Office of Fusion Energy Sciences

Excellent Science in Support of Attractive Energy

U.S. Fusion Energy Sciences Program

Presented to the

Fusion Energy Sciences Advisory Committee

By

Dr. Anne Davies

Associate Director
for Fusion Energy Sciences
Office of Science
Department of Energy

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www.ofes.fusion.doe.gov

Excellent Science in Support of Attractive Energy

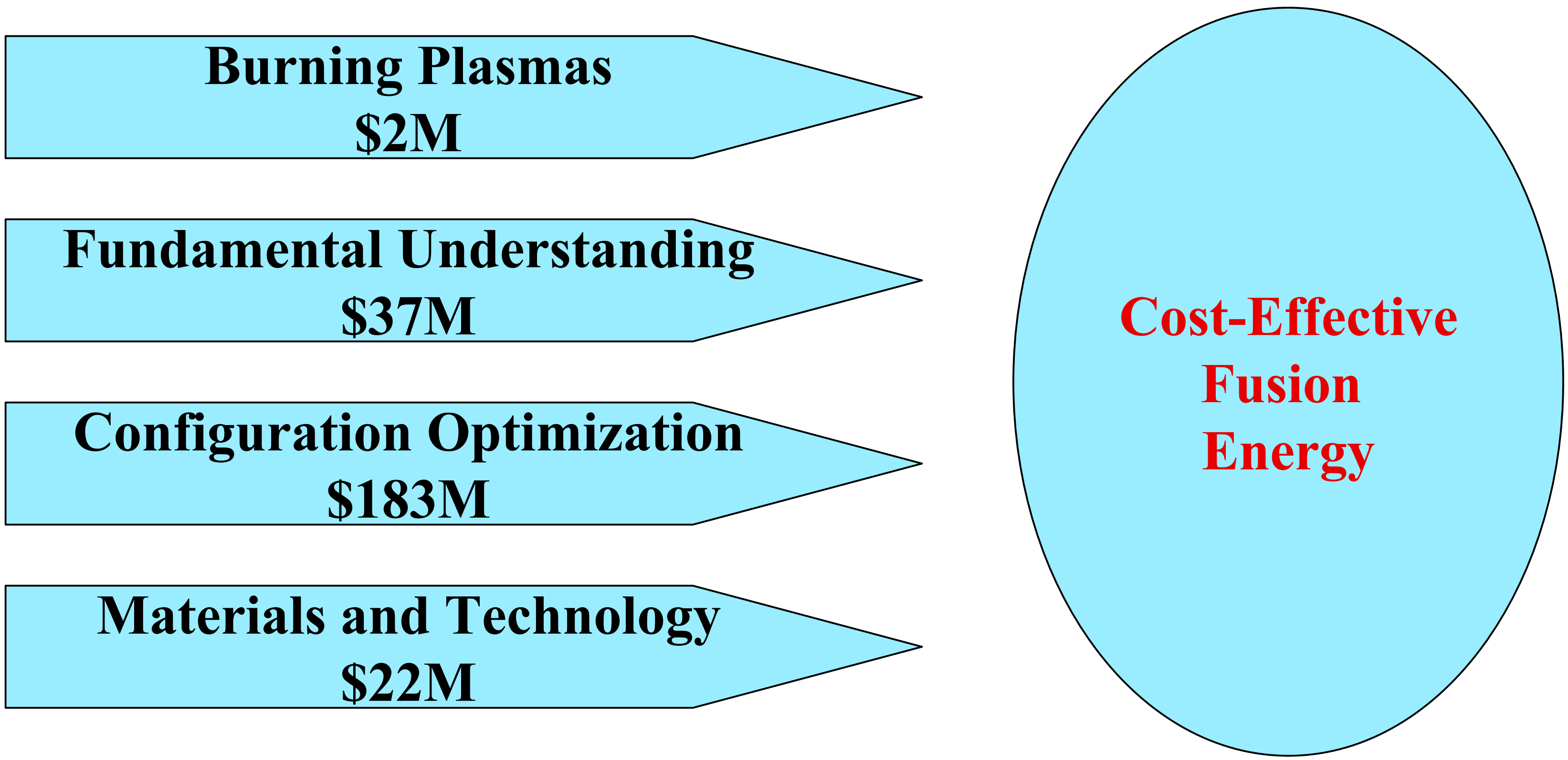
FY 2003 FES Budget

- **President's Request** **$257.3M**
- **House Mark** **$248.5 M**
  - $2.5 M ear marks for NSTX and NCSX
  - $2.0M general reduction
- **Senate Mark** **$259.3 M**
  - $2.0 M ear mark for evaluating "fast ignition"
- **Initial Fin Plan** **$248.5 M**
  - Continuing Resolution terms not yet defined
- Conference not yet scheduled
- Department appealing to President's Request

Burning Plasma Consensus Building

September 2001	FESAC Report on Burning Plasma Physics
July 2002	Fusion Community Workshop to assess options for a Burning Plasma Experiment
September 2002	FESAC Recommendations for a Burning Plasma Program Strategy
December 2002	NRC Letter Report on Strategy
December 2002	FESAC Preliminary Report on Development Path
December 2002	Lehman Review of ITER Cost Estimate

Four Thrust Areas are Required for Practical Magnetic Fusion Energy

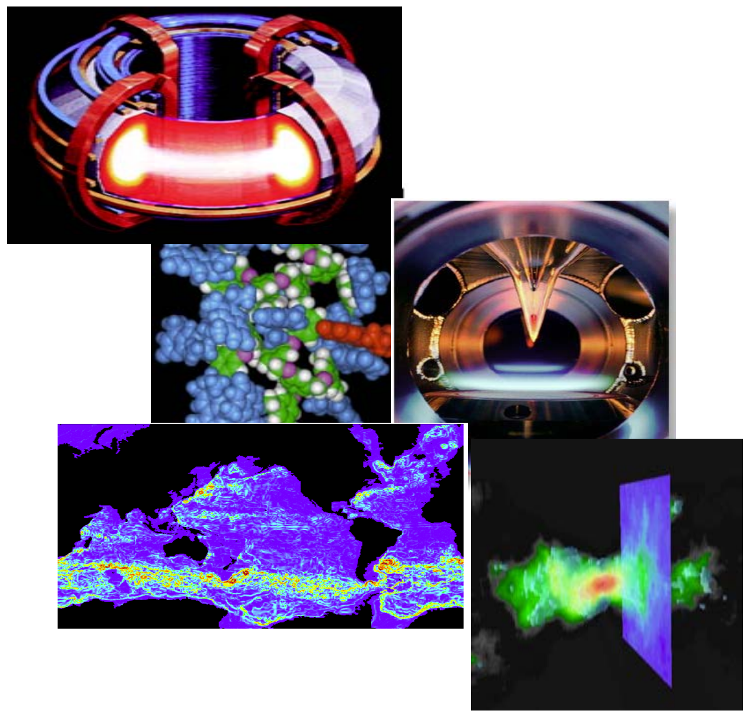


Areas defined by the
Fusion Energy Sciences Advisory Committee.

$ are FY 2003 President's Request

The SC Strategic Plan: An Overview

Context……Content…….Paths Forward



The SC Plan in Context

DOE

- 25-year time horizon
- Top-down process
- Organized around 15-20 main goals
- Implications for SC: one goal on scientific research, one on science facilities, and numerous crosscutting management goals.
- Draft nearing completion, to dash-1 for comments, out for public comment within a month.

SC

- 10-year time horizon
- Participatory process from the outset
- A focus on the compelling science of the future, with additional focus on facilities and science management opportunities and challenges.
- Clear, intuitive linkage to DOE Plan structure
- Complete plan by March of 2003

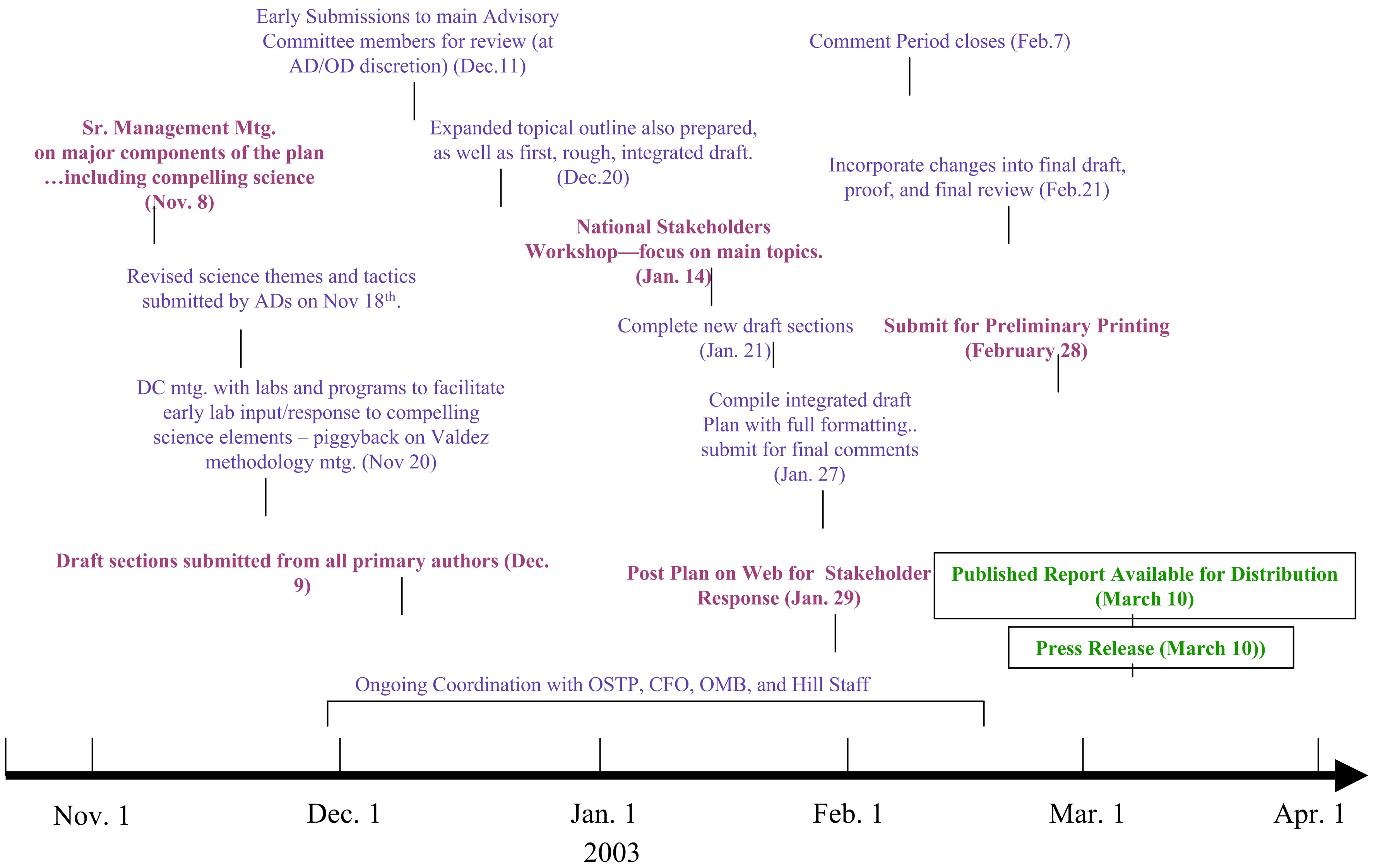
Our Planning "~~M~~Billion Dollar" Questions

•What is the **compelling science** we want to be doing a decade from now?

•What are the powerful **science tools/facilities** we'll need to provide for SC's future research…and for the research of the Nation?

•How will we **manage the enterprise** with foresight, assuring that we develop and apply our critical resources effectively, anticipate and overcome barriers, and meet our science goals with high efficiency and effectiveness?

Production Timeline



FES Strategic Themes and Tactics

BURNING PLASMAS: *Exploring self-heated fusion plasmas for fusion energy*
- Join international collaboration to construct ITER
- Continue design of U.S.-based alternate (FIRE) as backup during negotiations for ITER

FUNDAMENTAL UNDERSTANDING*:* *Revealing plasma complexity across many dimension in space and time; developing a predictive capability for fusion energy systems*
- Theory & Modeling
- Turbulence & Transport
- Macroscopic Stability
- Waves-Particle Interactions
- Plasma Boundary Effects
- Stewardship for Plasma Science

CONFIGURATION OPTIMIZATION: *Seeking innovative approaches to confining hot plasmas for ultimate fusion energy systems*
- Enhancing the Tokamak
- Enabling R&D (heating, current drive, pellet fueling)
- Magnetic Alternates (e.g., compact stellarator, reversed field pinch)
- Inertial Fusion Energy

MATERIALS AND TECHNOLOGY: *Using science to probe the material limits of fusion confinement systems to maximize environmental & economic aspects of fusion energy systems*
- Study & test innovative systems for heat removal & tritium breeding
- Use nanoscale technology to design & test low-activation materials
- Join international collaboration to build and operate a point neutron source for materials testing
- Join international collaboration to build and operate a blanket test facility

FES Strategic Theme and Tactics Revised

CREATING A STAR ON EARTH—PROVIDING A FUNDAMENTALLY NEW ENERGY SOURCE FOR ALL MANKIND

BURNING PLASMAS: Through international collaboration, explore self-heated fusion plasmas and demonstrate the scientific and technological feasibility of fusion energy

FUNDAMENTAL UNDERSTANDING*:* Reveal plasma complexity across many dimensions in space and time. Integrating theory, simulation and experimental results, develop a predictive capability for fusion energy systems

CONFIGURATION OPTIMIZATION: Explore a wide range of innovative approaches to confining hot plasmas for ultimate fusion energy systems, including both MFE and IFE concepts

MATERIALS AND TECHNOLOGY: Use modeling, nanotechnology, and neutron irradiation to develop materials and energy conversion systems for fusion applications, in order to maximize environmental & economic aspects of fusion energy systems

BES Strategic Theme #1

BASIC RESEARCH FOR A SECURE ENERGY FUTURE: BES-sponsored research will provide the scientific basis for revolutionary advances in the areas of energy resources, production, conversion, efficiency, and the adverse impacts of energy production and use.

a. By FY 2004, BES will implement a comprehensive new plan for energy-related basic research based on the findings and recommendations of the Basic Energy Sciences Advisory Committee.

b. Solar photoconversion efficiencies will be significantly increased using new methods including materials that integrate inorganic, organic, and biological components.

c. New materials will be developed that impact solid state lighting, smart windows, vehicular transportation, thermoelectric conversion, hydrogen storage, electrical storage, and improved fuel cells leading to significant increases in efficiency, the utilization of waste heat, and new energy economies.

d. Innovative structural materials will be developed leading to improved performance under the extreme conditions of fossil-fuel, nuclear-fuel, and fusion energy generation.

e. Subsurface reservoir structures will be imaged at high spatial resolution; multiphase flow in porous, reactive formations will be modeled and predicted with high confidence.

BESAC Workshop "Basic Research Needs to Assure a Secure Energy Future"

Preliminary List of Proposed Research Directions from the breakout sessions

Fossil Energy

1. Reaction pathways of inorganic solid materials: synthesis, reactivity, stability
2. Advanced subsurface imaging and manipulation of fluid-rock interactions
3. Development of an atomistic understanding of high temperature hydrogen conductors
4. Development of predictive fuel conversion models

Nuclear Energy

1. Materials degradation: mechanical and chemical degradation of reactor materials and waste package components
2. Actinide and fission product chemistry to support a sustainable recycle system
3. Fuel behavior for advanced high temperature fuels
4. Heat transfer

Fusion

1. Multiscale modeling of microstructural stability of irradiated materials
2. Deformation and fracture modeling
3. Plasma-surface interaction
4. Thermofluids and "smart liquids"
5. Plasma aerodynamics

Distributed Energy, Fuel Cells, and Hydrogen

1. Hydrogen synthesis
2. High capacity hydrogen storage
3. Novel membrane assemblies
4. Designed interfaces

Renewable Energy

1. Develop methods for solar energy conversion that result in a 10-50 fold decrease in the cost to efficiency ratio for the production of fuels and electricity.
2. Design and synthesize new classes of complex materials, including hybrids that integrate organic, inorganic and biological constituents to revolutionize the development of renewable technologies
3. Develop functional genomics and biochemistry for the tailoring of plants and microorganisms to increase the production of fuels and chemicals by 100-fold
4. Develop the knowledge base to enable the widespread creation of geothermal reservoirs
5. Effectively convert solar, wind, and geothermal energy into stored chemical fuels

Transportation

1. Integrated quantitative knowledge base for joining of lightweight structural materials for transportation applications
2. Vehicular energy storage
3. Fundamental challenges in fuel cell stack materials
4. Integrated heterogeneous catalysis for transportation
5. Thermoelectric materials and energy conversion cycles for mobile applications
6. Complex systems science for sustainable transportation

Industrial, Residential, and Commercial

1. Sensors
2. Solid state lighting
3. Innovative materials
4. Multilayer thin film materials and deposition processes

Crosscutting Research

1. Education / workforce
2. Nanomaterials