reactor, and increased the potential for producing economically viable fusion power. The structural feasibility of a commercial reactor is now reasonably assured. And the scientific engineering data base needed to engineer materials for specific commercial applications and to ensure safe and environmentally acceptable sources is beginning to firm.

Increased Service Life for Structural Materials – A key component in a fusion power reactor is the blanket structure that the energy released in the fusion reactor is converted to usable heat. This conversion occurs when high energy neutrons from the fusion reactor strike the blanket. This heat is, in turn, extracted by a coolant to be converted into useful work. The structural materials that absorb the neutrons are subject to two effects: changes in mechanical properties and changes in dimensions, most often in the form of swelling. Both changes are caused by damage to the material's crystal structure by energetic neutrons. The swelling is aggravated by the agglomeration of helium (and perhaps hydrogen) produced in nuclear transmutation reactions.

When neutron damage becomes too severe, the blanket structure—especially the so called first wall that faces the plasma directly—must be replaced. The challenge when the materials research effort began in the mid-1970's was to increase predicted first wall lifetimes by at least tenfold from an unacceptable 0.4 years to 4 years or more. Predictions now are for service lives at least five times those that could be assumed in the mid-1970's, and further increases are projected. As a result, the feasibility of reactor-grade materials has been established.

Improvements in structual materials are expected because of advances over the past 10 years in understanding the fundamental processes of radiation damage and extrapolation from the growing data base on the subject. For example, it was originally predicted that the fatigue resistance of structural materials would be seriously degraded in a fusion reactor; this has been dispelled by experimentation. Substantial improvements have been made in reducing the swelling of austenitic steel, one of the primary candidate alloys for reactor structural materials. These improvements result from better alloy mixes and advanced manufacturing and processing techniques.

The question is no longer whether structural materials exist from which a commercial fusion reactor can be built; they do. For both the experimental and engineering community, the question now is how to modify known materials in ways to decrease cost, improve performance further, and minimize waste disposal requirements.

Of particular interest are structural materials that minimize residual induced radioactivity so that they can be disposed of safely without the long-term hazard associated with fission waste. Here, too, much progress has been made toward practical choices of first wall and structural materials that can be disposed of by shallow burial, perhaps at the plant site. Research on such low waste alloys will continue to be an important component of fusion materials research.

Durable Magnet Materials – At the beginning of the fusion program, information was needed about the maximum tolerable neutron exposure for superconducting magnet components: the superconductor, the stabilizer, and the insulator. Without this information, early reactor designs had to assume poor radiation tolerance and accommodate massive and costly shielding to protect the magnets. Based on current tests, the fusion materials program has now confirmed that the superconducting materials with the best operating characteristics for fusion magnets (Niobium-Titanium and Niobium-Tin) are sufficiently durable for magnets to function as intended with much less shielding than was thought possible earlier in the program. This will lead to savings of millions of dollars in construction costs for a power reactor.

High Performance First Wall Materials – Even though the plasma fuel is confined in a "magnetic bottle" during normal operation, it still drifts outward until it touches and is neutralized on "limiters," protecting the vacuum chamber walls. There the particles dislodge atoms or other particles, which enter the plasma as impurities. Once in the plasma, the impurities act like wet wood thrown on a fire. They absorb and radiate energy intended to heat the plasma without contributing to the energy producing process. To make matters worse, impurity atoms (which do not react) dilute the fuel plasma. The heavier the impurity atom, the worse the energy drain.

By 1978 energy losses due to impurities became the critical impediment to raising plasma to the temperatures required for energy breakeven. A solution came from the understanding of the plasma-edge environment that had been accumulating in plasma physics studies, and from the knowledge gathered in materials research about the interaction between the plasma particles and materials. Knowledge of the mechanical and thermal stresses on the limiters led to a search for superior materials to limit the plasma. The answer was to fabricate the limiters out of carbon in place of the heavier refractory materials which were in use at the time.

The change in material for limiters was responsible for a 30 million degree Celsius increase in plasma temperature on the PLT.

Ceramics for Insulation and Fuel Breeding – Ceramics are required for a variety of insulator applications in a fusion reactor, some of which will receive high neutron exposure. In