the restrictions on Russia in this context – for the ITER project and other collaboration projects that could be delayed.

Israel has many assets in the field of science and innovation, which could be an important component for strengthening its technological ties with Western and Chinese countries and companies. In addition to the Ministry

of Energy initiatives, the Chief Scientist in the Ministry of Science and Technology and the Directorate of Defense Research and Development (Mafat) in the Ministry of Defense should set up a national mechanism for promoting local research and development on the subject of energy, incorporating efforts from the government, academic, and scientific sectors. This can help assist Israeli technologies and help position Israel as an active player in the field of energy. Israel can be encouraged to realize its relative advantages and strengthen its political, scientific, technological, and economic ties worldwide – whether as part of the ITER venture or in other interntional or regional ventures, and particularly with its neighbors in the Middle East.

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