

FY 2000 System Studies Activities

Farrokh Najmabadi

VLT/FWP Meeting

April 6-9, 1999

OFES Headquarters, Germantown

Electronic copy: <http://aries.ucsd.edu/najmabadi/TALKS>

ARIES Web Site: <http://aries.ucsd.edu/ARIES>

Program Elements

- **Strategic planning and forecasting -- role of fusion energy in a sustainable global energy strategy.**
 - A new initiative in FY99 (\$555k in FY99);
 - FY00 proposal: \$500k
- **Power Plant Studies:**
 - National power plant studies team (ARIES). New projects started in 1/99 (\$1,655k in FY99).
 - FY00 proposal: \$1,800k
 - Pre-conceptual designs (analysis of critical issues) of advanced fusion concepts (no new studies in FY99).
 - FY00 proposal: \$100k

* VLT director budget of \$2,400k

Role of Fusion in a Sustainable Global Energy Strategy

- **Objective:** Assess the role of fusion energy in a long-term, sustainable global energy strategy, taking into account the portfolio of energy options available.
- Most of the socioeconomic studies were launched in FY 99:
 - * Study of options to deploy large fusion power plant including hydrogen production and co-generation. (ORNL & Partners).
 - * Establish the merits and address issues associated with fusion implementation (PPPL).
 - * Macro-economics modeling of global energy market and role of fusion (PNL) (Continuation of previous work).
 - * Comparison of various sources of energy based on equivalent CO₂ emission (U. Wisc.).

Socioeconomic Studies of Fusion Power (ORNL & Partners)

- **Objective:** An assessment of the projected competitiveness of future fusion-based electrical power generation with fission, fossil, and renewable electricity sources.
 - Principal Jerry Delene.
 - To be completed: 9/99.
- **Objective:** Study of options to deploy large fusion power plant including hydrogen production and co-generation.
 - Principals: Boeing, Center for Energy and Environment at Princeton University, Duke E&ES, TVA, and ORNL).
 - Completion date nominally 9/99, realistically 12/99.

Socioeconomic Studies of Fusion Power (PPPL)

- **Objective:** To establish the merits and address issues associated with fusion implementation.
- **Focus:** With potential implementation scenarios establish the:
 - Environmental impact of reduced CO₂ emission, waste disposal, and waste recycling;
 - Resource needs of special materials and tritium;
 - Economics;
 - Potential role of fusion/fission combinations.
- To be completed: 9/99.

Socioeconomic Studies of Fusion Power (PNL)

- **Objective:** Establish economic benefit of fusion research and fusion energy using macroeconomic models.
- **Focus:** Economic impact on GNP and balance of trade using parametric variations of
 - Busbar cost of fusion electricity;
 - Time of introduction and growth of fusion electricity.
- **Timeframe:** on-going for several years.

Socioeconomic Studies of Fusion Power (U. of Wisconsin)

- **Objective:** To calculate the energy payback ratio and CO₂ gas emission rates from fusion and natural gas electrical power generating stations.
- **Plans for FY 99:** To calculate the energy payback ratio and CO₂ emission rates for DT fusion and comparison to coal, LWR, and wind electrical generating facilities.
 - To be completed: 9/99
- **Plan for FY 00:** To apply the same analysis techniques to natural gas power plants and compare them to fusion, fission, coal, and wind power plants .

Socioeconomic Studies of Fusion Power

VLT PAC Review (12/98)

“At present, studies of the role of fusion energy are limited to a handful of disparate tasks performed by fusion researchers. The VLT can perform the much needed function of formulating a coherent plan to integrate fusion energy into the planning and vision of the larger energy research community. For impact beyond our own community, we recommend that a substantial amount of the research be contracted to researchers from outside the fusion program. Naturally, a measured involvement of fusion researchers is necessary as a liaison between outside researchers and the fusion program.”

Socioeconomic Studies of Fusion Power Plans for FY 2000

- There is a need to make a case for fusion energy in the context of a sustainable global energy future.
- In FY99, \$555k is allocated to this research. Some of these projects will be completed in 9/99.
- Per PAC's recommendation, a planning group will be formed to draft "a coherent plan to integrate fusion energy into the planning and vision of the larger energy research community." This plan will be submitted to the VLT PAC for the June meeting.
- Target funding for this research in FY00 is set at \$500k.
- Additional resources may be needed if outside researchers are contracted for this work.

National Power Plant Studies Program

Initiated New Projects in 1/99

- **Proposed topics were developed under the VLT framework and discussion with physics and technology program leaders***
- Advanced ARIES-RS (45% of effort)
- Fusion Neutron Source (45% of effort)
- Support for on-going examination of fusion systems as producers of hydrogen (5% of effort)
- Impact of ferromagnetic material on plasma performance (5% of effort)
- Support for proof-of-principle concepts

Advanced ARIES-RS Study

- ARIES-RS is the vision for the advanced tokamak program and is used to plan R&D directions.
- Advanced ARIES-RS study assesses “how good” advanced tokamaks can be using higher performance physics (more optimized profiles, reduced current drive power, etc.) and higher performance technologies (high-temperature superconductors, SiC blankets with liquid metal breeder/coolant, etc.)
- This is an important study as the fusion program debates the future of tokamak research and its balance against other elements of the program.

Advanced ARIES-RS Study -- Tasks

- Systems Studies UCSD
- Physics:
 - MHD and lead PPPL
 - Current drive UCSD
 - Transport, Divertor GA
- Engineering
 - Magnets (high T_c) MIT, PPPL, ORNL
 - Blanket UCSD, ANL
 - Neutronics and shielding U. Wisc.
 - Safety INEEL
 - Configuration & maintenance UCSD

Fusion Neutron Source Study

- Scoping studies have indicated that fusion neutron sources may lead to attractive, near term products for the fusion program leading to new clients and to additional resources for fusion:
 - * Typical applications ($\sim 10^{19}$ - 10^{21} n/s) :
 - Transmutation of fission waste;
 - Hybrids for fuel and/or energy production;
 - Fusion materials and engineering testing.
 - * Post-cold-war additions:
 - Tritium production;
 - Burning of plutonium from dismantled weapons.
 - * Recent application ($\sim 10^{11}$ - 10^{13} n/s)
 - Radioisotope production;
 - Medical radiotherapy;
 - Detection of explosives.

Fusion Neutron Source Study

- Metrics to evaluate the potential of a fusion neutron source:
 - * Cost (capital cost, neutron cost in \$/mole)
 - * Total number of moles of neutrons produced per year;
 - * Value of the product;
 - * Magnitude of the extrapolation from the current physics and technology databases;
 - * Complexity of the system;
 - * Environmental, safety and health effects;
 - * Timeframe and cost of the development plan;
 - * Political issues associated with certain applications (e.g., association with nuclear weapons, etc.)
- Study will be performed in two phases. Concept definition phase would be completed by 9/99 with a preliminary report for the snowmass meeting. A detailed design will be launched assuming favorable results.

Fusion Neutron Source Study has focused on high-strength ($\sim 10^{19}$ - 10^{21} n/s) applications -- Tasks

- Continued assessments to identify the most useful application and product (Boeing);
- Continued interactions with the fission and accelerator communities to understand the potential of reactors and accelerators for neutron source applications (RPI, INEEL, U.Wisc., ANL, UCSD);
- System studies to assess the performance/metrics of fusion-based neutron sources for both the D-T and D-D-T fuel cycles (UCSD, Team input);

Fusion Neutron Source Study has focused on high-strength ($\sim 10^{19}$ - 10^{21} n/s) applications -- Tasks

- A compilation and assessment of the engineering and nuclear performance of the various concepts proposed for neutron-source applications including fusion, fission and accelerator systems (UCSD, U.Wisc., ANL, TSI);
- An assessment of the environmental, safety and licensing implications of fusion neutron-source applications such as plutonium disposition and radioactive waste transmutation (INEEL, Team input);
- Assessment of the political issues associated with certain applications (e.g., association with nuclear weapons, attacks from environmental and/or fission communities, etc.)

National Power Plant Studies Program

VLT PAC Review (12/98)

- “The ARIES program has performed a series of key tokamak system studies, and is a valuable resource for continued evaluation of power plants based on various fusion concepts. As new studies are initiated, we recommend that they be planned and executed as a partnership between Aries team members and advocates from the fusion concept under study.”
- VLT PAC has agreed to help define new studies.

National Power Plant Studies Program

Plans for FY 2000

- The original planning for the 2-year study was based on \$2,000k per .
- In FY99, \$1,655k is allocated to this research resulting in the stretching of the first year schedule and reduction in scope.
- Proposed funding of \$1,800k in FY00 allows completion in the two-year period (at reduced scope).
- The stellarator and MTF proof-of-principle program planning committees have asked the ARIES Team for help in their program. Additional resources can be used in this area and will be highly leveraged.