ENERGY TECHNOLOGY INNOVATION POLICY

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DOE FY09 Budget Request for Energy Research, Development & Demonstration – Commentary

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Energy Technology Innovation Policy

The overarching objective of the Energy Technology Innovation Policy (ETIP) research group is to determine and then seek to promote adoption of effective strategies for developing and deploying cleaner and more efficient energy technologies, primarily in three of the biggest energy-consuming nations in the world: the United States, China, and India. These three countries have enormous influence on local, regional, and global environmental conditions through their energy production and consumption.

ETIP researchers seek to identify and promote strategies that these countries can pursue, separately and collaboratively, for accelerating the development and deployment of advanced energy options that can reduce conventional air pollution, minimize future greenhouse-gas emissions, reduce dependence on oil, facilitate poverty alleviation, and promote economic development. ETIP's focus on three crucial countries rather than only one not only multiplies directly our leverage on the world scale and facilitates the pursuit of cooperative efforts, but also allows for the development of new insights from comparisons and contrasts among conditions and strategies in the three cases.

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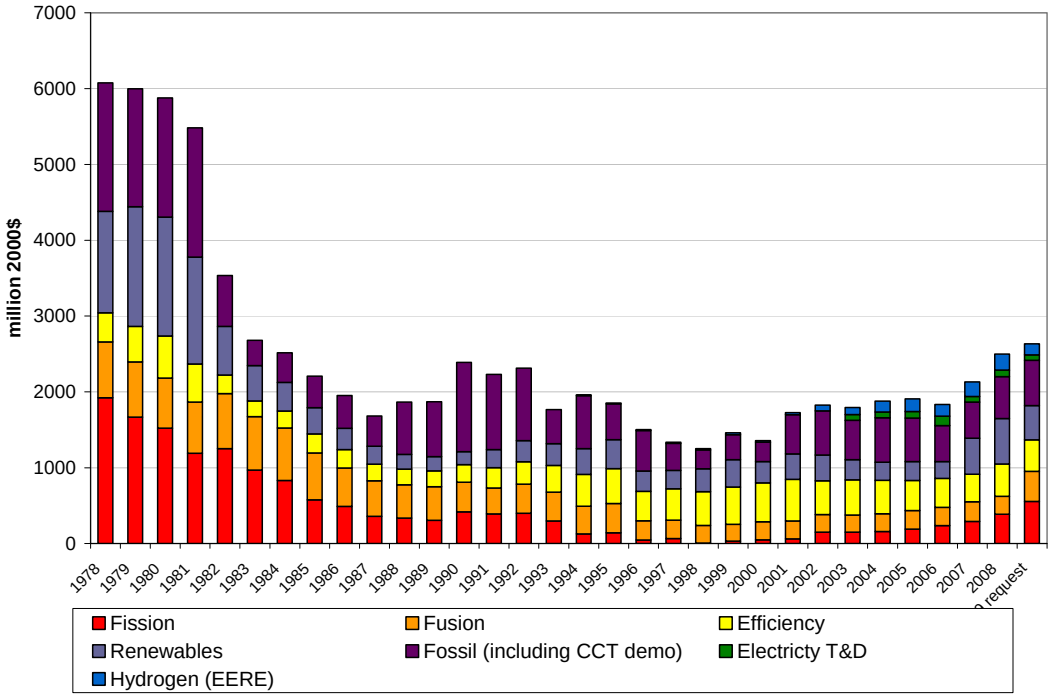
GOVERNMENT FUNDED ENERGY RD&D FOR 2009 BOLSTERS FOSSIL AND NUCLEAR ENERGY AT EXPENSE OF EFFICIENCY AND RENEWABLES

Summary: The FY09 budget request would increase energy research, development, and demonstration (RD&D) by 8%, but the increase is achieved by beefing up fission and fossil RD&D programs and significantly cutting energy efficiency and renewable energy RD&D budgets.

In his 2008 State of the Union address, President George W. Bush emphasized the importance of empowering American scientists and engineers to "pursue the breakthroughs of tomorrow."[1] He called on the government to: fund improvements in fossil fuel technologies; increase the use of renewable and nuclear power; invest in advanced battery technology and renewable fuels to power future vehicles; and start an international clean technology fund to ease the transition of developing countries to low-carbon technologies.

The fiscal year 2009 (FY09) budget request for the Department of Energy (DOE), however, does not reflect all of these priorities. The President's request calls for an energy RD&D budget of $3.2 billion, only a fraction of the energy RD&D budgets of the 1970s, and well below the level suggested by current energy technology challenges and opportunities (see Figure 1 below). The request would ramp up nuclear fission RD&D funding by 46% over the FY08 appropriation, to $689.1 million, and would increase fossil energy RD&D by 10%, to $743.7 million (see Table 1 at end of document). But it would also cut renewable energy R&D funding by 23%, to $562.5 million, and reduce energy efficiency funding by 28%, to $595.1 million (when deployment programs such as weatherization are included). In addition, the FY09 request would cut electric transmission and distribution (ET&D) funding by 15% from FY08. Given that improved and flexible transmission and distribution systems are essential to accommodate an increased use of renewable energy sources and further reduce emissions,[2] a decline of investment in ET&D RD&D is also inconsistent with the policy aim of creating a U.S. future with more renewable energy and energy efficient systems.

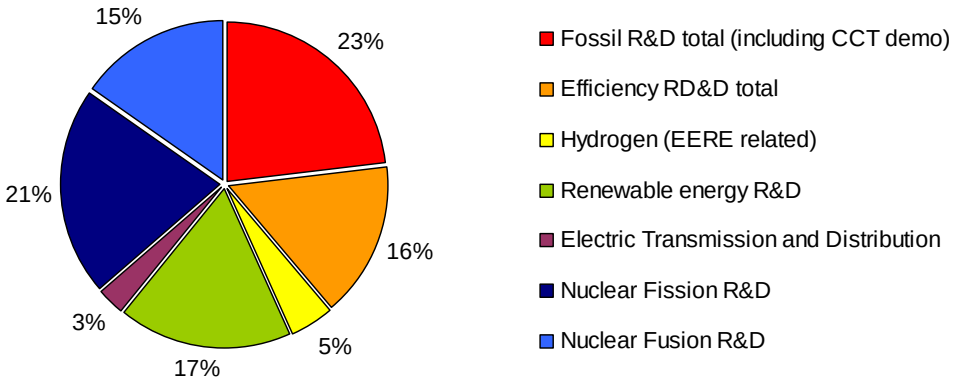
Figure 1: U.S. DOE Energy RD&D Spending FY1978-FY2009, in millions of 2000$.



Renewable energy: cuts take spending back to FY07 level

If approved, the proposed $167.5 million cut would return renewable energy RD&D funding to the levels of FY07 – before the recent spikes in fossil fuel prices and the release of the latest report from the Intergovernmental Panel on Climate Change. Almost 90% of the proposed cut, however, comes from eliminating congressionally directed projects (otherwise known as earmarks). The 2009 request only allocates 17.4% of the total $3.2 billion in energy RD&D funding to renewable energy. In comparison, fossil energy (primarily coal), nuclear fission, and nuclear fusion RD&D receive 23%, 21.3% and 15.2% of the budget, respectively (see Figure 2).

Figure 2: U.S. DOE Energy RD&D FY09 Budget Request (total = $3239.3 million)



The renewable energy sources slated for funding boosts in the 2009 request are biomass and geothermal energy. The FY09 budget request would increase biomass RD&D funding from $198.2 million in the 2008 appropriation to $225 million. With this increase, biomass energy RD&D would account for almost half (48%) of the renewable energy funding portfolio. The biomass RD&D program is focused on improving three key technology areas: feedstock infrastructure, biochemical and thermochemical conversion of biomass to fuels (particularly work on fuels from cellulosic biomass), and demonstration of industrial biorefineries. The $30 million geothermal RD&D funding request for FY09 represents an increase of almost 52% from the FY08 appropriation – particularly noteworthy for a program the administration had previously tried to cancel. The roughly $10 million increase would be dedicated to setting up public-private partnerships and supporting RD&D in the areas of reservoir stimulation, fracture mapping, and fluid circulation of enhanced geothermal systems (which are reservoirs engineered to produce energy economically). RD&D funding for wind would increase by 6%, to $52.5 million, in the FY09 request. Funding for solar energy, by contrast, would decline by 7%, to $156.2 million.

There are three other initiatives within the Renewable Energy RD&D budget that are worth mentioning. The first is the Renewable Energy Production Incentive (REPI) subprogram, which the FY09 budget request proposes to terminate. REPI provided financial incentives for non-private and native institutions generating renewable electricity and had a budget of $5 million in FY08. DOE's rationale for terminating the program is that the appearance of state incentives and policies, such as Renewable Portfolio Standards, and the growing number of applicants (which has significantly reduced the sums that can be paid out to each applicant) have reduced the value of REPI. The second initiative is the Asia Pacific Partnership (APP). Although Congress has refused to fund it so far, the FY09 budget request calls for $7.5 million to provide the APP with funds to install new renewable power, transfer or demonstrate best manufacturing and construction practices, and promote energy efficient appliance standards. Finally, the International Renewable Energy Program will not receive funding under the FY09 request. This program has not received DOE support since FY07, when it was allocated $9.5 million.

Efficiency: 28% cut if deployment programs included

The $595.2 million requested for the energy efficiency research, development, demonstration and deployment programs represents a 28% decline from the $822.2 million appropriated in FY08. Two main factors cause this large drop: the termination of the Conservation Weatherization Program, and the disappearance of earmarked projects. If the deployment programs (which include the Weatherization Program but not the earmarks) are not included, the budget request would cut the remaining RD&D program by only $2 million from the FY08 appropriation.

Since 1976, the weatherization program, which had a budget of $222.7 million in FY08, has helped over 5 million low-income American families reduce their energy bills by an average of $358 per year while increasing the comfort and safety of their homes. In addition, the weatherization program supported 8,000 technical jobs through a network of partnerships with more than 970 Weatherization agencies. DOE's budget justifications assert that the program is to be cancelled because it had a historical benefit-cost ratio of 1.5 -1, leading DOE to prefer to redirect the money to efficiency R&D, which is claimed to have a benefit-cost ratio of 20-1.[3] The fact is that the funds from terminating weatherization were *not* redirected to energy efficiency R&D, which was also reduced slightly. Energy efficiency earmarks added up to $40.4 million in the FY08 omnibus appropriation, and as expected, they disappeared from the FY09 request.

The budget request would divide the energy efficiency portfolio as follows: 50% would go to vehicle technologies, 14% to industrial efficiency projects, 28% to building technologies, and 8% to distributed energy sources. The vehicle technology program, which accounts for half of the energy efficiency budget, will help develop both more efficient vehicles and improved battery technologies, which, in the near term, will help car makers meet the new 35-mile-per gallon Corporate Average Fuel Economy standard by 2020 – reducing both oil use and carbon emissions.

Hydrogen: cut by one-third, focus on storage and fuel cells

The FY09 request would also result in a sharp decline in the funding of hydrogen technology in the RD&D portfolio. DOE's FY09 $146.2 million request for hydrogen RD&D is 31% lower than the $211 million appropriated in FY08. This cut was driven by the disappearance of the Hydrogen Production and Delivery R&D program, which had a budget of $39.6 million in FY08, and, to a lesser extent, the transfer of the Technology Validation, Safety & Codes & Standards, and Education programs (worth a total of $15 million) to the Vehicle Technologies program within the Energy Efficiency portfolio.[1] The

[1] The transfer of the Technology Validation, Safety & Codes & Standards, and Education programs within the Hydrogen technologies portfolio, to the Vehicle Technologies program within the energy efficiency portfolio, is small enough ($15 million) compared to the $595.2 million requested for the energy efficiency portfolio for FY09, that it makes sense to compare the FY08 appropriation with the FY09 budget request for energy efficiency.

budget request identifies the hydrogen storage and fuel cell RD&D activities as high priority, proposing to increase their budgets by an average of 40%, to $59.2 million and $72.7 million, respectively.

Energy Storage: recognized as crucial, growing, but not sufficient

The ability to store energy is very important in today's increasingly carbon- (and oil-) constrained world. Intermittent and solar energy sources could play a much larger role in providing emissions-free electricity and heating services, and the transportation sector could be increasingly de-coupled from oil, once efficient, robust, and low-cost energy storage technologies become available.[2] Therefore, energy storage technologies will have a major impact on the scale and speed of deployment of low-carbon domestic energy solutions. Although there is no "energy storage" program *per se*, it is useful to evaluate the evolution of DOE's efforts in the terrain of energy storage RD&D.

As discussed earlier, the FY09 budget request asks for a 40% funding increase for the hydrogen storage sub-program of the Hydrogen Technology program, making up a total of $59.2 million. The budget would keep work on vehicle batteries and capacitors funded through the Office of Energy Efficiency and Renewable Energy (EERE) roughly constant, rising from $48.2 million in FY08 to $49.5 million in FY09. The Office of Electricity Delivery and Energy Reliability (EDER) would see its work on both portable and stationary energy storage technologies increase four-fold, but from a very low level, rising to $8.8 million. Some of the renewable energy programs also fund their own storage work, such as work on storing heat from solar thermal systems in hot molten salts, or development of compressed-air approaches to storing energy from wind power.

Given the strategic importance of energy storage, these storage RD&D budgets appear to be far less than is needed. In some cases, U.S. automotive firms are now forced to import advanced batteries from Asia, and it is not in the U.S. interest to lose any more ground in the development of energy storage technologies.

Fossil: growing budget devoted to coal and carbon sequestration

In FY09, the Bush Administration is asking for a modest 10% increase from the FY08 appropriated levels for RD&D on fossil energy, to $743.7 million. This comparatively small budget increase, however, disguises two significant changes in the FY09 fossil RD&D budget request. First, the request advocates a termination of the oil and natural gas programs within the fossil energy RD&D portfolio, which added up to $5.0 million and $19.8 million, respectively, in the FY08 appropriation. The proposed termination of these programs was justified in terms of their "ineffectiveness"[4] – as determined using the Program Assessment

[2] Another key enabling technology for intermittent electricity generation resources is the creation of smart-grids, which decrease the variability in electricity supply from intermittent energy sources by connecting large areas with many generation stations.

Rating Tool (PART) developed by the Office of Management and Budget. Both programs already experienced large budget cuts back in 2006. With oil and gas out, coal and carbon sequestration are all that is left in the fossil RD&D portfolio. Second, the request calls for a restructuring and a budget doubling (from $74.3 million in the FY08 appropriation to $156 million in the FY09 request) for the FutureGen project. FutureGen's original goal was to build the first near-zero emissions commercial prototype of a coal power plant. Its restructured program is supposed to accelerate the commercial use of near-zero emissions coal with the demonstration of several 300-600 MW facilities – with the private sector paying to build the advanced plants and DOE focusing its work on carbon capture and storage – instead of a single 275 MW R&D facility with a more central DOE role. In principle, the restructured FutureGen should have a higher chance of success and do more to accelerate the commercial deployment of carbon sequestration technologies. But the new approach would require bigger private sector financial commitments, and it remains to be seen whether DOE can get the private investments needed for the new approach, when carbon capture and storage technologies for coal plants have not yet been demonstrated and integrated gasification plants are more expensive than other types of coal-fired power plants.

Another striking feature of the fossil energy RD&D portfolio is the steady increase in the budget for the carbon sequestration program. Non-existent in 2003, the size of the program has grown at an average rate of $23.5 million per year, reaching $149.1 million in the FY09 request. The goal of the carbon sequestration program is, by 2012, to develop technologies capable of capturing and storing CO_2 that result in a less than 10% increase in the price of electricity. The amount requested for FY09 would, among other things, be used to fund existing work on: (a) monitoring, mitigation and verification operations in 25 saline formations, depleted oil and gas fields, and unmineable coal seams; (b) injection of CO_2 and monitoring at three large-scale demonstration projects; (c) CO_2 capture using membranes, ionic liquids, and metal organic frameworks; and (d) pilot-scale testing of two projects involving "oxycombustion" (burning coal in an oxygen atmosphere, resulting in a high-concentration CO_2 exhaust which is easier to capture).

While the budget for RD&D on coal with carbon sequestration has grown substantially, there is clearly a need for large-scale demonstrations of sequestration in a wide range of geologies, as called for in the 2007 Energy Independence and Security Act (EISA). Congress should consider increased appropriations for large-scale demonstrations.

Nuclear: growing budgets, excessive focus on reprocessing

The nuclear fission RD&D budget request for FY09 is $689.1 million, 45% greater than the FY08 appropriation and three times larger than the FY05 budget ($214.4 million). Three out of the four components in the nuclear fission RD&D budget – the Nuclear Power 2010 (NP2010) program, the Advanced Fuel Cycle Initiative (AFCI), and the Nuclear Hydrogen Initiative (NHI) – would increase significantly from FY08.

NP2010 is a cost-shared program with industry to get over the final design

certification and licensing obstacles to getting construction of new nuclear plants started in the United States. (The program would also oversee implementation of the stand-by support and loan guarantees called for in the Energy Policy Act.) The FY09 budget request calls for an 80% boost for this effort, to $241.6 million. With several U.S. utilities actively preparing to build new nuclear power plants, however, NP2010 already appears to have achieved its objective of getting new nuclear plants to the point at which industry would take on the job on its own. It seems highly likely that industry would complete the remaining activities envisioned in the program with or without government help – and the request for this project is four times the request for wind RD&D; more than $80 million more than solar RD&D; bigger than all R&D on biomass; roughly $100M more than all R&D on carbon sequestration; more than all RD&D on efficient and alternative-fuel vehicles; and four times RD&D on industrial efficiency.

Similarly, the $301.5 million AFCI funding request is 68% more than the FY08 appropriation, accounting for 46% of the total FY09 budget request for fission RD&D. This request is higher than the request for RD&D on *any* other energy source or efficiency program except clean coal. AFCI supports the administration's Global Nuclear Energy Partnership (GNEP) concept for a future nuclear world of fast-neutron reactors and reprocessing and recycling of the actinides from spent fuel – but there are strong reasons to believe that implementing that vision with any technologies likely to be available in the near term would pose more proliferation and terrorism risks and higher costs than would continuing with once-through use of spent fuel.[5] A 2007 National Research Council review recommended unanimously that "the GNEP program should not go forward" (in the form of construction of large-scale facilities), and "should be replaced by a less-aggressive research program."[6] In FY08, Congress cut the administration's request to $180 million for AFCI, and barred any expenditure on facility construction. A similar approach seems appropriate this year, with instruction to redirect GNEP to focus on long-term research on improving both open and closed fuel cycles.

The NHI program is aimed at demonstrating the potential for hydrogen generation using advanced reactors. Since its inception in 2003, the program has experienced a volatile budget. The FY09 budget request of $16.6 million is 68% more than the F08 appropriation, but 12% below the FY07 level.

The only nuclear fission R&D program the proposed budget would reduce is the Generation IV nuclear energy systems initiative. Originally designed to support long-term R&D on a broad range of advanced reactor and fuel cycle technologies, the program is now primarily focused on near-term development of the Very High-Temperature Reactor (VHTR). The proposed cut from $114.9 million in FY08 to $70 million in FY09 would essentially reverse the increase from the request that Congress provided in FY08.

Finally, the FY09 request boosts the nuclear fusion energy sciences program budget by 72% over its 2008 appropriation to a total of $493.1 million. This large increase is almost completely driven by the fact that the FY09 budget allocates $214.5 million to fund the

International Thermonuclear Experimental Reactor project (ITER),[7] which was left unfunded in FY08. When combined, fission and fusion R&D account for over one third of DOE's FY09 energy RD&D budget request.

International efforts: a new fund, but few details

In his 2008 State of the Union address, President Bush announced that the United States would increase its efforts to aid developing countries to reduce their greenhouse gas emissions by creating an international clean energy technology fund. The fund is aimed at confronting climate change worldwide and accelerating the deployment of cleaner energy technologies, by leveraging private-sector capital.[8] In his speech, the president committed $2 billion over the next three years to this initiative; this burden was taken up by the Treasury Department, which has allocated $400 million for the fund in FY09 (a level that would require a rapid ramp-up in later years to meet the president's $2 billion target).[9] The new clean energy technology fund would be administered by the World Bank, through a range of Multilateral Development Banks, and its specifics are being developed jointly by the United States, the United Kingdom, Japan, and other potential donors. The administration has suggested that only countries already "undertaking credible national plans" to reduce greenhouse gas emissions, and prepared to lock in those plans in post-Kyoto agreements should have access to this clean technology fund.[10] The specifics about how this fund will work will be crucial in determining how effective the effort can be in motivating accelerated deployment of low-carbon technologies in developing countries. The other most important international collaborative RD&D effort is ITER, discussed above.

Looking ahead: ensuring U.S. competitiveness in low-carbon energy technologies

Development and deployment of new energy technologies will be critical to meeting the climate-change and energy-security challenges of the 21st century at reasonable cost – and developing and deploying them in the United States is likely to be critical to U.S. economic competitiveness.

The FY09 request does build on the substantial boost in energy RD&D that Congress provided in the FY08 omnibus appropriation. But measured by the scope of the energy challenges and the opportunities for new technologies to address them, the request falls short. Clearly, the request is a far cry from the Manhattan Project for clean energy technology that some have proposed. In 2004, the National Commission on Energy Policy recommended that energy RD&D be doubled from FY05 to FY10 in real terms;[11] the FY09 request is only 39% more than the FY04 appropriation. Indeed, spending on efficiency RD&D has actually declined in real terms.

Insufficient U.S. investments in energy RD&D may allow other countries to seize the lead in the multi-trillion-dollar future market for advanced energy technologies. Already, the United States imports wind turbines from Europe, imports advanced batteries from Asia,

hires nuclear energy construction firms from Europe and Asia, and has lost the lead in installing solar energy. The European Union (EU) and Japan are adopting more stringent policies to create market incentives for the development and deployment of low-carbon technologies. The EU, seeking to become the world leader in clean energy technology, recently released a Strategic Energy Technology Plan (SET-Plan), which would not only increase energy technology RD&D funding, but also focuses on improving the effectiveness of this investment through better use of the different capabilities of the EU states.[12, 9]

In short, the time has come for bolder U.S. action on energy RD&D. Rather than being cut back, both renewable and efficiency RD&D should be substantially increased, as should funding for carbon sequestration RD&D. The request for nuclear RD&D should be reduced in some areas and redirected to those technologies likely to have the most benefit for low-carbon energy supply in the decades to come.[13] Further developments in efficiency can reduce both carbon emissions and oil dependence, often at low or negative net cost to society. Carbon capture and storage is the only way to use fossil fuels without emitting the resulting CO2 into the atmosphere. But it will require substantial development and demonstration to validate the option and bring it into large-scale commercial use, so a larger RD&D investment will surely be needed, especially for large-scale demonstration projects.

The proposal to create a new fund to finance international clean energy projects is positive – but is too small, vague, and tied to countries' willingness to make up-front commitments to seize the opportunity for international clean energy collaboration. The key energy challenges are global and will require global responses. International cooperation in energy RD&D can reduce the U.S. share of the cost of bringing new technologies to market, make those technologies available for deployment in key countries around the world, foster new business opportunities for U.S. firms, and help solve multinational problems such as global climate change.[14] A much more substantial fund should be established for international cooperation on low-carbon RD&D.

Finally, to get the world's fossil-fueled economy moving in a low-carbon direction, major innovations in technology policy are required to push and pull low-carbon technologies into the marketplace. Putting a price on carbon emissions; creating new institutions for the management of RD&D; performance standards; institutional arrangements to reduce the safety, security, and proliferation risks of nuclear energy and deal with its wastes; are all examples of such policy innovations. Congress and the administration are moving, largely in the right directions – but not at the pace and scale that is required.

Table 1: U.S. DOE Energy RD&D FY08 Appropriation and FY09 Budget request – breakdown (in millions of current U.S. dollars)

	FY08 appropriation	FY09 request	$ change	% change
FOSSIL ENERGY				
Coal R&D (excl. FutureGen and sequestration, incl. clean coal power initiative)	300.5	318.6	18.1	6.02%
FutureGen	74.3	156.0	81.7	109.96%
Carbon Sequestration	118.9	149.1	30.2	25.40%
Petroleum	5.0	0.0	-5	-100.00%
Gas	19.8	0.0	-19.8	-100.00%
Program direction and management	149.0	126.3	-22.7	-15.23%
Plant, capital equipment, and construction	12.9	5.0	-7.9	-61.24%
Cooperative R&D	5.0	0.0	-5	-100.00%
Congressionally directed projects	48.1	0.0	-48.1	-100.00%
Prior year balances and adjustments	0.0	-11.3	-11.3	
Fossil R&D total (excluding Clean Coal Technology, CCT, demonstration)	**733.5**	**743.7**	**10.2**	**1.39%**
Fossil (other non-CCT demo)	9.6	10.1	0.5	5.21%
Fossil (total all items excluding CCT demo)	743.1	753.8	10.7	1.44%
Clean Coal Technology (CCT demonstration program)	-58.0	0.0	58	-100.00%
Fossil R&D total (including CCT demo)	**675.5**	**743.7**	**68.2**	**10.10%**
ENERGY EFFICIENCY				
Vehicle technologies (prior to FY03, transportation)	213.0	221.1	8.1	3.80%
Industry	64.4	62.1	-2.3	-3.57%
Buildings	109.0	123.0	14	12.84%
Multi-sector	0.0	0.0	0	0.00%
Facilities	0.0	0.0	0	0.00%
Policy and management (FY05-estimated efficiency portion)	68.5	79.3	10.87	15.87%
Distributed energy resources (FY03-on)	25.5	33.3	7.8	30.59%
Congressionally directed projects	40.4	0.0	-40.4	-100.00%
Prior year balances and adjustments (excludes PODRA adjustments)	-0.7	-0.7	0	
Efficiency RD&D total (no deployment items)	**520.1**	**518.1**	**-1.93**	**-0.37%**
Conservation Weatherization Program	222.7	0.0	-222.7	-100.00%
Federal Energy Management Program	19.8	22.0	2.2	11.11%
State & local grants	44.1	50.0	5.9	13.38%
Efficiency (total other)	15.5	5.0	-10.5	-67.74%
Use of prior year balances	0.0	0.0	0	
Efficiency (total all items, including deployment)	**822.2**	**595.1**	**-227.03**	**-27.61%**
HYDROGEN				
EERE, energy efficiency and renewable energy-related	**211**	**146.2**	**-64.8**	**-30.71%**

	FY08 appropriation	FY09 request	$ change	% change
RENEWABLES				
Solar (includes biofuels, wind, ocean up to FY98)	168.5	156.2	-12.3	-7.30%
Biomass (included in solar until 1998; FY05-on includes biorefinery systems)	198.2	225.0	26.8	13.52%
Wind (included in solar until FY98)	49.5	52.5	3	6.06%
Geothermal (R&D)	19.8	30.0	10.2	51.52%
Water Power (Prior to FY08- hydropower, now includes tidal)	9.9	3.0	-6.9	-69.70%
Other	69.3	4.0	-65.3	-94.23%
Policy and management (FY05-on, estimated renewables portion)	68.5	84.3	15.78	23.04%
International renewable energy program (Note: for FY09 request, this is directed to Asia Pacific Partnership)	0.0	7.5	7.5	100.00%
Congressionally directed projects	146.3	0.0	-146.3	-100.00%
Prior balances	0	0	0	
Renewable energy R&D total	**730.0**	**562.5**	**-167.52**	**-22.95%**
ELECTRIC TRANSMISSION AND DISTRIBUTION				
Research & Development	59.7	66.9	7.2	12.06%
Congressionally-directed projects	24.3	0	-24.3	-100.00%
Program Direction	17.6	19.7	2.1	11.93%
Electric Transmission and Distribution Total	**101.6**	**86.6**	**-15**	**-14.76%**
NUCLEAR FISSION				
Program direction policy and management - TOTAL	80.9	80.5	-0.40	-0.49%
Nuclear energy technologies (FY05-on, re-labeled Nuclear Power 2010)	133.8	241.6	107.80	80.57%
Generation IV nuclear energy systems initiative	114.9	70	-44.90	-39.08%
Nuclear hydrogen initiative	9.9	16.6	6.70	67.68%
Advanced fuel cycle initiative	179.4	301.5	122.10	68.06%
Use of prior balances - R&D share	0	0	0.00	
Program direction policy and management - (estimate of R&D share of total nuclear energy)	34.2	59.4	25.21	73.78%
Use of prior balances - TOTAL	0	0	0.00	
Nuclear Fission R&D total	**472.2**	**689.1**	**216.91**	**45.94%**
Nuclear (other - includes advanced radioisotope power system, isotope support and production, nuclear facilities, MOX facilities, uranium programs)	326.9	38.7	-288.20	-88.16%
Non-fusion Nuclear (total all items)	**799.1**	**727.8**	**-71.29**	**-8.92%**
NUCLEAR FUSION				
Nuclear Fusion R&D	**286.5**	**493.1**	**206.60**	**72.11%**
TOTAL ENERGY TECHNOLOGY RD&D	**2996.8**	**3239.3**	**242.46**	**8.09%**

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[5] See Matthew Bunn, "Risks of GNEP's Focus on Near-Term Reprocessing," testimony to the Senate Committee on Energy and Natural Resources, 14 November 2007, available as of 14 May 2008 at http://belfercenter.ksg.harvard.edu/files/bunn-GNEP-testimony-07.pdf. For recent reports representing a range of views that have all recommended against near-term reprocessing in the United States, see, for example, John Deutch and Ernest J. Moniz, co-chairs, *The Future of Nuclear Power: An Interdisciplinary MIT Study* (Cambridge, MA: Massachusetts Institute of Technology, 2003, available as of 12 November 2007 at http://web.mit.edu/nuclearpower/); National Commission on Energy Policy, *Ending the Energy Stalemate: A Bipartisan Strategy to Meet America's Energy Challenges* (Washington, D.C.: National Commission on Energy Policy, December 2004, available as of 12 November 2007 at http://www.energycommission.org/files/contentFiles/report_noninteractive_44566feaabc5d.pdf), pp. 60-61; Committee on Review of DOE's Nuclear Energy Research and Development Program, *Review of DOE's Nuclear Energy Research and Development Program* (Washington, D.C.: National Academy Press, October 2007, available as of 12 November 2007 at http://www.nap.edu/catalog/11998.html); Nuclear Energy Study Group, American Physical Society Panel on Public Affairs, *Nuclear Power and Proliferation Resistance: Securing Benefits, Limiting Risk* (Washington, D.C.: American Physical Society, May 2005, available as of 12 November 2007 at http://www.aps.org/policy/reports/popa-reports/proliferation-resistance/upload/proliferation.pdf); and Keystone Center, *Nuclear Power Joint Fact-Finding* (Keystone, Colo: Keystone Center, June 2007, available as of 12 November 2007 at http://www.keystone.org/spp/documents/FinalReport_NJFF6_12_2007(1).pdf).

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[14] J.P. Holdren, *et al., Powerful Partnerships: The Federal Role in International Cooperation on Energy Innovation.* (Office of Science and Technology Policy, Washington D.C., 1999).