Paths to fusion energy
The next 30 years, the next 10 years

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Synopsis

In the US, we need to prepare for, and fight for,

- An aggressive fusion program, looking ahead 30 years

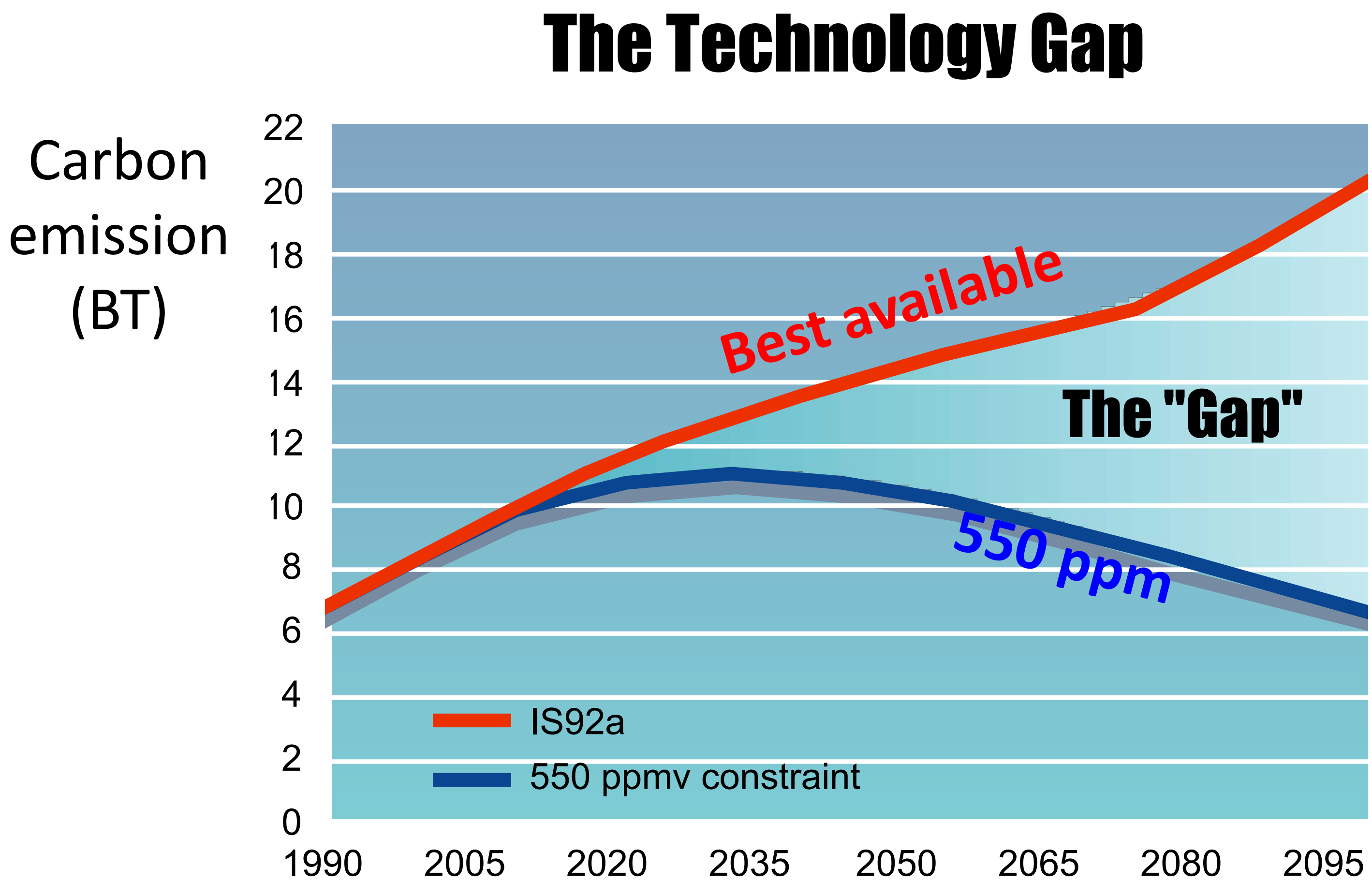
  and

- A budgetarily "realistic" program with ITER construction and an (at least) level research program for 10 years

Comments on an aggressive program

Common views on an aggressive program

- Fusion can deliver on a time scale that matters



Common views on an aggressive program

- Fusion can deliver on a time scale that matters

- ITER is a crucial step

- We are ready now for an aggressive R&D program to accompany ITER and deliver fusion

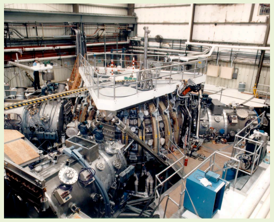
- With an aggressive program we can arrive at a demonstration power plant in ~ 25 years

Common views on an aggressive program

- Fusion can deliver on a time scale that matters
- ITER is a crucial step
- We are ready now for an aggressive R&D program to accompany ITER and deliver fusion
- With an aggressive program we can arrive at a demonstration power plant in ~ 25 years
- Most roadmaps agree on time scale, differ in details

A roadmap to fusion energy discussed in US

GA



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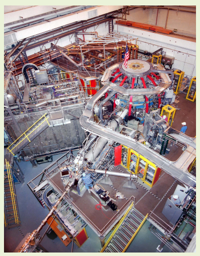
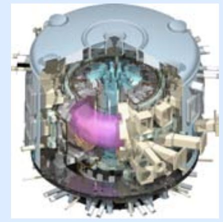


MIT

Plasma confinement research program

present

ITER



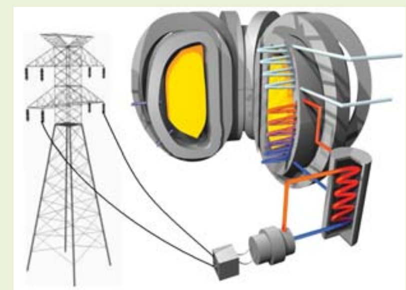
Base Research Program

Plasma confinement
Materials science/engineering

Fusion Nuclear Science Facility

2020 – 2035
The ITER era

Demonstration Power Plant



~ 2035
The fusion era

Issues for a fusion roadmap

- Trade-off between FNSF vs straight-to-DEMO
  (risk vs speed; FNSF mission in first phase of DEMO)

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- FNSF and DEMO timing relative to lTER

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- Trade-off between FNSF vs straight-to-DEMO
  (risk vs speed; FNSF mission in first phase of DEMO)

- FNSF and DEMO after ITER or somewhat in parallel?

- Prominence of the stellarator path to fusion
  (a form of “advanced tokamak” for steady-state, high gain)

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- Trade-off between FNSF vs straight-to-DEMO
  (risk vs speed; FNSF mission in first phase of DEMO)

- FNSF and DEMO after ITER or somewhat in parallel?

- Prominence of the stellarator path to fusion
  (a form of "advanced tokamak" for steady-state, high gain)

- Trade-off between a steady-state PMI facility vs first phase of FNSF

Some issues treated in the talk by Dale Meade,
Requires a national study

The US is not now on an aggressive path to fusion energy,

The current challenge:
to increase the budget to fund ITER construction while (at least) maintaining a level research program

As a bridge onto an aggressive roadmap,
we must define an exciting ten-year program for an about level research program accompanying ITER (essential even to maintain level funding)

Criteria for a level "domestic" program:

- World-leading research on important topics

  Focus on original, important, selected, exciting activities where the US can lead or be at the world forefront

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- Preparatory for ITER and a fusion roadmap to DEMO

  Research to contribute to ITER, move beyond ITER, and prepare to breakout into fusion energy development program

Strongly collaborative internationally

Therefore,

- Choose work with breakthrough potential

- Do not choose development work that is incremental or secondary to similar but larger efforts elsewhere

- Choose activities over full range of three topic categories
    - Confinement (high performance, steady-state, burning)
    - Plasma-material interface
    - Harnessing fusion power

Sample research activities where the US can be a leader
(~ $15M to ~ $50M blocks)
(listed in unprioritized order)

1. Plasma confinement

   (high performance, steady-state, burning plasmas)

      Integrated fusion simulation

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1. Plasma confinement

   (high performance, steady-state, burning plasmas)

   Integrated fusion simulation

   Magnet development

   High field, high Tc superconductors

   potentially significant implications for tokamak, stellarator

   e.g., reduction in size

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1. Plasma confinement

   (high performance, steady-state, burning plasmas)

   Integrated fusion program

   Magnet development

   Tokamak facility (AT or ST)

   investigating novel features (e.g, new divertors, new PFCs, new operating regimes)

   preparing for ITER, FNSF

   maintaining tokamak operational expertise

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1. Plasma confinement

   (high performance, steady-state, burning plasmas)

   Integrated program

   Magnet development

   Tokamak facility (AT or ST)

   Stellarator program

   steady-state, disruption-free, high gain

   novel designs for US research

   new confinement science

Sample research activities where the US can be a leader
(~ $15M to ~ $50M blocks)
(listed in unprioritized order)

1. Plasma confinement

   (high performance, steady-state, burning plasmas)

   - Fusion simulation program
   - Magnet development
   - Tokamak facility (AT or ST)
   - Stellarator program
   - Exploratory fusion concepts
     - re-evaluate opportunities

Sample research activities where the US can be a leader (~ $15M to ~ $50M blocks) (listed in unprioritized order)

2. Plasma-material interface

New divertor geometries

(e.g, snowflake, X-divertor, super-X)

Examples of research activities for US leadership in 10 yrs (~ $15M to ~ $50M blocks) (listed in unprioritized order)

2. Plasma-material interface

New divertor geometries

Liquid metals

- unique advantages as first wall
- US at forefront, can lead
- some synergies with blanket liquid metal issues

Sample research activities where the US can be a leader
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2. Plasma-material interface

New divertor geometries

Liquid metals

Tungsten development

- studies in plasma test stands and confinement facilities
- high temperature
- developing new tungsten alloys
- (need to distinguish from work elsewhere)

Sample research activities where the US can be a leader (~ $15M to ~ $50M blocks) (listed in unprioritized order)

2. Plasma-material interface

    New divertor geometries
    Liquid metals
    Tungsten development

3. Harnessing fusion power

    Modified US accelerator neutron source

Sample research activities where the US can be a leader
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(listed in unprioritized order)

2. Plasma-material interface

    New divertor geometries
    Liquid metals
    Tungsten development

3. Harnessing fusion power

    Modified US accelerator neutron source
    Blanket studies
        possible niche is DCLL
        engage in ITER TBM program
        (need to distinguish from work elsewhere)
        possibly needed capability for breakout potential

Sample research activities where the US can be a leader
(~ $15M to ~ $50M blocks)
(listed in unprioritized order)

4. Scoping studies for activities after 2023

    Mission/conceptual design studies

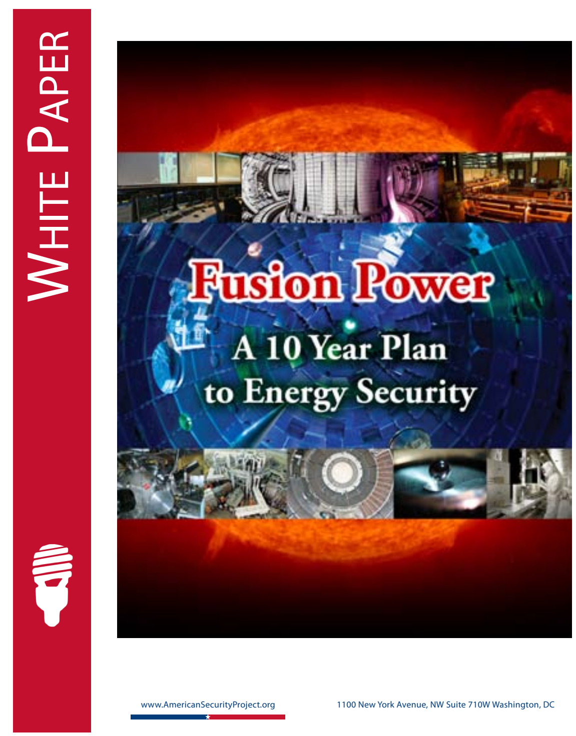
    - Fusion Nuclear Science Facility (FNSF)
    - S.S. toroidal facility for plasma-materials interface
    - Stellarator

    Roadmapping and socioeconomic studies

Summary

- We should prepare now an aggressive, credible plan for fusion energy for the US, exploiting the developments in ITER and discoveries to come.

- We should continue to fight for a US commitment to realize fusion energy on a fast track



Summary

- We should prepare now an aggressive, credible plan for fusion energy for the US, exploiting the developments in ITER and discoveries to come.
- We should continue to fight for a US commitment to realize fusion energy on a fast track
- We should define now an exciting ~ ten-year, ~ level-funding research program, while we construct ITER