Optimizing the Next 10 Years of Fusion Research Toward the Goal of Fusion Energy

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The achievement of fusion energy by mid-century will require a focused coordinated effort by the world's leading fusion research programs. The next 10 years will be a critical period that must not only prepare for exploiting ITER, but must also make significant progress toward resolving technical issues that will not be addressed by ITER. An informal community Road Map study initiated by the Magnetic Fusion Program Leaders Group has been underway in the U. S. with the goal of assessing various pathways to magnetic fusion energy. During this study a framework was developed to facilitate the analysis of the multitude of challenging fusion issues, which often require solutions in the integrated fusion environment.

Our Road Map to a Fusion Power Plant is defined by five major mission elements that must be accomplished to achieve fusion energy. These major missions are: 1) Create a Fusion Power Source, 2) Tame the Plasma-Material Interface, 3) Develop Materials for Fusion, 4) Harness the Power of Fusion and 5) Establish the Economic Attractiveness and Environmental Benefits of Fusion Energy. This mission breakout is an extension of the 2007 FESAC Report.[(1).] In our work, each of these major missions was divided into roughly five sub-elements to provide sufficient detail for analysis.

An important part of a road map is to have mileage markers to measure progress/gaps. We are using dimensional and dimensionless parameters as well as Technology Readiness Levels as metrics. This allows one to assess status, gaps and the impact of a new initiative to reduce a gap. The attainment of a particular TRL can be specified by a set of milestones. This also provides input for the construction of a decision logic flow chart [(2)] for a particular pathway e.g. ITER=> Tok-DEMO, or ITER + FNSF=> AT-DEMO, or ITER + Stell's => Stell DEMO. The decision logic flow chart provides a structure for defining milestones and decision points needed to initiate the next step, or change to another pathway. One can then identify the characteristics of facilities (existing, planned or needed) that can be used to resolve the technical issue.

A draft Facilities Road Map (including international facilities) was developed that encompasses all three pathways mentioned above. The Road Map also identifies key decision points across the complete set of missions/facilities. Many of the key decision points occur within the next decade, and serve to define a set of milestones (deliverables) to enable transition to a stronger energy driven program with an FNSF-like facility as a central focus.

Our group has intentionally refrained from making prioritizations or recommendations on particular facilities or paths, but has attempted to provide a framework that could help the fusion community arrive at a plan for the future.

We have not attempted to estimate the resources needed to carryout the tasks required to accomplish fusion power. Various estimates have been made in the past, and one can also compare the resources being directed to MFE in Europe and Asia. The conclusion is obvious, there will have to be a significant increase in U. S. fusion research funding if the U. S. is to remain among the world leaders in fusion and demonstrate practical fusion energy by mid-century. In any event, a solid plan for the next ten years with identified deliverables and key decision point milestones could be the catalyst to enable the transition to a robust fusion energy program.

(1) Priorities, Gaps and Opportunities: Towards a Long Range Strategic Plan for MFE, DOE/SC-0102
(2) Technical Planning Activity Final Report, Argonne National Lab Report ANL/FPP-87-1 (1987),
U. S. Technical Planning Activity, Charles Baker, Journal of Fusion Energy, **6**, 2, p203-207, 1987