Fusion Industry Committee US Analysis

ITER Project Issues and Prognostication

Historical Baseline

In 1969, Milt Shaw of the Atomic Energy Commission decided to focus Advanced Reactor Development on the Liquid Metal Fast Breeder Reactor (LMFBR). The "pre-commercial" demonstration of this technology was called the Clinch River Breeder Reactor Plant (CRBRP). The objective of the LMFBR was to decouple nuclear fission from the U-235 fuel cycle because the price of uranium was expected to grow dramatically as the number of nuclear fission plants was forecast to *exceed 1200* by the year 2000.

In 1973, the United States experienced the first of two "energy crises" (an oil embargo gave rise to petroleum rationing, gas lines and a fourfold increase in the price of crude oil). "Project Independence" was launched at that time and the Atomic Energy Commission (AEC) (then the ERDA/DOE) projects grew dramatically. In particular, the LMFBR and fusion programs grew rapidly as both promised essentially "inexhaustible" electric energy fuel supplies. Until 1973, projections for electric power growth had been 7 % per year which had been the previous twenty year experience of the electric utilities. However, the demand for energy dropped precipitously because of the 1974/75 recession and simple price-demand elasticity. This was quickly recognized by the utilities and orders for new fossil and nuclear reactor plants started to decline.

In the late 1970s, the U.S. experienced the second "energy crisis" (price increase) and, again, energy demand dropped substantially. Electricity demand then settled into the 2-3% percent per year range that persists to today. Also by that time, nuclear power had experienced tremendous cost growth due to increasingly stringent safety requirements. Nuclear reactor orders dropped to zero, and massive cancellations began. The TMI accident had occurred, thus giving rise to public concern over the safety of nuclear power. Conservation and solar (renewables) programs experienced rapid budget growth due to the prejudices of the Carter administration. Additionally, the U.S. Synfuels Corporation was formed with the objective of converting domestic coal resources to transportation fuels at a target cost of approximately $40.00/bbl of oil equivalent.

Early in the 1980s, after the inauguration of the Reagan Administration, it became obvious that nuclear fission growth was zero (or less). Deregulation of the price of oil caused energy prices to collapse. It was recognized in Washington that the "energy crisis" was over (which was true), energy became a non-issue and support for all DOE energy programs began to weaken. U.S. Synfuels Corporation was declared a failure and the project effectively canceled. The Nuclear Waste Policy Act was enacted in 1982 with the objective of establishing a deep geological repository for commercial power plant high level nuclear waste by 1996. Utilities were/are taxed one mill per kWhr of nuclear-produced electricity to pay for the system.

In 1983, the Republican-controlled Senate killed the CRBRP as it was viewed as no longer economically justifiable. Fusion, advanced fission and solar/conservation entered nearly a

decade of declining budgets. Only advanced coal ("clean coal") programs fared reasonably well.

In the late 1980s/early 1990s, the DOE budgets stabilized to the minimum levels thought necessary to preserve the basic sciences and technologies. The Soviet Union collapsed and that, coupled with START, precipitated the U.S. into the anti-plutonium posture that exists today. In 1992, the National Energy Policy Act was passed with the major result being massive deregulation of the electric power industry and the entrance of "Independent Power Producers" (IPPs) for electricity generation. The conventional technology of choice of IPPs is gas-fired combustion turbines. Wind-electric turbine systems appear to be emerging as a IPP choice for "renewable energy" with electric power production costs in the range of 4-5 cents per kWhr. The Clinton Administration has tried to eliminate virtually all nuclear fission programs and the Congress (particularly the House) appears to be complying. The Administration has proposed dramatic increases in the Renewables and Conservation budgets.

The establishment of a deep geological repository for high level nuclear waste has been pushed into the second decade of the next century. Utilities are continuing to store nuclear waste at their reactor sites and have sued the Federal Government for failure to meet its "promise" to provide a waste disposal site.

ITER Costs

The "Temple Panel" analysis confirmed those produced earlier by SWEC, Bechtel and Ebasco - the resources provided for ITER Design are low by factors between two and three for a FOAK facility. It also is noted that this conclusion has been reached by both the EC and Japan. However, only a "Band-Aid" solution (moving R&D money to Design) has been proposed to date. Slipping the project by two years also is emerging as a "solution" if such a slip can be funded at $250 million/year and be directed mostly towards ITER Design.

The ITER EDA is based on the CDA which was a fusion establishment activity. It did not benefit from real industrial views on the true costs of such a project. In fact, the EDA suffers the same problem although there are signs that the DOE is starting to recognize it.

Industry *certainly* understands the implication of cost on project approval having just experienced the "SSC" debacle. However, it is *absolutely* necessary to face the cost problem since the Congress has made such an issue of it. The current plan is to have a reasonably good estimate in March of next year. In this estimate, FOAK engineering *must* be included too as it is a real project cost.

Industry fears that the number will be *much* too high for the Congress to accept unless the U.S. foregoes the "honor" of siting the ITER. However, even in this case, the Congress may accept the view of fusion critics and will determine that the ITER is not timely/attractive. Remember the Swett-Threat.

The cancellation *process* of the SSC provides two lessons-learned: (1) Some facilities are simply too expensive compared with their benefits and (2) "cost-creep" is a killer in any event (the CIT/BPX experience also illuminates this fact of life).

The ongoing "success" of the Space Station funding process suggests another lesson-learned: when a project gets too expensive versus its benefits (assuming that there *are* some from the space station program), identify and pursue lower cost and scaled-back missions/approaches.

In fusion, *little* has been done in regard to the latter. To some extent, this is driven by program inertia where most of the partners (Japan, a possible exception) have bet their fusion future on the ITER. In the U.S., this also is driven by Congressional politics - Senator Johnston has said that (paraphrased) "You have told me that ITER is the next logical step, so go do it to the exclusion of everything else." In fact, it is reported that he wants a debate on the attractiveness, timeliness and cost of the ITER (and the fusion program). Some have said that he's set a trap for the fusion program.

Fusion Market Pull

It is clear that the market is now *very* weak for large-scale (particularly nuclear-based) central station electric power systems. This is not to suggest that the future demand for such systems will be weak, but today the funding environment is not healthy.

While fusion energy does enjoy generic support by investor-owned utilities (the "customer"), the tokamak is not viewed as obviously extrapolating to a commercial power plant. Power density and complexity (maintainability) are thought to be the major detractors.

Industry has been encouraged to elicit utility involvement/support for fusion RD&D. This can be accomplished to some extent, but such support will not be large or particularly vocal. This results from a number of factors:

- **Investor-owned utility preoccupation with economic survival and evolution due to the new competitive environment imposed by the 1992 Energy Policy Act,**
- **General disinclination toward supporting generation options that face public opposition (and Public Utility Commission disapproval) because of perceived safety and/or radioactive waste problems,**
- **Notwithstanding the above, more appealing large-scale long-term generation options such as advanced coal, the WEC AP-600 or the GE SBWR, and**
- **The anticipated time-frame in which fusion is projected to be a commercial power plant option.**

ITER Radiological Profile

Fusion has been promoted as a "environmentally benign" nuclear power option for nearly four decades. In fact, fusion *does* have the potential to have greatly reduced radioactive waste disposal requirements, but Fusion Nuclear Technology (FNT) development has been seriously neglected because the major program emphasis has been placed on advancement of plasma physics understanding and plasma performance. The fusion establishment is now starting to recognize this technical and political misjudgment.

The ITER is the focus of the World's fusion programs. However, if it is to be constructed according to the current schedule, it will be built using only existing engineering materials (those that have a sufficient data-base for "regulatory approval"). Should this come to pass, it has been estimated that:

> "Waste volumes for shallow land burial will generally be large (30,000 - 100,000 m^3) because of the physical size of components."

This is an unfortunate estimate given the growing "environmentalist" opposition to fusion energy that was demonstrated during the House Appropriations hearings this year. (In fact, such opposition has been known since the 1988 Sierra Club policy paper on fusion.) There is no doubt that such data will be used in future political debates on fusion funding to the detriment of the Nation's fusion program.

It is fair to note that the above quote refers to shallow burial which implies that the waste is not particularly noxious (which is true in comparison with fission reactor waste). However, the distinction between high-level and Class C waste is not made by truly hostile environmentalists who view "waste as waste" regardless of biological hazard potential. The stalemate in California over the Ward Valley low-level waste disposal site is a clear indicator of the hostility toward radioactive waste and the legal maneuvers that can and will be undertaken towards ITER-class-facility waste disposal in the United States.

Prognosis

Thermonuclear fusion development is now at a critical point. The market-pull is very weak and the radiological profile of the ITER is not attractive. The DOE is in a zero-sum game and the conservation and renewables advocates are coveting the fusion budget. The ITER cost estimate presently scheduled for release in June of 1995 is expected to be on the order of $ 10 billion which, even if the U.S. is expected to pay only 1/4 of it, implies annual appropriations in the order of the current level of the fusion program budget. The Federal Government may not have the will or the capability to support such appropriations at the time of the proposed ITER construction phase.

The TPX has been promoted as a facility to improve tokamak physics to the extent that an ITER would have better and steady-state performance in a smaller and less expensive machine. The VNS has been promoted, by its advocates, as serving as a test bed for the development/demonstration of Fusion Nuclear Technologies having more attractive environment and safety features in comparison with today's materials.

The ITER itself is being delayed because of insufficient funding to support the EDA (particularly in the Design area). Further, because of the failure to build a CIT or BPX, the plasma physics phase for ITER will substantially delay the planned FNT phase well past the point of being relevant for DEMO design.

Given the above, it is plausible to conjecture that the ITER project will be portrayed and viewed as premature as early as the FY 1996 Appropriations budget cycle (that starts in March of 1995). If this were to happen, it then would be prudent for the U.S. to have a contingency plan. To first order, such a plan should depend on the international ITER *process* but adjust to pursue lower risk and cost parallel facilities. In the U.S., the TPX would be the featured facility but might be designed to answer questions that the JT 60-SU is not planned to do. The VNS, possibly in a partnership with another quadripartite partner, would seem to be an additional attractive option for the U.S. as well.

Other ITER *process* missions would be a Materials Test Facility for the rapid testing of small materials samples for irradiation performance. It is reported that Japan would be very interested in hosting such a facility. Finally, there exists the need for understanding of the physics of long-pulse (~ 100 second) ignited tokamak plasmas (a primary ITER mission). The BPX was designed to partially achieve this objective. Another device, possibly a higher field machine reminiscent of the FED-R might be a good candidate for such a mission.

Recommendation

Industry (FICUS) should *very discretely* develop its views on the above mentioned situation over the next six months. Industry should suggest options for the U.S. in the event that ITER is not pursued. (Japanese managers have openly stated that Japan will proceed with the JT 60-SU if ITER is not built. The positions of the the EC and Russia are not clear at this time.)