A Plan for the Development of Magnetic Fusion Energy

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The purpose of this plan is to identify a goal and a timely, cost-effective strategy to demonstrate fusion as a viable power source and to enable the US to benefit from its commercialization.

Executive Summary

Fusion energy should be a long-term vital part of the US National Energy Strategy.

Fusion may be the safest and most environmentally acceptable source for meeting future base-load electricity needs.

Fusion fuel supply is widely available and essentially inexhaustible.

Good progress has been made in fusion research towards an energy producing system.

Plasma science advances have improved plasma control and confinement (concept improvement), e.g.:

Plasma pressure limits are well understood; modified configurations of magnetic field are extending these pressure limits.

Non-inductive methods for driving current in the plasma have been developed; agreement between theoretical and experimental efficiency gives confidence in extrapolated performance.

Self-controlling properties of magnetoplasmas have been discovered; this allows larger currents to heat the plasma and may eliminate the need for external heating in some magnetic field configurations.

Advances in fusion technology have been made in superconducting magnets, particle beams and radio frequency energy for plasma heating, control of plasma-wall interactions, tritium processing, development of low-activation radiation-damage resistant materials, etc.

More than a ten-thousand fold improvement of power gain (fusion power output relative to power input to plasma) has been achieved in the past 15 years. Experiments (TFTR and JET) have operated at near-breakeven conditions that would have produced about 10MW of fusion power if tritium had been used.

A short-pulse burning plasma experiment (CIT) is being designed to study the physics and operational behavior of largely self-heated plasmas producing 100 - 500 megawatts of fusion power.

The International Thermonuclear Experimental Reactor (ITER) conceptual design will be complete by the end of 1990. Designed to produce about 1000 megawatts of fusion power, ITER would test long-pulse (over 200 seconds and ultimately steady-state) burning plasmas and develop the technologies required to handle the heat and utilize the neutrons from fusion reactions to breed tritium.

Goal: The goal of the US fusion program is to demonstrate early in the 21st century that fusion is a practical, safe, reliable, and environmentally attractive energy source.

Strategy:

1. Develop plasma-confinement-concept improvements, plasma technologies, and materials needed for practical fusion applications in a core program of science and technology.
2. Construct a burning plasma experiment (CIT) in the US to provide physics information and operating experience for an engineering test reactor, and contribute to the design of a fusion power demonstration facility.
3. Participate in an international engineering test reactor (ITER) to acquire experience with long-pulse burning plasmas and nuclear technologies needed to design a fusion power demonstration facility.
4. Construct a fusion power demonstration facility (DEMO) in the US, which would produce net electric power and provide a basis for fusion commercialization.

This strategy was selected to reduce US cost by use of well-established international collaboration, while retaining for the US the benefits of technological spin-offs and ultimately the commercialization of fusion. To realize these benefits, a strong national program must be maintained with increased involvement of US industry.

Budget and Schedule

The total integrated cost of the US program from its beginning to the operation of a demonstration reactor would be about $36 billion (in 1990 dollars) according to estimates by ERDA in 1976. By comparison $29 billion is estimated here, assuming a more focused plan that relies more heavily on international collaboration. Since about $11 billion (1990 dollars) have been spent by the US through fiscal year 1990, the majority of the investment ($18 billion) remains to be made to meet the goal of fusion power.

To meet a nominal 2020 operational date for a fusion power demonstration facility, the annual budgets need to be increased to about $600 million per year by the mid-1990s, and remain at that level (in 1990 dollars) until construction of the DEMO starts.

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