



U.S. Department of Energy's  
Office of Science

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# Fusion Energy Sciences Program Update

Fusion Energy Sciences Advisory Committee



**Dr. N. Anne Davies**  
Associate Director  
for Fusion Energy Sciences

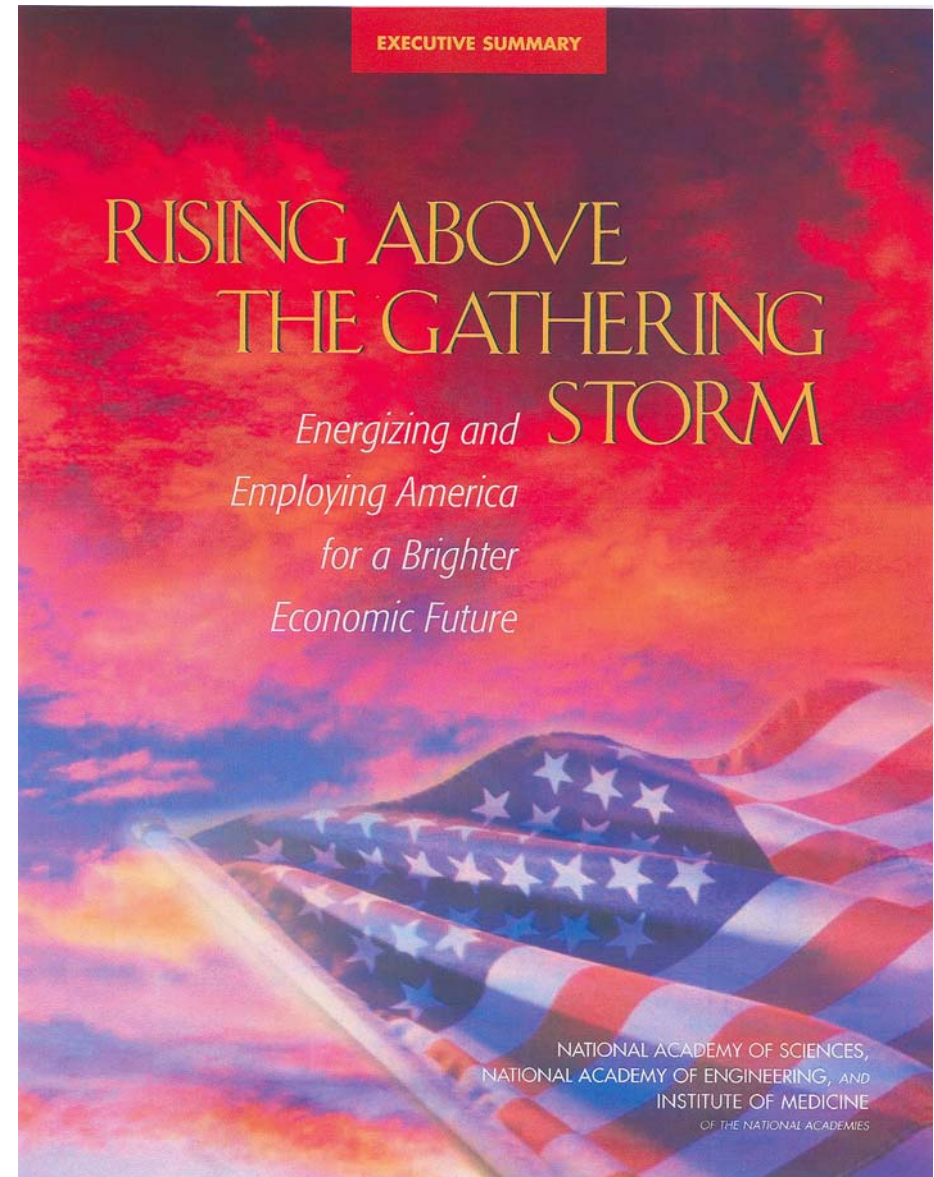
[www.ofes.fusion.doe.gov](http://www.ofes.fusion.doe.gov)

*February 28, 2006*

# National Academy of Sciences Report

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Fusion is part of  
SC's part of the  
American  
Competitiveness  
Initiative





# Office of Science

## FY 2007 Congressional Budget Request

(dollars in thousands)

	FY 2005 Approp.	FY 2006 Approp.	FY 2007 President's Request	FY 2007 vs. FY 2006
Basic Energy Sciences.....	1,083,616	1,134,557	1,420,980	+286,423
Advanced Scientific Computing Research.....	226,180	234,684	318,654	+83,970
Biological and Environmental Research				
Base program.....	487,474	451,131	510,263	+59,132
Congressional-directed projects.....	79,123	128,700	—	-128,700
Total, Biological and Environmental Research.....	566,597	579,831	510,263	-69,568
High Energy Physics.....	722,906	716,694	775,099	+58,405
Nuclear Physics.....	394,549	367,034	454,060	+87,026
Fusion Energy Sciences.....	266,947	287,644	318,950	+31,306
Science Laboratories Infrastructure.....	37,498	41,684	50,888	+9,204
Science Program Direction.....	154,031	159,118	170,877	+11,759
Workforce Development for Teachers and Scientists.....	7,599	7,120	10,952	+3,832
Small Business Innovation Research/Technology Transfer.....	113,621	—	—	—
Safeguards and Security.....	67,168	68,025	70,987	+2,962
Subtotal, Science.....	3,640,712	3,596,391	4,101,710	+505,319
Use of prior year balances.....	-5,062	—	—	—
Total, Science.....	<b>3,635,650</b>	<b>3,596,391</b>	<b>4,101,710</b>	<b>+505,319</b>

# FY 2007 Fusion Energy Sciences Congressional Budget Request

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	(\$ Millions)		
	FY 2005	FY 2006	FY 2007
	<u>Actual</u>	<u>Appropriations</u>	<u>Request</u>
Science	148.5	156.9	154.2
Facility Operations	89.7	103.5	121.6
Enabling R&D	<u>28.7</u>	<u>27.2</u>	<u>43.2</u>
<b>OFES Total</b>	<b>266.9</b>	<b>287.6</b>	<b>319.0</b>
DIII-D	55.8	54.7	56.7
C-Mod	22.0	21.7	22.8
NSTX	34.5	34.0	35.1
NCSX	18.3	17.8	16.6
ITER	5.4	25.1	60.0
Non-ITER	261.5	262.5	259.0

## FY 2007 Fusion Program Highlights

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- o Continue U.S. ITER Fabrication Effort (\$60.0M, +\$34.9M)
  - \$37.0M for MIE Project (Total Estimated Cost funding)
  - \$23.0M for R&D support (Other Project Costs funding)

# ITER Outyear Funding Profile

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## U.S. Contributions to ITER - Annual Profile

(\$ in Millions – in as spent dollars)

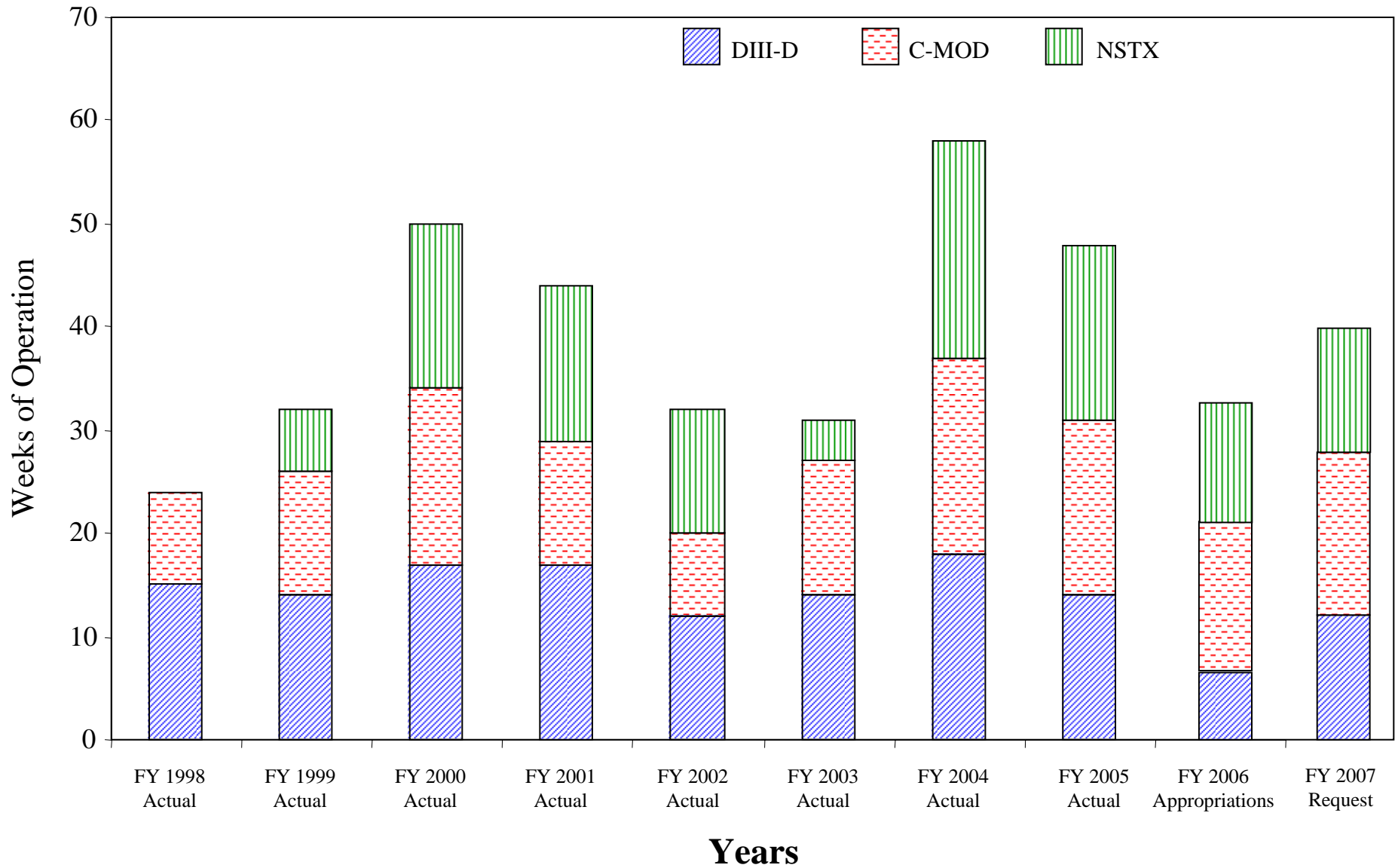
<u>Fiscal Year</u>	<b>Total Estimated Costs (TEC)</b>	<b>Other Project Costs (OPC)</b>	<b>Total Project Costs (TPC)</b>
2006	15.9	3.4	19.3
2007	37.0	23.0	60.0
2008	149.5	10.5	160.0
2009	208.5	6.0	214.5
2010	208.5	1.5	210.0
2011	180.8	.5	181.3
2012	130.0	0	130.0
2013	116.9	0	116.9
2014	30.0	0	30.0
<b>Total</b>	<b>1,077.1</b>	<b>44.9</b>	<b>1,122.0</b>

## **FY 2007 Fusion Program Highlights** (continued)

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- o **Increase Major Facility operations and research** (+\$4.2M)
  - 12 weeks on DIII-D, 15 weeks on C-Mod, 12 weeks on NSTX

# Major Fusion Facilities Operating Times





# Major Facilities

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<u>Funding (\$ in Millions)</u>	<u>FY 2005</u>	<u>FY 2006</u>	<u>FY 2007</u>
DIII-D	55.8	54.7	56.7
C-Mod	22.0	21.7	22.8
NSTX	<u>34.5</u>	<u>34.0</u>	<u>35.1</u>
<b>Totals</b>	<b>112.3</b>	<b>110.4</b>	<b>114.6</b>

- o The three facilities are the backbone of the U.S. Magnetic Fusion Program:
  - Provide opportunities to ~500 scientists for fusion experiments;
  - Advance fusion scientific understanding of plasmas in the U.S. and provide a strong U.S. presence in international collaborations;
  - Give credibility to U.S. partnership in ITER.
- o In FY 2007, the total research and facility operations budget for the three facilities increases from \$110.4M to \$114.6M
  - DIII-D operations will increase from 7 weeks in FY 2006 to 12 weeks in FY 2007; C-Mod increases from 14 weeks to 15 weeks; NSTX from 11 weeks to 12 weeks.
  - Coordinated experiments on burning plasma physics and ITER physics support through the International Tokamak Physics Activity (ITPA) will have high priority
- o The U.S. will continue collaboration on foreign tokamaks for increased experimental opportunities.

## **FY 2007 Fusion Program Highlights** (continued)

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- o **Increase SciDAC** (+\$2.7M)
  - Includes two additional SciDAC projects

# Scientific Discovery through Advanced Computing

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	<u>FY 2005</u>	<u>FY 2006</u>	<u>FY 2007</u>
Funding (\$ Millions)	4.0	4.3	7.0

- o Supports multi-disciplinary teams of computer scientists, applied mathematicians, and physicists to achieve scientific advances through computer simulations
- o Existing fusion SciDAC projects in the areas of **macroscopic stability, electromagnetic wave-plasma interaction, and turbulent transport** will be continued
- o Two fusion simulation prototype centers, initiated at the end of FY 2005 in the areas of **RF wave interactions with MHD, and the plasma edge** will continue developing components for integrated simulations
- o In FY 2007, projects focused on the development of **fusion collaboratories, integrated frameworks for fusion simulations**, and other scientific application partnership areas will join our SciDAC portfolio

## **FY 2007 Fusion Program Highlights** (continued)

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- o Reduce Innovative Confinement Concepts research (-\$1.8M)
- o Reduce HEDP research (-\$3.9M)
- o Reduce Theory (-\$1.0M)
- o Reduce NCSX funding per baseline plan (-\$1.1M)
- o Reduce Plasma Technologies to focus on ITER specifics (-\$1.3M)
- o Reduce fusion materials science research (-\$2.4M)

# Innovative Confinement Concepts CE Program

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	<u>FY 2005</u>	<u>FY 2006</u>	<u>FY 2007</u>
<b>Funding (\$ Millions)</b>	<b>21.7M</b>	<b>21.8M</b>	<b>20M</b>
<u>Projects approximately 1M or more</u>			
Labs	7.1M	7.2M	6.7M
Non-Labs	6.5M	6.2M	5.6M
<u>Projects considerably less than 1M</u>			
Labs	1.01M	1.03M	0.95M
Non-Labs	6.2M	6.3M	5.8M
Other	0.79M	1.05M	0.7M

- o The reduction (8.4%) in FY 2007 will be taken uniformly across all projects
- o After 7 years of intensive review, the surviving crop of presently funded ICC CE projects have reviews rated in the Very-Good-to-Excellent range
  - Most are entering their second data gathering and analysis cycle
  - A major review of the program is planned for FY 2008/2009 time frame

# HEDP

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	<u>FY 2005</u>	<u>FY 2006</u>	<u>FY 2007</u>
Funding (\$ Millions)	14.6	15.8	11.9

- o Research in fast ignition and plasma jets is reduced by \$1.8M
- o Research in heavy ions is reduced by \$1.1M
- o Research using the Atlas pulsed power facility is discontinued (\$1M)

# Theory Program Summary

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Funding (\$ Millions)	<u>FY 2005</u>	<u>FY 2006</u>	<u>FY 2007</u>
Labs	11.5	11.0	10.4
Non-Labs	<u>14.2</u>	<u>13.9</u>	<u>13.5</u>
<b>Total</b>	<b>25.7</b>	<b>24.9</b>	<b>23.9</b>

- o FY 2006 Theory solicitation resulted in 27 proposals with 13 being funding. FY 2007 Theory solicitation is currently underway
- o Reviewed PPPL theory program, and will review the LANL and LLNL theory programs this fiscal year
- o Created a partnership with OASCR to develop a continuum kinetic edge code, which will complement the Fusion Simulation Projects
- o FY 2007 funding reductions taken across the board

## NCSX Project

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Funding (\$ Millions)	<u>FY 2005</u>	<u>FY 2006</u>	<u>FY 2007</u>
MIE	17.5	17.0	15.9
MIE Research	<u>.8</u>	<u>.8</u>	<u>.7</u>
<b>Total</b>	<b>18.3</b>	<b>17.8</b>	<b>16.6</b>

- o A new baseline was established in July 2005 for NCSX that resulted in a 14-month delay in the schedule with completion in July 2009 and a new TEC of \$92,401,000. The FY 2007 request of \$15,900,000 supports this new baseline.



## Enabling R&D

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Funding (\$ Millions)	<u>FY 2005</u>	<u>FY 2006</u>	<u>FY 2007</u>
Plasma Technologies	18.4	14.2	12.9
Materials Research	7.3	7.1	4.7

- o Plasma Technologies develops the cutting edge technologies that enable both current and future U.S. and international fusion facilities to achieve their goals.
- o Materials Research is critical to establishing the environmental attractiveness of fusion
- o Both programs are being reduced to provide resources for ITER

# Fusion Energy Sciences

(\$ in thousands)

<b>Science</b>	<b>FY 2005 Sept AFP</b>	<b>FY 2006 Appropriations</b>	<b>FY 2007 Request</b>	<b>Enabling R&amp;D</b>	<b>FY 2005 Sept AFP</b>	<b>FY 2006 Appropriations</b>	<b>FY 2007 Request</b>
DIII-D Research	24,042	24,412	24,300	Engineering Research			
C-MOD Research	8,636	8,510	8,890	Plasma Technologies (MFE)	18,403	14,205	12,945
International Collaborations	5,116	4,826	5,064	Advanced Design & Analysis (MFE)	2,979	2,489	2,550
Diagnostics	3,894	3,763	3,854	Enabling R&D for ITER	0	3,449	23,000
Other	5,364	5,006	3,730	Materials Research (MFE)	7,338	7,043	4,687
SBIR/STTR (science)	0	6,945	7,262	<b>Enabling R&amp;D Total</b>	<b>28,720</b>	<b>27,186</b>	<b>43,182</b>
<b>Subtotal Tokamaks</b>	<b>47,052</b>	<b>53,462</b>	<b>53,100</b>	<b>Total Fusion Energy Sciences</b>	<b>266,947</b>	<b>287,644</b>	<b>318,950</b>
NSTX Research	15,992	15,845	16,696	DIII-D	55,751	54,692	56,662
Experimental Plasma Research	21,656	21,778	19,990	Alcator C-Mod	22,038	21,717	22,831
HEDP	14,640	15,856	11,949	NSTX	34,387	33,985	35,118
ATLAS	(0)	(990)	(0)	NCSX	18,273	17,770	16,597
MST Research	6,423	6,320	6,970	ITER (Preparations & MIE)	5,451	25,150	60,000
NCSX Research	773	751	697	Non-ITER	261,496	262,494	258,950
<b>Subtotal Alternates Research</b>	<b>59,484</b>	<b>60,550</b>	<b>56,302</b>				
<b>Theory</b>	<b>24,928</b>	<b>25,749</b>	<b>23,900</b>				
<b>Advanced Computing/SciDAC</b>	<b>4,033</b>	<b>4,222</b>	<b>6,970</b>				
<b>General Plasma Science</b>	<b>12,176</b>	<b>13,760</b>	<b>13,941</b>				
<b>Science Total</b>	<b>148,494</b>	<b>156,922</b>	<b>154,213</b>				
<b>Facility Operation</b>							
DIII-D	31,709	30,280	32,362				
Alcator C-Mod	13,402	13,207	13,941				
NSTX	18,495	18,140	18,422				
NCSX	17,500	17,019	15,900				
Facility Ops times in weeks	16/18/18	7/14/11	12/15/12				
Other	1,433	1,298	2,020				
GPE	100	100	100				
GPP	1,643	1,791	1,810				
ITER Preparations	5,451	5,835	0				
U.S. Contributions to ITER (MIE)	0	15,866	37,000				
<b>Facility Operations Total</b>	<b>89,733</b>	<b>103,536</b>	<b>121,555</b>				

## **Representative Sherwood Boehlert (R-NY) During House Debate on 11/9/05**

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"I want to make clear to everyone concerned that I will do everything in my power to kill the ITER project if there is not an agreement by March that the domestic fusion program has to be scaled back to pay for ITER. I am not going to allow the U.S. to enter into an international commitment that it cannot afford. I would rather kill the ITER project. The fusion community will have to be realistic. It cannot have all its current projects and ITER. And it will not."

# American Competitive Initiative and Earmarks

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Funds provided in a tough federal budget must be used for relevant, peer reviewed research

Earmarks will be removed from agency budget in the next year

## Outreach to S&T Communities

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*“... Most scientists funded by [OFES] do not actively participate in the wider scientific culture. As a result, the flow of scientific information out of and into the field is weak. ...Nor is the high-quality science in the program widely appreciated outside the field. Indeed, the broader scientific community holds a generally negative view of fusion science.”*

- National Research Council's Assessment of the DOE's Office of Fusion Energy Sciences Program, 2001

*The Secretary of Energy must submit to Congress a plan which ensures that “communication of scientific results and methods between the fusion energy science community and the broader scientific and technology communities is improved.”*

- Energy Policy Act of 2005, Sec. 972(b)(1)(E)

# Outreach to S&T Communities

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- o All of fusion will benefit from greater communication with and respect from other areas of science and technology
  - No direct incentive for broader communities to initiate
  - Energy Policy Act requirement and a good idea
- o OFES will track
  - Number of presentations at local colleges, alma maters, and other universities
  - Collaborations with scientists outside of plasma physics
  - Talks at non-plasma specific science meetings
  - Attempts to publish in broader science journals
    - Rejections okay – data still useful
- o First annual report from major facilities, ICC, and Theory leaders to be presented at March 2007 budget planning meeting
- o Line in grants and cooperative agreements may be added

# New Charge to FESAC

## Evolution of the Fusion Energy Sciences Program

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Department of Energy  
Office of Science  
Washington, DC 20585  
February 27, 2006

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Professor Stewart C. Prager, Chair  
Fusion Energy Sciences Advisory Committee  
Department of Physics  
University of Wisconsin  
1150 University Avenue  
Madison, Wisconsin 53706

Dear Professor Prager:

For many years, the fusion program has benefited from international collaboration in all aspects of the program. With the advent of the ITER project, the program will achieve a new and unprecedented level of collaboration. Also, during the time before ITER operations begin, our ITER partners will be bringing a new suite of advanced tokamak facilities on line around the world. It is time for us to begin to plan for the transition to the operating phase of ITER, and, in so doing, assess how we can optimize our experimental physics program, considering all the facilities that will be available worldwide.

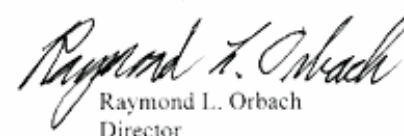
Therefore, I would like for FESAC to address an important set of issues: how the program should evolve over the coming decade to take into account new and upgraded international experiments and how the program should prepare to make the transition to ITER. Viewing the world fusion program as a fully integrated international endeavor rather than a series of national efforts, where will synergies, redundancies, and gaps in research arise, and how should the U.S. program adjust to minimize duplicate effort and fill important gaps? Should existing facilities remain in their current configurations, or should they be reconfigured to pursue the science of different concepts? Serious consideration should also be given to whether a point exists within the next 10 years when funds for any of the four major U.S. facilities may be better used for hardware and research on more capable facilities abroad.

FESAC has recently produced two comprehensive reports on the U.S. Magnetic Fusion Program, one titled "Scientific Challenges, Opportunities, and Priorities for the U.S. Fusion Energy Sciences Program" in December 2004, and the next titled "Characteristics and Contributions of the Three Major United States Toroidal Magnetic Fusion Facilities" in July 2005. These reports should provide a starting point for your work. This report should look strategically to the future, providing decision points and criteria for making those decisions. I will be able to provide budget guidance as soon as the Office of Science five-year budget is public. Given that funding will be finite, you will need to recommend priorities among the opportunities that you will identify.

This is an exciting time for the fusion program, a time for the fusion community to look forward with confidence that we will have a burning plasma experiment, as well as support for the balance of the program. It is also a time to reassess our portfolio of experiments and optimize what we are doing in the context of the world fusion program.

I would like to receive your report by the end of February 2007. Thank you for your time and your hard work.

Sincerely,

  
Raymond L. Orbach  
Director

# Associate Director Position Vacancy Information

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To find out more information on the position for  
[Associate Director for Fusion Energy Sciences](#)

Go to [www.usajobs.opm.gov](http://www.usajobs.opm.gov)

Click on “**Search Jobs**”

In “**Keyword Search**” type in **Fusion**

At bottom of page, click “**search for jobs**”

Closing Date for application submission is March 31, 2006