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STRONG ARMS FOR 1,500-TONNE LOADS

IN THIS ISSUE

EDITORIAL

Everything must be in place for the machine's First Plasma in December 2025 – the inaugural event of an experimental campaign that will play out over 20 years. To prepare for the machine assembly phase, powerful workhorses have been installed in the Assembly Building . . . two overhead bridge cranes that are capable of delivering component loads of up to 1,500 tonnes to the installation arena (page 2).

Sixty years ago, the Soviets first lifted the veil on their fusion research program. That event, on 25 April 1956, was the founding act of what was to become a truly international fusion community (see more on page 4).

Finally one man – a polar explorer – has placed energy at the centre of his reflection. Jean-Louis Etienne believes in ITER and he tells us why on page 3.

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STRONG ARMS FOR 1,500-TONNE LOADS

In the final stages of the lift operation, 43 metres above the basemat of the Assembly Hall, workers pull on cords to adjust the position of the girders.

1,500 tonnes – or the equivalent of four Boeing 747s fully loaded with passengers and fuel. That's what the recently installed Assembly Building bridge cranes will be capable of handling when operated together.

In June, a powerful crawler crane was positioned outside of the Assembly Building in order to raise and position the main elements of the overhead lift system. From its extended boom, a large hook passed through an opening in the roof and was lowered 43 metres to the basemat below, where four girders and their motorized trolleys were lined up for lifting.

The operation, which lasted some ten days, was a mix of brute force, high technology, and skill. Workers on the basemat below adjusted cables, slings, braces and shackles in order to perfectly balance the loads, while the crane operator – connected by radio from his cabin – slowly lifted each component. Surveyors used laser beams to ensure that everything was proceeding as planned and technicians tugged on ropes to bring the largest components (47 metres long, 186 tonnes) into position.

The overhead crane will have a double role to play in ITER, first handling the machine components during the installation and assembly phase ... and then again during the dismantling phase of the project.

Working together, the cranes will have the capacity to lift ITER's heaviest components. Among them: the cryostat sections (the cryostat base will be the heaviest single load at 1,250 tonnes) and the sub-sections of the vacuum vessel (approximately 1,000 tonnes each).

When the seven levels of the adjacent Tokamak Building are completed the rails of the overhead crane will be extended by 80 metres, creating a 170-metre crane bay along which loads will be transported to the assembly arena.

Seen from the outside: a hook is lowered through the roof from the boom of a giant crawler crane.

First Plasma: 2025

To determine the precise date of ITER's First Plasma, hundreds of engineers, technicians and schedulers worked for nearly 18 months to reconcile the latest information from manufacturers in over twenty countries with construction progress on site. A number of variables – such as how much time could be gained by hiring more specialists or increasing the budget – were also taken into account. The result? An updated calendar and a new date for First Plasma: December 2025.

In offices and factories on three continents, ITER teams are fully aligned behind this new schedule which the ITER Council has validated as "challenging but technically achievable." Weekly and monthly tracking of the key milestones is carried out to monitor progress and to act quickly in the case of slippage.

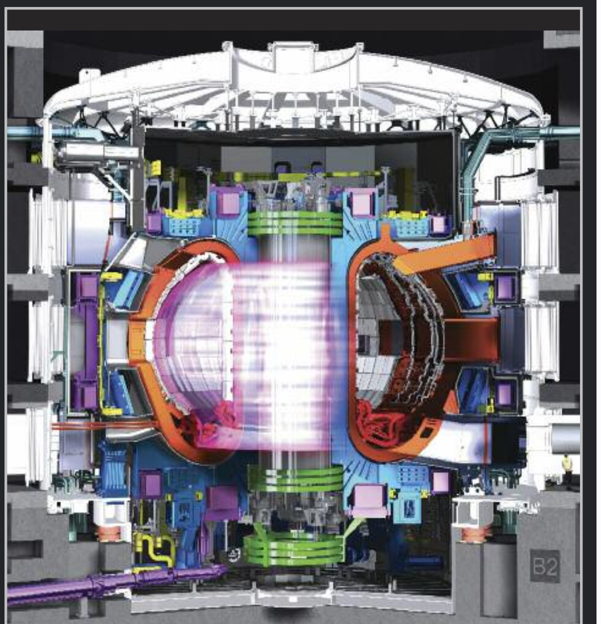
Thus, in November 2025, the first "small star" will be created inside the ITER Tokamak – exactly 40 years after a vast international initiative in fusion was set in motion by Mikhail Gorbachev and Ronald Reagan at the Geneva Superpower Summit (November 1985).

The long gestation period of the ITER Project can be explained in part by the challenges of creating an international organization from scratch, the complexity of its organization and governance (7 Members, 35 countries), and finally the huge scientific, technological and financial challenges of the program.

But all of the incremental steps that must be achieved are now defined leading up to the machine's First Plasma – which will mark not only an important technical milestone, but also the beginning of an experimental campaign that will last at least 20 years.

Beyond its symbolic importance, ITER's First Plasma will also be an important trial run for the machine – the first occasion to verify the geometry of the machine's magnetic fields and the correct functioning of key systems (electrical supply, cryostat, cooling water, cryogenics, etc.).

The very first low-power hydrogen plasma – lasting only a few milliseconds – will be followed by other "shots" of increasing power and duration. This shakedown mode lasting a few weeks will be followed by a shutdown phase, during which the systems that are indispensable for hydrogen and helium plasmas at nominal power will be installed. The first production of fusion power will take place during the machine's nuclear phase, scheduled for the middle of the following decade.



Beyond its symbolic importance, First Plasma – scheduled for November 2025 – will also be the occasion to verify the geometry of the machine's magnetic fields and the correct functioning of critical systems.

JEAN-LOUIS ETIENNE, POLAR EXPLORER, ON ENERGY AND ITER

Doctor, mountaineer, navigator, Jean-Louis Etienne was the first man to reach the North Pole solo, over land, in 1986. In the Artic or in Antarctica ... by foot, dog sled or airship ... energy questions have always been at the heart of his preoccupations.

In 1986 Jean-Louis Etienne set out for the North Pole alone, on foot, from Ward Hunt Island in the extreme north of Canada – a voyage across the frozen Artic Ocean that lasted 63 days.

Doctor, mountaineer, navigator . . . Etienne has said that reaching the North Pole "doesn't require any particular talent," only endurance, determination and near-superhuman fortitude. The experience determined the course of his life; since, either alone or as part of international expeditions, he has explored the poles by dog sled, by Rozière balloon and airship (dirigible), and even on a schooner adrift in ice-locked waters.

Jean-Louis Etienne is an explorer but also a scientist concerned by the fragility of our planet, and the question of energy occupies a central role in his reflection.

He spoke with ITER Communication during a recent visit to the site.

How important is energy management when travelling alone to the North Pole?
On the trek to the North Pole in 1986 I had two sources of energy: white gas for my camp stove (a very pure, oil-free gas that doesn't freeze) and lithium-ion batteries for the high frequency radio and the Argos transmitter. These two energy sources were vital to my survival and conservation quickly became an obsession. In extreme situations, appreciation is heightened for the role energy plays in our lives.

Was it this experience that brought you to have an interest in energy issues in a more global sense?
During each expedition, the production and the consumption of energy was a constant preoccupation. Trying to optimize local resources led me to think in a more global way about the potential and the limitations of renewable energy sources. For example, the challenge of storing electricity ...

Planet wide, the International Energy Agency forecasts an 80 percent increase in the demand for electricity by 2040. Do you feel that the political decision makers are fully aware of the challenge?
If we aggregate the growing demand for electric transport, that of huge megacities where 75 percent of the world's population will be concentrated, and the requirements of data centres, portable phones, tablets, connected objects . . . it becomes obvious that energy consumption is set to explode. I think our political decision makers are well aware of the situation, surrounded as they are by experts. But easy access to fossil fuels – especially low-cost coal – doesn't incite governments to engage on the path to new energy sources. One exception to that is renewables, which have been imposed through governmental promises to reduce emissions as well as by the expectations of the public.

Nuclear energy, in its different forms, will occupy an important place in the "energy mix" of the decades to come. Some voices from the "green" or "ecological" spheres have expressed surprise at your opinions on nuclear energy . . .
Attitudes on energy are more often a result of posturing and herd behaviour than a real reflection of knowledge about the subject, which takes time and effort. We have to start planning an exit from dependence on fossil fuels for the environment (the climate) and also because deposits will eventually dry up or become too costly to exploit. After finite energy sources, it is now time to pass on to flow energy sources. The challenges of renewable energy sources – low density production; acceptability issues for wind turbines, hydroelectric dams, solar parks; and electricity storage issues among them – mean that renewables will not suffice. In that context, will we be able to do without nuclear energy? I'm speaking about fourth generation fission reactor concepts or ITER. For these reasons, I support the pursuit of nuclear energy research.

You have spoken out on different occasions in support of the ITER Project. What draws you to this research program in fusion energy?
With the exception of geothermal energy, all other energy sources that we find in nature have a common source – the Sun. There are those that are considered unlimited, such as solar, wind, biomass, hydroelectric (evaporation, precipitation) and indirectly marine currents, which are linked to the position of the Sun and the moon. Then there are fossil fuels, which result from the transformation over millions of years of vegetal matter (produced by photosynthesis) in the heat and pressure of the Earth's crust. This energy of the Sun, transformed over an incredibly long time frame, cannot be reproduced within our lifetime. With all of these energy sources originating from the Sun, the temptation is strong to reproduce a "Sun on Earth." This is why I consider ITER to be a bold and worthwhile project.

A trek of 63 days over the frozen Artic Ocean – a transformational experience that led Jean-Louis Etienne to an interest in the future, and the fragility, of our planet.

What do you consider to be the advantages of fusion energy?
No long-lived radioactive waste, quasi unlimited fuel, no risk of explosion, and a reaction that can be halted immediately in the case of a problem.

You visited ITER recently. Were you surprised by what you saw? How would you describe the experience?
The building project is monumental. The challenges are both enormous and enormously exciting: we're talking about the fusion reactions that are produced in the very core of the Sun. It's a planetary project that reminds me of CERN (Geneva) in the complexity of its structure and the ambitions of its research program . . . a pairing of fundamental science and state-of-the-art technology.

For more information see: http://www.jeanlouisetienne.com/EN/

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60 YEARS AGO:
THE SPEECH THAT CHANGED EVERYTHING

Nikita S. Khrushchev, physicist Igor V. Kurchatov (in the middle, with beard) and Nikolai A. Bulganin on 26 April 1956 in Harwell, the Holy of Holies of Britain's nuclear research. It was the improbable beginning to what was to become a "world fusion community."

On 18 April 1956 a Soviet warship, escorted by two destroyers, pulled up to the dock in Portsmouth, UK. On board were two of the most powerful and enigmatic men of the time: Nikolai Bulganin, President of the Council of Ministers of the USSR, and Nikita Khrushchev, Secretary of the Central Committee of the Communist Party.

The invitation had been extended by Prime Minister Anthony Eden at a Summit meeting held in Geneva the year before. Three years after Stalin's death, the time seemed ripe for an easing of tensions between the two "blocks" and for a shift toward "the peaceful coexistence between states with differing political and social systems," to use Khrushchev's words to the Twentieth Congress of the Communist Party (February 1956).

The arrival of the cruiser *Ordzhonikidze*, marking the first-ever state visit of Soviet leaders to the West, caused a sensation.

If Bulganin and Khrushchev were the focus of the crowds and the media at first, a third man was about to steal the show: Igor Kurchatov. In charge of the Soviet nuclear program since 1943, he had spearheaded the construction of an atomic bomb in 1949 and a hydrogen bomb three years later, effectively allowing the Soviet Union to reach strategic equilibrium with the US … the sine qua non condition for "peaceful coexistence" with the West.

With the USSR on equal footing, "The Beard," as he was known to colleagues, had turned his remarkable energy to another quest, perhaps the most promising but also the most difficult of all: "the thermonuclear synthesis problem" – in other words, the harnessing of thermonuclear energy for peaceful uses.

And now, with the blessing of his political patrons, "The Beard" was ready to share his results, doubts, and expectations with scientific peers from the West.

Why the sudden transparency? Neither history, nor archives, nor published memoirs furnish a satisfactory answer. Kurchatov may have been convinced that the resources of one nation alone would never be enough to solve the fusion challenge. Or perhaps showing his hosts that his country was at least as advanced as theirs on a scientific and technological level was too great a temptation to resist.

Whatever the motivation it remains hard to imagine, from a distance of 60 years, the impact and echo of Igor Kurchatov's conference at the Atomic Energy Research Establishment in Harwell, Oxfordshire – the Holy of Holies of Britain's nuclear research.

Soberly titled "The possibility of producing thermonuclear reactions in a gaseous discharge," his address was a watershed moment in the young history of fusion research … but not because it contained any revelation. The 300 Harwell physicists who attended the conference discovered that Soviet scientists "had been following very similar lines of research into magnetic confinement as the UK and the US," write Gary McCracken and Peter Stott in *Fusion: The Energy of the Universe*.

Like their American and European counterparts, the Soviets had developed straight and toroidal pinch experiments, observed neutron emissions and short spurts of hard X-rays in deuterium plasmas, and acknowledged that quite a number of facts "remained to be explained."

Backed by equations, diagrams and high-speed photographs of plasma discharges, Kurchatov's speech did not contain an explicit call for international collaboration. But in shedding light on methodology and experimental results it challenged scientists in the West to reciprocate.

While scientists on both sides were eager to collaborate, many in Western government circles were reticent, especially in the US where it was felt that the Soviet opening was a ruse – a trick to lure politically naïve physicists into giving away precious state secrets.

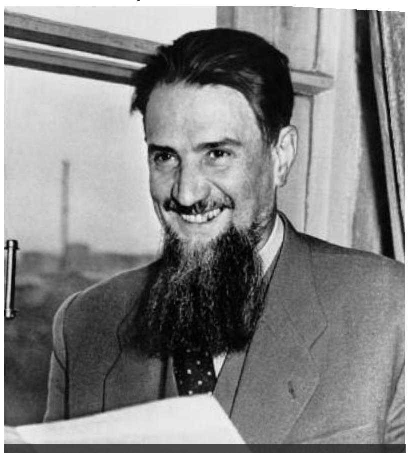
It took time to convince politicians that, at that stage, collaboration in the field of fusion was about fundamental science and didn't pose any threat of a strategic or military nature.

Only two years later in Geneva, where the United Nations held its Second International Conference on the Peaceful Uses of Atomic Energy (Atoms for Peace, September 1958), did the seeds that were sowed in Harwell begin to sprout.

For the first time, and with the blessing of their governments, the main actors on both sides of the Great Divide –Artsimovitch, Teller, Spitzer, etc. – met face-to-face and exchanged notes. "They had a tremendous amount in common," writes Robin Herman in *Fusion, The Search for Endless Energy* – "an idealistic goal, a daunting intellectual problem and [...] a parallel history of frustration."

A "world fusion community" was born, determined to embrace what Kurchatov's speech had described as "the extraordinarily interesting and very difficult task of controlling thermonuclear reactions."

Sixty years after Harwell, the task – considerably longer and more difficult than anticipated – is nearing completion.



Having contributed to the successful realization in the Soviet Union of the atomic bomb in 1949 and the H-bomb in 1953, Igor Kurchatov (1903-1960) was turning his energy to the "thermonuclear synthesis problem" – in other words, the mastery of fusion energy.

Further reading:

Herman, Robin. 1990. *Fusion: The search for endless energy.* Cambridge: Cambridge University Press.
McCracken, Garry, and Peter Stott. 2005. *Fusion: The Energy of the Universe.* US: Elsevier Academic Press.