US Fusion Program Strategy in the ITER Era

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Introduction - As the world program is constructing ITER and preparing to enter the burning plasma era, it is important for the US Fusion Energy Sciences (FES) Program to develop a long-range strategic plan for the United States (US) Domestic Program in the context of the world program. Our vision and goals are consistent with FES Program mission to "expand the fundamental understanding of matter at very high temperatures and densities and build the scientific foundation needed to develop a fusion energy source." The timely deployment of fusion as an attractive energy source should be our overarching goal. We further submit that maintaining a criterion of scientific excellence (in all areas, plasma, materials, nuclear, etc.) provides the most rapid path to the successful development of fusion energy.

Vision - The US Domestic Fusion Program for the next 10 years should be strongly based on our longer range vision for the US and world program. For the longer-range (~ 25 years) we expect to be engaged in designing and constructing a DEMO fusion plant to demonstrate net electricity production through integrated fusion science and engineering. In 10 years, ~2025, we expect ITER to begin operations and the US to have a leadership role in its scientific exploitation. In addition, we envision that the US (potentially with international partners) will be designing and constructing a Fusion Nuclear Science Facility (FNSF) that will enable the US to have a world leadership role in fusion nuclear science. FNSF, and associated program elements, will address closing the fusion fuel cycle, materials, and components in extreme conditions, and steady-state high performance operation, in an integrated facility, thus addressing key challenges of fusion not resolved by ITER. Although the US Domestic Fusion Program funding counts for only ~ 1/8 of the world program, a program that judiciously invests in resolving overarching issues on the path to fusion energy can prepare the US for leadership in key areas and position the US to deliver fusion energy in time to meet the world's energy demand.

Tokamak Facilities for the Future - The commonly identified DEMO in fusion roadmaps is a tokamak, and FNSF is envisioned to be a tokamak. The tokamak has by far the highest performance (16 MW of fusion power), the most developed theory and modeling, the most advanced scientific and technical base, and the largest experienced workforce. The ITER tokamak will provide significant advances in demonstrating the feasibility of fusion energy. The science and technology developed with a tokamak is easily transferable to other fusion configurations that might come later. We submit that a strong, stable US tokamak program, partnering with the international community, offers the best opportunity for sustained scientific excellence and best prepares the US for fusion energy development.

US Leadership and Impact - There are a number of scientific topics where the US clearly plays a leadership role: developing validated models and integrated simulations; developing tokamak plasmas for high performance steady-state, plasma control; edge-localized mode and disruption avoidance and control; and energetic particles and energetic particle instabilities. In addition, there are very high impact topics in nuclear and material science that will prepare the US for world leadership positions, including material development and PMI research, nuclear irradiation of materials, and developing the science required for fusion blankets in a high temperature and high field environment. Consideration of how these leadership and high-impact topics support the vision of the future should provide useful guidance for prioritizing US initiatives and fusion program investments.

High Priority US Initiatives - The following US initiatives will provide US leadership in key scientific areas, prepare the US to have a leadership role in ITER, and prepare the US to move forward with FNSF in the next decade: high power upgrade to DIII-D, model validation and integrated simulation initiative, divertor upgrade to DIII-D or NSTX Upgrade, a non-nuclear fusion blanket development facility, a materials test facility, a nuclear irradiation facility, and enhanced diagnostic development. Investments in US tokamak user facilities over the next decade will provide world-class science and best prepare the US for the future.