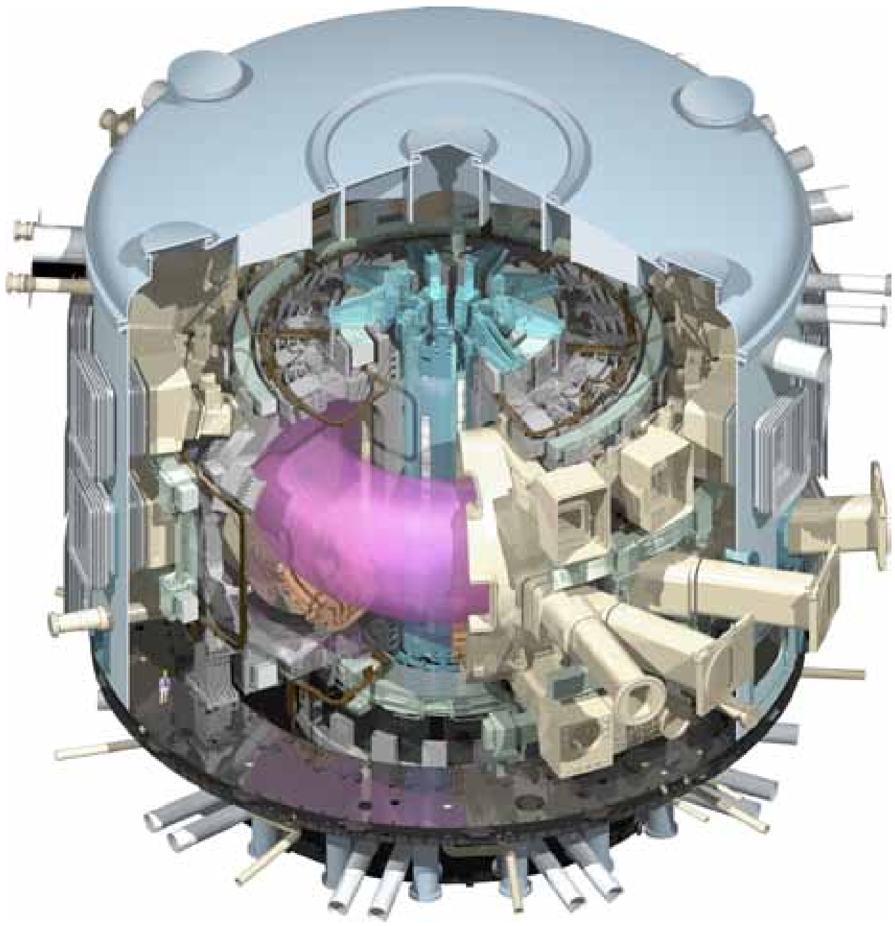
ITER and the Promise of Fusion Energy

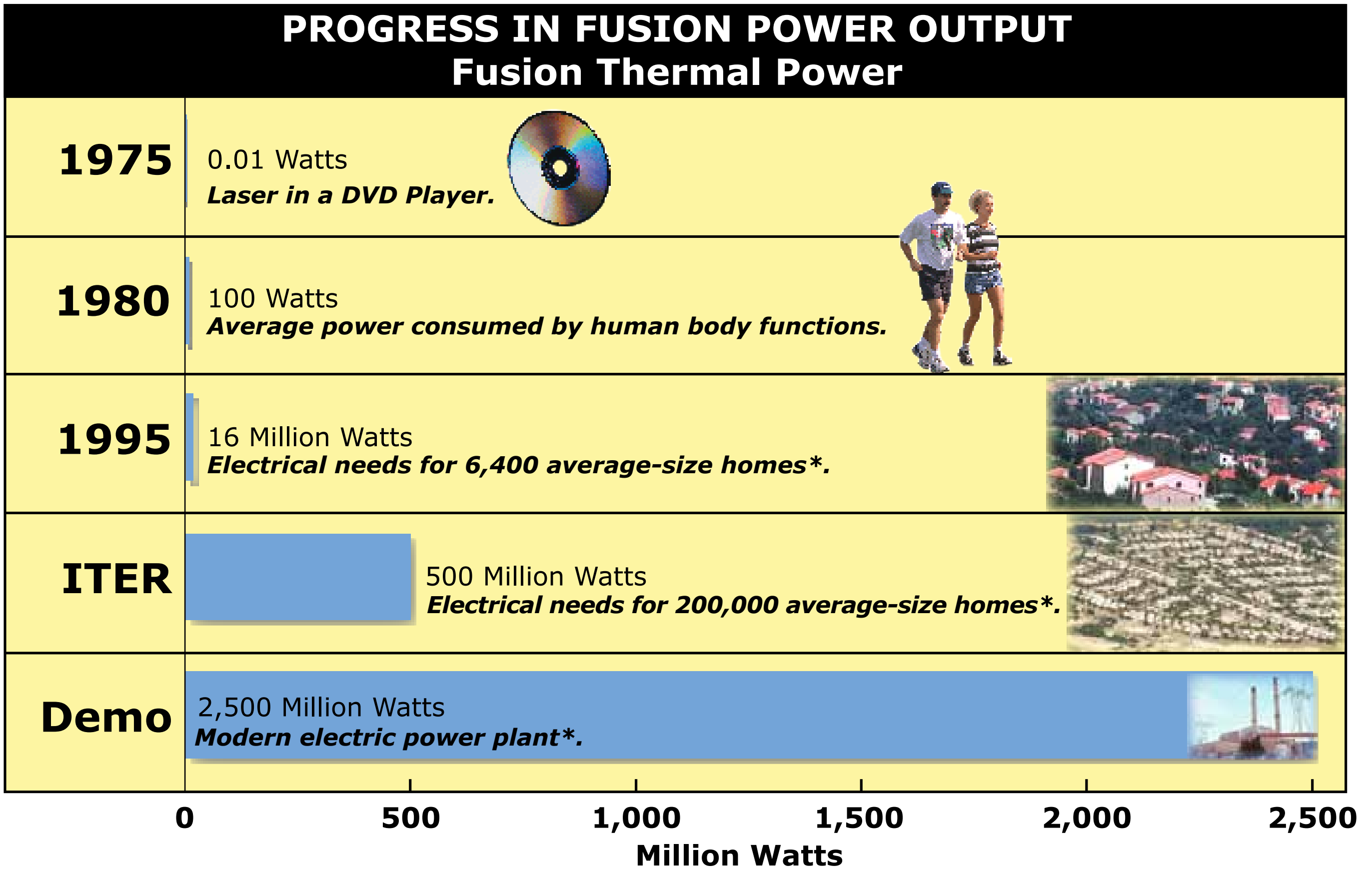


What is ITER?

ITER is a large international fusion experiment aimed at demonstrating the scientific and technological feasibility of fusion energy. ITER (Latin for "the way") will play a critical role advancing the worldwide availability of energy from fusion — the power source of the sun and the stars.

To produce practical amounts of fusion power on earth, heavy forms of hydrogen are joined together at high temperature with an accompanying production of heat energy. The fuel must be held at a temperature of over 100 million degrees Celsius. At these high temperatures, the electrons are detached from the nuclei of the atoms, in a state of matter called plasma. In magnetic fusion energy, such as will be studied in ITER, magnetic fields are used to confine the high-temperature plasma with a density typically one millionth that of air at sea level.

For decades, scientists around the world have been addressing the development of fusion energy by studying the underlying physics of plasma through experiments at universities and national laboratories. ITER is a critical step between today's studies of plasma physics and tomorrow's fusion power plants producing electricity and hydrogen. An unprecedented international collaboration of scientists and engineers led to the design of this advanced physics experiment. Project partners are Chi-



** Assumes 40% efficiency in the conversion of heat to electricity.*

na, the European Union, India, Japan, Russia, South Korea, and the United States. ITER is technically ready to start construction, with experimental operations planned to begin in 2019. The site selected for the project is Cadarache, in southeastern France. The experiment is expected to operate for 20 years.

What Scientific Capabilities will ITER Provide?

Scientific and technological advances in fusion research provide high confidence that the international ITER fusion experiment will be able to produce a burning plasma. A burning plasma is predominantly sustained at high temperature by the power of its own fusion reactions. ITER will produce 500 million watts of fusion power for a period of at least 400 seconds. The heat produced by ITER will be at least 10 times greater than the external power provided to heat the fusion fuel — a "gain" of over 10. Consequently ITER, an experiment the same size as a power plant, will provide an essential bridge from previous physics experiments, which produced up to 16 million watts of fusion heat for time periods approaching one second, to a Demonstration Power Plant (Demo) producing 2,500 million watts of fusion heat (1000 million watts of electricity) continuously with a gain of over 25.

How Will the Costs for ITER be Shared?

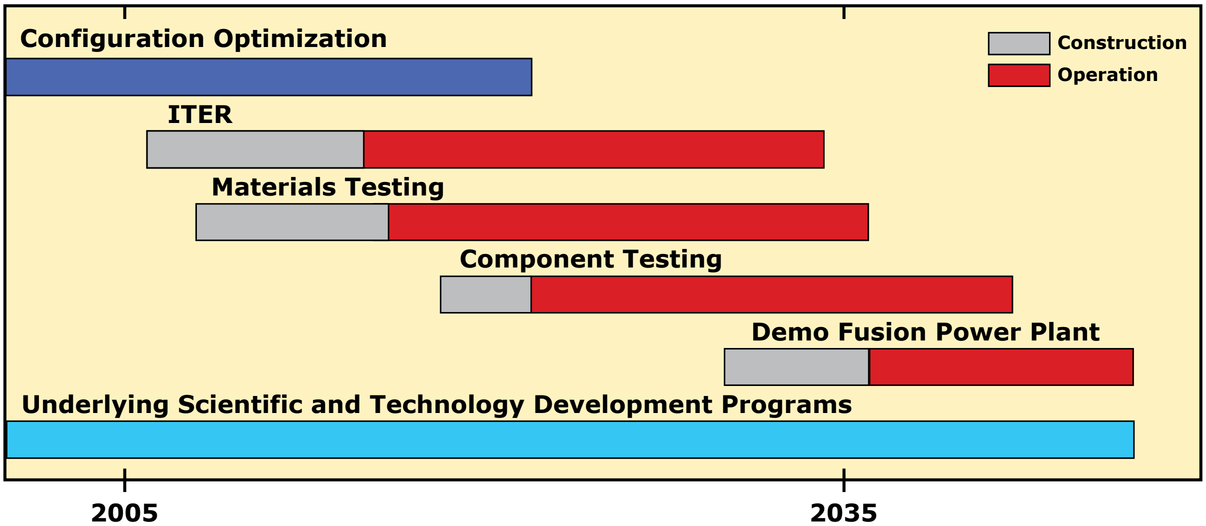
America's decision to join the ITER project allows us to share the experience and knowledge resulting from the design, construction, and eventual operation of this essential experiment at greatly reduced cost, compared to a national venture of the same scale. Components for which the U.S. is responsible will be built under subcontracts with industry.

What Else Needs to be Done for Practical Fusion Energy?

Overlapping steps in science and technology are essential for the development of practical fusion energy. ITER provides one major step, a burning plasma on the scale of a fusion power plant, but other, smaller elements are needed as well.

A practical fusion power plant the size of ITER must produce about five times more fusion heat than ITER, continuously, with a gain of over 25. Configuration Optimization involves identifying the most efficient and effective magnetic field geometry for shaping and confining the plasma to meet these goals. The advanced tokamak, the spherical torus, and the compact stellarator configurations are currently the leading options for taking advantage of the scientific results from ITER to meet the cou-

Advanced Tokamak | Spherical Torus | Compact Stellarator



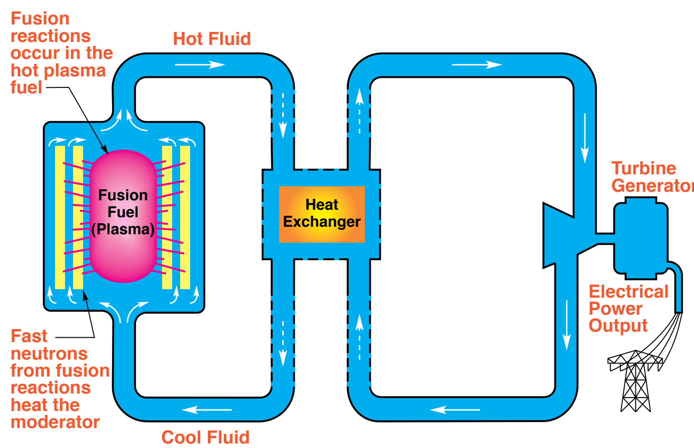
pled goals of high power, continuous operation, and high gain. Other promising innovative configurations are being studied broadly around the nation as well. U.S. domestic research on facilities investigating these configurations is supported and supplemented by theoretical and experimental research, as well as development of enabling technologies, at universities and laboratories. Efforts also leverage off of the National Ignition Facility to support the development of inertial confinement fusion as an attractive energy source.

It is U.S. innovation, coupled with participation in ITER, which will allow the nation to be competitive in the worldwide development and deployment of fusion power.

In a fusion power plant, the energy of motion of the high-speed neutrons produced in the fusion reactions will be converted to heat to make steam for the generation of electricity. The conversion to heat will occur in the chamber wall enclosing the plasma. The structural material of the wall must withstand the energy deposited by the neutrons. Attractive candidate materials need to be tested in small samples in an intense, narrow beam of energetic neutrons. Japan and Europe are partnering on the engineering design and prototyping for a facility to support such tests. Beyond this, Component Testing in a larger scale facility, more closely resembling a fusion power plant, is necessary to support a successful U.S. Demo.

Knowledge obtained from the operation of ITER, coupled with the continuing development of fusion science and technology taking place in the U.S., will allow the operation of a competitive U.S. Demo around the year 2035.

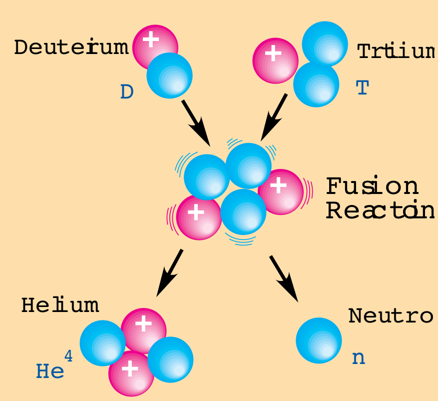
In the near term, the right strategy for U.S. fusion research is to combine participation in ITER with innovative domestic research in the context of a strong overall DOE Office of Science program. This strategy will provide the U.S. with advanced scientific information, with trained scientists and engineers, and with access to ITER — for the benefit of the U.S. and the world.



Fusion Energy

- Worldwide long-term availability of low-cost fuel.
- No chemical combustion products and therefore no contribution to acid rain or global warming.
- No possibility of a runaway reaction or meltdown.
- Low risk of nuclear proliferation.
- Short-lived radioactive waste.
- Steady energy source requiring small land use and no significant energy storage, which can be located where needed.
- Estimated cost of electricity comparable to other long-term energy options.

With these advantages, fusion complements other nearer-term energy sources to address the world's long-range energy needs.



Payback — About 450 : 1