TAX INCENTIVES FOR INNOVATIVE ENERGY-EFFICIENT TECHNOLOGIES (UPDATED)

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EXECUTIVE SUMMARY

As part of his National Energy Policy Report (NEP), President Bush has proposed tax credits to stimulate the commercialization and sale of several innovative energy efficiency and renewable energy technologies. Since then, the U.S. House of Representatives passed H.R. 4, a bill establishing tax credits for a somewhat longer list of efficiency technologies.

This report reviews previous experience with tax credits for energy efficiency measures; outlines principles to follow when designing new tax credits; provides comments on the energy efficiency tax credits proposed by the Bush Administration and Congress; and estimates potential energy, economic, and environmental benefits that could result from Administration and Congressional proposals.

Review of Previous Energy Efficiency Tax Incentives

Tax incentives to stimulate adoption of both residential and industrial energy efficiency measures were first enacted during the 1970s. The Energy Tax Act of 1978 included a 15 percent tax credit up to a maximum of $300 for residential conservation and renewable energy measures including insulation, storm windows and doors, weatherstripping, and furnace modifications. From 1978 through 1985, there were about 30 million claims for the residential tax credit, amounting to nearly $5 billion in lost revenue for the U.S. Department of Treasury. Studies indicate that most of the energy efficiency measures probably would have been installed even without incentives, resulting in a high free rider level.

The Energy Tax Act of 1978 also included a 10 percent tax credit for specified energy efficiency measures installed by businesses. The measures covered included heat recovery equipment, waste heat boilers, energy control systems, and economizers. The Act was amended in 1980 to add cogeneration equipment. This credit cost the Treasury approximately $5 billion for the period 1978 through 1982. Due primarily to the small amount of the credit, the legislation had little effect on corporate decision-making. Again, most of the measures probably would have been installed in any case. Both the residential and business tax credits applied to conventional efficiency measures, and therefore did not strongly encourage technological innovation.

Principles for New Energy Efficiency Tax Incentives

Based on the previous experience with tax credits as well as the current policy, market, and technological context, the following principles are suggested for crafting new energy efficiency tax incentives. These principles are meant to yield the greatest return on investment, assuming that the funds available for these tax credits are limited. To be effective, tax incentives should:

- Stimulate commercialization of advanced technologies;
- Establish performance criteria and pay for results;
- Pay substantial incentives;
- Choose technologies where first cost is a major barrier;
- Be flexible in terms of who receives the credit;

- Complement other policy initiatives;
- Select priorities but ‘hedge bets”; and
- Allow adequate time before phasing out the incentives.

Review of Administration and Congressional Energy Efficiency Tax Incentive Proposals

The Bush Administration, through the NEP, has proposed tax credits for several technologies, including combined heat and power (CHP) systems and hybrid and fuel cell vehicles. The NEP also encourages “market-based” incentives for additional technologies and programs.

This year, in response to both the Bush Administration plan and energy challenges in California and other states, Congress drafted a significant number of proposed energy bills that include tax incentives. CHP, hybrid vehicles, fuel cell vehicles, alternative fuel supplies and infrastructure, and new energy-efficient homes have received the greatest attention. In the House of Representatives, an omnibus bill, the “SAFE Act of 2001” (H.R. 4) was approved and contains tax incentives for energy-efficient appliances, fuel cell vehicles, hybrid and electric vehicles, and efficient commercial buildings and homes. In the Senate, a number of tax incentive bills have been introduced containing similar measures as those in the House package, but differing on some important points. Tax incentives for energy efficiency may be considered by the Senate later this year, and if not this year, then early next year.

Vehicles

Cars and light trucks are an obvious target for tax credits since innovative, fuel-efficient vehicles are under active development worldwide. Hybrid vehicles combine a small energy storage system, such as a battery, and an internal combustion engine, thereby overcoming the range problem inherent in all-electric vehicles. Tax credits for hybrid vehicles should include minimum fuel economy thresholds reflecting significant efficiency improvements relative to typical vehicles in any size class plus requirements that criteria emissions at least meet the prevailing standards for gasoline-fueled cars in the same model year.

Manufacturers have announced plans to introduce these vehicles but market acceptance is uncertain and first cost could be a barrier. The NEP has recommended the creation of an income tax credit for the purchase of hybrid and fuel cell vehicles. Working from language developed in a collaborative effort involving public-interest organizations (including ACEEE) and the automakers Honda, Toyota, and Ford, Senator Hatch (R-UT) introduced S. 760, the ‘‘Clean Efficient Automobiles Resulting from Advanced Car Technologies (CLEAR) Act of 2001.” The CLEAR Act was later introduced in the House of Representatives by Representative Dave Camp (R-MI). These identical bills set tax credits for efficient fuel cell, hybrid, electric, and alternative fuel vehicles, as well as alternative fuel supplies and infrastructure.

An amended version of the CLEAR Act was included in H.R. 4. The new language is seriously flawed due to industry-requested changes that aim to qualify low-efficiency cars and light trucks for sizeable federal incentives and that also eliminate emissions requirements from the qualification criteria. One provision, entitled a “conservation credit,” perversely credits the very lowest mileage vehicles. These changes should be rejected, and policy-makers should look towards the original CLEAR Act instead.

Buildings

H.R. 4 includes tax credits for new homes ($2,000 per home) that reduce energy use at least 30 percent relative to a widely used model building code. Most of the other bills that have been introduced in Congress provide less money for homes that save 30 percent, and include a higher tax credit for homes that save at least 50 percent over the model code. The multi-tier approach is preferable because it would encourage and reward higher levels of energy performance. S. 207 (sponsored by Senator Bob Smith [R-NH]), for example, provides a credit of $750 for a 30 percent improvement and $2,000 for a 50 percent improvement relative to the model code. By contrast, the House bill is overly generous—in many cases the $2,000 tax credit for 30 percent savings would exceed the cost of the efficiency upgrades.

Commercial buildings have been recognized for years as a significant source of untapped energy efficiency savings potential. Given the great range in building sizes and energy use, approaches to incentives for commercial building energy efficiency are usually based on energy intensity, or energy use measured on a per square foot basis. Following the per square foot formula, H.R. 4 authorizes a deduction of $2.25 per square foot for commercial buildings certified to achieve at least 50 percent in projected energy savings relative to the most widely used model code. This credit would be a useful inducement for the design and construction of a new generation of high-efficiency buildings.

H.R. 4 also includes a tax credit of up to $2,000 for saving energy in existing homes. The credit would go to homes that reduce energy use at least 20 percent using insulation and window improvements. These "tried and true" efficiency measures are well developed in the market and hence tax credits would primarily serve to promote additional sales of these products, but probably would not contribute to long-term market development. For this reason, an existing homes tax credit, while it would save some energy, is probably not as good an investment of federal funds as many of the other credits discussed in this report.

Building Equipment

Several federal programs and policies currently promote the adoption of energy efficiency measures in residential and commercial buildings, including state and local building codes, appliance and equipment efficiency standards, and labeling and promotion efforts such as the U.S. Environmental Protection Agency/Department of Energy's (EPA/DOE) ENERGY STAR® labeling program. Federal tax credits for building equipment should complement rather than duplicate these important efforts. The credits should be available to both individuals and businesses, and should include central air conditioners and electric heat pumps, furnaces, advanced water heaters, natural gas heat pumps, and building fuel cells. This year, energy efficiency tax incentives were introduced for building equipment in several bills, including S. 596 introduced by Senator Bingaman (D-NM), H.R. 2392 introduced by Representative Inslee (D-WA), and S. 207 introduced by Senator Bob Smith. In H.R. 4, fuel cells for buildings are included, but other promising technologies are not listed. No tax credits for high-efficiency building equipment has been proposed by the Bush Administration.

In the Senate, S. 596 and S. 207 each include tax credits for energy-efficient air conditioners and heat pumps, proposing a 10 percent credit up to $250 for central air conditioners and heat pumps with a seasonal energy efficiency rating (SEER) of at least 13.5 and a 20 percent credit up to $500 for central air conditioners and heat pumps with a SEER of at least 15.0. The tax credits would help to increase the market share and reduce the first cost premium for high-end units that now have only about a 1 percent market share.

Heat pump water heaters are two to three times more efficient for heating water than conventional electric resistance water heaters. Heat pump water heaters have been produced on a limited basis for many years but have never caught on due to high first cost, limited availability, and technical problems. Several new units are about to enter the market, making this a good time to stimulate production of and demand for this promising technology. Tax credits for heat pump water heaters are included in H.R. 2392.

The average gas water heater sold today has an Energy Factor of approximately 0.56; very few units are sold with an Energy Factor of 0.65 or greater. New efficiency standards recently set by DOE take effect in January 2004 and raise the average Energy Factor for gas water heaters to about 0.58–0.61, varying with storage capacity. A 10 percent credit up to $250 for units with an Energy Factor of at least 0.65 and a 20 percent credit up to $500 for units with an Energy Factor of at least 0.80 could increase availability and sales of these advanced units. In addition, combined water heating/space heating systems should be eligible for the same credit, provided that their water heating efficiency meets the 0.65 or 0.80 levels. Tax credits along these lines are included in the Inslee bill.

Distribution transformers are used to reduce electricity voltage from the high voltage levels used for distribution down to the levels used by consumers. Higher-efficiency transformers are now commercially available that reduce losses by about 30 percent on average. But further efficiency levels are possible through use of improved core materials. Tax credits for very efficient transformers would help spur commercialization and sale of transformers that significantly exceed the performance level of the ENERGY STAR transformer program.

Furnaces and furnace fan motors are significant sources of potential savings due to continuing advances in furnace and blower-motor design. In particular, improvements in motors used to distribute conditioned air are an attractive opportunity for significant homeowner savings. Also, since most furnace fans are also used to distribute air from central air conditioning systems, efficiency improvements would also reduce peak power demand, lessening the stress on utilities. S. 596 and H.R. 2392 include credits for advanced natural gas furnaces that achieve a 90 percent annual fuel utilization efficiency (AFUE) and seasonal electricity use of less than 300 kilowatt-hours (kWh) per year.

Fuel cells are a very promising distributed generation technology offering the potential to cogenerate electricity and useful thermal energy with very low emissions and high electrical conversion efficiencies. All types of fuel cells are still burdened with high capital costs.

Phosphoric acid fuel cell systems cost about $3,000 per kilowatt (kW), similar to the expected market entry cost for other types of fuel cells. A 10 percent federal tax credit could be valuable for stimulating initial sales. H.R. 4 includes a 10 percent credit up to a maximum of $1,000/kW for fuel cell cogeneration systems installed in buildings.

Appliances

Among the various household appliances, two types stand out as candidates for tax credits—refrigerators and clothes washers. In both cases, large energy savings are technically feasible and cost-effective on a life-cycle cost basis. In the case of refrigerators, a new federal refrigerator efficiency standard went into effect in July 2001 that brings the average energy use of new refrigerators down to 500 kWh per year. Still, substantial additional efficiency improvements are possible, with some studies estimating that annual energy use could ultimately be reduced to under 300 kWh. We recommend that credits be offered for products that exceed the new federal standard by 10–15 percent (as contained in S. 686 by Senator Lincoln [D-AR] and H.R. 1316 by Congressman Nussle) and that credits also be considered for higher levels of efficiency improvement. Similarly, new clothes washer standards have just been set, with the more stringent standard taking effect in 2007. Tax credits in the Lincoln and Nussle bills would promote these efficiency levels prior to 2007, and also include higher credits for units that exceed these new standards.

Combined Heat and Power Systems

A wide range of advanced CHP technologies are under development for supplying electricity and useful heat in buildings applications. These technologies include engine-based, gas turbine-based, and fuel cell-based systems, operating on natural gas or other clean fuels. Tax credits would assist CHP in overcoming several barriers, including technology cost, bureaucratic and regulatory burdens, and interconnection costs. If these challenges were addressed, CHP has the potential to provide an estimated 50,000 megawatts (MW) of power capacity to U.S. electric grids by 2010.

In the NEP, the Administration proposed either investment tax credits or shorter depreciation periods for qualifying CHP systems. Following the release of the NEP, several bills were introduced in Congress that proposed a 10 percent investment tax credit for qualifying CHP systems. Among these bills are H.R. 1945, the "Combined Heat and Power Act of 2001," and S. 596 and S. 389 by Senators Bingaman and Murkowski (R-AK), respectively. The House-passed bill, H.R. 4, includes a 10 percent investment tax credit for qualifying CHP systems installed by businesses, coupled with a longer 22-year depreciation schedule for systems earning the credit. This longer depreciation period runs counter to efforts to encourage new CHP systems and this provision should be removed. The House bill also limits the tax credit to systems over 50 kW; this provision should be removed since incentives are even more important for small systems than for large systems.

Under all of the bills, a qualifying system would need to produce at least 20 percent of its useful energy as electrical or mechanical power and at least 20 percent as thermal energy, with an overall efficiency of at least 60 percent (up to 70 percent for larger systems).

In lieu of or in addition to tax credits, shorter depreciation periods for CHP assets should be considered. Across the range of applications, depreciation levels vary widely, with many longer than equipment life. Most CHP equipment currently sold has a life of 7 to 10 years before major maintenance must be preformed. For this reason, 7- to 10-year depreciation periods make sense.

Potential Impacts

Over the past several years, members of Congress have drafted a host of bills containing various energy efficiency tax credits and depreciation modifications. In order to be able to judge the merit of these bills, Congress and the Administration have requested estimates of the revenue effects. The Treasury and the Congressional Joint Committee on Taxation (JCT) have provided "scorekeeping" for a variety of measures. There is considerable variation in scorekeeping estimates among the various entities. These inconsistencies reflect differences in assumptions and methods but also the difficulty in long-term forecasting of participation levels and other associated inputs to the estimates. In July 2001, JCT provided Congress with the estimated revenue effects of both the energy efficiency and supply-side provisions of H.R. 4. The total estimated revenue impact of the efficiency-related provisions was estimated to be approximately $5.4 billion, with the advanced vehicles and new homes provisions accounting for three-quarters of the total impact. In September 2001, JCT submitted revenue impact estimates for selected provisions in S. 596, and energy efficiency measures were estimated to have an approximately $4.5 billion impact. However, this estimate does not include vehicles, an item that JCT estimated would cost approximately $2.7 billion.

In 1999, the Treasury estimated that a program of energy efficiency tax credits similar to those described in this report would cost the federal government $8.3 billion during 2000–2009. Over the lifetime of products qualifying for the credits, carbon emissions would decline by 100–150 million metric tons (MMT). The Treasury also estimated that due to the credits, consumers and businesses would realize energy savings worth $22–33 billion. Around the same time, DOE's Energy Information Administration (EIA) estimated that a similar package of energy efficiency tax credits would only cut carbon emissions by 1.6 MMT in 2010. The large difference in savings is attributable to the fact that EIA estimated very small savings from many of the credits, estimates that have earned EIA substantial criticism.

Both the Treasury and EIA analyses considered only the direct effects of the tax credits—impacts from measures actually receiving credits. This is also true for analyses conducted by JCT. But economies of scale, technology learning, and market development are very likely to lead to indirect impacts many times greater than the direct impacts, as the Treasury and DOE acknowledge. While somewhat speculative, estimates of plausible indirect effects are presented below, assuming that the credits discussed above (along with research and development (R&D), and related deployment efforts) are successful in stimulating commercialization and sale of the various advanced energy-efficient technologies.

Energy Savings

ACEEE estimated annual energy savings from 2002 through to 2020. Annual energy savings potential from the listed tax incentives are impressive: 0.6 Quads in 2006; 1.1 Quads in 2010; 2.1

Quads in 2015; and 3.2 Quads in 2020 (the United States used about 100 Quads in 2000). Energy savings continue to increase after expiration of tax credits due to indirect impacts—i.e., sales of the products after the incentives expire. These sales result from increased purchaser knowledge about, and interest in, the efficient products as well as lower product prices engendered by the impact of tax credits on product development and sales. Of the cumulative savings achieved, about 40 percent are achieved by CHP systems, with new commercial buildings accounting for 25 percent and new homes, fuel cell cogeneration, and hybrid vehicles each accounting for 4–9 percent of the savings. Other measures accounting for at least 2 percent of the savings are gas furnaces, heat pump water heaters, energy-efficient appliances, and gas furnaces. These results are summarized in Table ES-1.

Table ES-1. ACEEE Estimates of Direct Costs, Cumulative Energy Savings, and Energy Savings per Dollar of Federal Spending from Selected Tax Credits

Tax Credit	Direct Cost ($million)	Lifetime Energy (Quads)	Energy Per Dollar (mmBtu/$)	Rank
Fuel cell cogeneration	100	4.2	42	1
Combined heat & power	1,000	29	29	2
Commercial buildings	1,400	18	13	3
Heat pump water heaters	250	2.2	8.9	4
Gas heat pumps	120	0.9	7.5	5
New homes	940	6.3	6.8	6
Hybrid vehicles	760	3.1	4.1	7
Transformers	290	0.9	3.1	8
Gas furnaces	750	2.3	3.1	9
Appliances	440	0.8	1.8	10
Central air/heat pumps	1,000	1.5	1.5	11
Electric/fuel cell vehicles	290	0.4	1.3	12
TOTAL	7,300	70	9.6	

Notes: Direct costs are the cost to the Treasury. Energy savings are lifetime savings for measures installed through 2020. A Quad is 10^{15} British thermal units (Btus).

Economic Impacts

ACEEE estimates the total cost to the Treasury, over the lifetime of the tax incentives listed in Table ES-1, will be $7.3 billion. Revenue losses for each of the specific tax credits are also listed in Table ES-1. Overall, our estimate of costs is similar to those of JCT and the Treasury, although estimates for individual measures do differ.

In addition to costs, we estimated the benefits of each of the measures. The energy savings in each year were monetized for measures installed from 2002 through 2020, resulting in total present value energy savings of about $200 billion. Comparing this estimate for the present value of lifetime energy savings with the present value of federal costs yields a benefit-cost ratio of about 30 to 1. Similarly, the present value of total costs associated with the credits (federal costs plus consumer costs) is estimated by ACEEE to be approximately $87 billion through 2020.

Comparing the present value of lifetime costs to lifetime benefits yields an overall benefit-cost ratio of about 2.3 to 1. Net benefits (value of energy savings minus costs) are about $190 billion from the federal perspective and $110 billion overall. Table ES-2 lists the benefit-cost ratios for each measure from both the federal and overall perspectives.

Table ES-2. Benefit-Cost Ratios for Tax Credit Measures From Both Federal and Overall Perspectives

Tax Credit	Overall Benefit-Cost Ratio	Federal Benefit-Cost Ratio
Commercial buildings	5.4	30
Transformers	3.9	8
Combined heat & power	3.1	100
Heat pump water heaters	2.5	32
New homes	1.6	15
Gas heat pumps	1.6	26
Central air/heat pumps	1.4	7.1
Gas furnaces	1.4	10
Hybrid vehicles	1.3	23
Appliances	1.2	7.4
Fuel cell cogeneration	1.2	130
Electric/fuel cell vehicles	0.5	7.5
OVERALL	2.3	30

Emissions

Emissions of selected criteria pollutants would also be reduced by tax credits. Emission reductions for sulfur dioxide (SO_2), nitrogen oxides (NOx), and carbon were estimated using factors relating emission rates to fossil fuel energy use. By 2020, the tax incentives would reduce annual NOx emissions by approximately 370,000 metric tons per year and annual SO_2 emissions by approximately 120,000 metric tons per year.

Regarding carbon emissions, we estimate that all equipment directly qualifying for the energy efficiency tax credits would reduce carbon emissions by about 12 MMT in the year 2006. With growing adoption of the advanced technologies following the phaseout of the credits, avoided carbon emissions could reach around 22 MMT per year by 2010 and 60 MMT per year by 2020. The cumulative reduction during 2000–2020 could be over 500 MMT. This is equivalent to about 4 months of U.S. carbon emissions at the current emissions rate.

Tax incentives would help to establish technologies that would have a modest but non-trivial impact on U.S. emissions of carbon and criteria pollutants within a decade. In addition, avoided emissions should continue to increase as market penetration grows, even after the incentives phase out.

Ranking the Credits

In recognition of federal budgetary uncertainties and the possibility that there might not be sufficient money to fund all the tax credits discussed in this report, we ranked the credits on several criteria (summarized in Table ES-3). First, the different tax credits were compared in terms of energy savings per dollar of federal spending. The five measures with the highest savings per federal dollar are fuel cell cogeneration, CHP systems, new commercial buildings, heat pump water heaters, and gas heat pumps. The five measures with the lowest savings per federal dollar are electric and fuel cell vehicles, residential central air conditioners and heat pumps, appliances, gas furnaces, and transformers. On the other hand, even for the lower-ranked measures, tax credits could lay the groundwork for stronger minimum-efficiency requirements, which would dramatically increase the energy savings achieved (all five of these products are covered by existing or pending federal standards).

Table ES-3. Ranking the Different Tax Credits Based on Three Criteria

Tax Credit	Overall Benefit-Cost Ratio	Rank	Total Savings (Quads)	Rank	Energy per Federal Dollar (mmBtu/$)	Rank	Average Rank	Rank
Combined heat & power	3.1	3	29	1	29	2	2.00	1*
Commercial buildings	5.4	1	18	2	13	3	2.00	1*
New homes	1.6	5	6.3	3	6.8	6	4.67	3
Heat pump water heaters	2.5	4	2.2	7	8.9	4	5.00	4
Fuel cell cogeneration	1.2	11	4	4	42	1	5.33	5
Gas heat pumps	1.6	6	0.9	10	7.5	5	7.00	6*
Transformers	3.9	2	0.9	11	3.1	8	7.00	6*
Hybrid vehicles	1.3	9	3.1	5	4.1	7	7.00	8
Gas furnaces	1.4	8	2.3	6	3.1	9	7.67	9
Central air/heat pumps	1.4	7	1.5	9	1.5	11	9.00	10
Appliances	1.2	10	0.8	8	1.8	10	9.33	11
Electric/fuel cell vehicles	0.5	12	0.4	12	1.3	12	12.00	12
OVERALL	2.3		70		9.6			

* Tied with other credits.

Second, we ranked the different tax credits on the basis of overall benefit-cost ratio. The five measures with the best (highest) benefit-cost ratios are commercial buildings, transformers, CHP systems, heat pump water heaters, and new homes. Measures that rank highly under this criteria overlap heavily with measures that rank highly under the previous criteria, although there are differences. Measures with the lowest benefit-cost ratios are electric and fuel cell vehicles, fuel cell cogeneration, appliances, hybrid vehicles, and gas furnaces. The lower-ranked measures involve either cutting-edge technologies such as fuel cells for which time is needed for costs to decline and sales to increase or technologies such as appliances and furnaces where substantial energy savings have already been achieved and remaining savings are more expensive.

Third, we compared measures on total energy savings, since an objective of a federal energy bill is to reduce national energy use and thus measures with high savings should be favored. By this measure, the highest-ranked measures are CHP systems, commercial buildings, new homes, fuel cell cogeneration, and hybrid vehicles.

Across the three sets of rankings, several measures are consistently high on the list, such as CHP systems and commercial buildings (top 5 on all three measures). Other measures are ranked high on some criteria and low on others. To help show overall trends, in the final column of Table ES-3 we calculate average rank across all three criteria. Using this overall average, the top five measures are CHP systems, commercial buildings, new homes, heat pump water heaters, and fuel cell cogeneration. Of course there are other ways to rank measures and thus these results should be considered indicative rather than definitive.

Conclusion

Tax incentives, if properly structured, could play a valuable role in stimulating the introduction and initial sales of important energy efficiency technologies such as hybrid and fuel cell vehicles, highly efficient building equipment, and very efficient new homes and commercial buildings.

In this area, the Bush energy plan and the House energy bill offer constructive proposals for tax credits for a variety of energy efficiency technologies. The Congress, with passage of H.R. 4 in the House of Representatives, has adopted selected energy efficiency tax proposals, but has also overburdened them with industry-requested, costly incentives that are not the most efficient uses of federal funds. By refining the House bill to reduce excessively generous credits for cars and new and existing homes, the cost-effectiveness of the credits could be significantly improved.

Since the funds available for tax credits are limited, so will be the direct impact on energy use and related emissions from the adoption of products qualifying for credits. But consideration of direct impacts is not a complete approach to estimating potential impacts. If the credits along with complementary policies and programs are successful, than the sales and market penetration of the advanced technologies would continue to grow after the incentives phase out, leading to indirect energy and economic savings and emissions reductions many times greater than the direct reductions. Put simply, tax credits for innovative energy efficiency technologies would have positive impacts on U.S. businesses, consumers, air quality, and public health, as well as help to reduce greenhouse gas (GHG) emissions and global warming. These credits should be included in any broad-based energy legislation or other appropriate tax bills.

INTRODUCTION

As part of the National Energy Policy Report (NEP), produced by the National Energy Policy Development Group, President Bush proposed tax credits to stimulate the commercialization and sales of several innovative energy efficiency and renewable energy technologies. Congress is also actively formulating tax incentive legislation, including H.R. 4, the “Securing America's Future Energy Act of 2001” (SAFE). The estimated cost of the financial incentives offered by H.R. 4 is approximately $35 billion spread out over 5 years, with about $8 billion applied to energy efficiency tax incentives.

The $8 billion estimate for energy efficiency tax incentives is relatively small considering that current U.S. energy expenditures are about $600 billion per year and total federal outlays are about $2,000 billion per year. Nonetheless, the tax credits could foster technological innovation and help consumers and businesses reduce energy use and GHG emissions while benefiting the economy.

Due to the dwindling federal budget surplus, the amount of money available for these tax credits appears to be relatively limited. Therefore, it is critical that the credits be designed in ways that provide the greatest possible return on investment. Credits should stimulate the development and deployment of new technologies that might not otherwise be implemented, rather than subsidize actions that would occur even if the tax credits were not provided. Credits should be applied to leverage private sector investments on a large scale in order to maximize energy and economic savings, emissions reductions, and other benefits over the long run.

The following section of this report reviews previous experience with tax incentives for energy efficiency measures since this experience presents important lessons that directly relate to the current national energy debate. Following this review, some general principles are recommended that should be followed when designing new tax incentives for energy efficiency measures. In the next section specific energy efficiency tax credit proposals made by the Bush Administration as well as proposals introduced in Congress are reviewed. Finally, analyses of the impacts of the tax credits are provided.

REVIEW OF PREVIOUS ENERGY EFFICIENCY TAX INCENTIVES

Tax incentives were enacted during the 1970s to stimulate adoption of both residential and industrial energy efficiency measures. The Energy Tax Act of 1978 included a 15 percent tax credit up to a maximum of $300 (i.e., a 15 percent credit on expenditures up to $2,000) for residential conservation and renewable energy investments made between April 1977 and December 1985. Eligible conservation measures included insulation, storm windows and doors, weatherstripping, and furnace modifications—standard energy efficiency measures at that time. During 1978–85, there were about 30 million claims for the residential energy conservation and renewable energy credits, amounting to nearly $5 billion in lost revenues for the Treasury.

Early studies of the net benefits of the residential tax credit were deemed inconclusive (OTA 1992) due, in part, to the fact that a variety of policy and market changes occurred simultaneously. However, evidence emerged that the tax credit had relatively little impact on consumer behavior. First, a household survey conducted in 1983 found that 85 percent of households that implemented energy efficiency retrofits in 1983 did not claim a tax credit; in addition 88 percent of the households that claimed a credit that year said they would have made the improvement even if the credit had not been available (EIA 1986). Also, the credits tended to be used by wealthier owner-occupied households. Based on this information as well as the small size of the credit, lack of promotion, and administrative burdens, one review concluded that the credit itself probably did little to motivate retrofitting and that most recipients were free riders who would have made the efficiency investment without the incentive (OTA 1992).

The Energy Tax Act of 1978 also included a 10 percent tax credit for specified energy efficiency measures installed by businesses. The measures covered included heat recovery equipment, waste heat boilers, energy control systems, and economizers (GAO 1985). The Act was amended in 1980 to add cogeneration equipment to the list of eligible measures. This credit was in effect during 1978–82 and it also cost the Treasury approximately $5 billion. Surveys and analyses indicated that due primarily to the small magnitude, the credit had little effect on corporate decision-making (ASE 1983; OTA 1983). In other words, most of the measures probably would have been installed without incentives, indicating a high free rider level. The industrial tax credit also has been criticized for covering a relatively limited list of conventional "add-on" efficiency measures and thereby not supporting technological innovation (ASE 1983). The credits generally did not address opportunities for industrial process improvement, nor were they based on performance.

In summary, it appears that both the residential and industrial tax credits in effect during 1978-–85 cost the Treasury a substantial amount of money but had relatively little net impact on fostering energy efficiency improvements. The credits were relatively small in percentage terms while eligibility was limited to widely available and commonly adopted efficiency measures. Consequently, free rider levels were probably very high.

PRINCIPLES FOR NEW ENERGY EFFICIENCY TAX INCENTIVES

Based on past experience with tax credits as well as the current policy, market, and technological context, the following principles should be adopted when crafting new energy efficiency tax credits. These principles are meant to yield the greatest return on investment.

1. *Stimulate commercialization of advanced technologies:* use the incentives to help new energy efficiency technologies and products become established in the marketplace; minimize free rider problems and maximize leveraging; and emphasize technologies that can have a large impact on energy use and GHG emissions over the long run.

2. *Establish performance criteria and pay for results:* stimulate innovation by defining targeted technologies broadly and setting performance criteria; allow manufacturers to meet criteria as they choose; and pay incentives as qualifying units are produced and sold. Use sliding scale incentives to encourage and reward higher levels of performance, where appropriate.

3. *Pay substantial incentives:* make the incentives large enough to influence corporate decision-making and cover a sizable fraction of the incremental cost (but not significantly more) in order to reduce commercialization risk but require cost-sharing from users.

4. *Choose technologies where first cost is a major barrier:* make sure financial incentives are needed and that there are not other more significant barriers inhibiting commercialization.

5. *Be flexible with respect to who receives the credits:* for mass-produced products, consider providing incentives to manufacturers as they are responsible for commercialization. In other cases (e.g., the industrial sector), it may be preferable to target technology users and look at modifying performance criteria and incentive levels as technologies and markets evolve.

6. *Complement other policy initiatives:* work in conjunction with federal energy efficiency R&D programs (e.g., Industries of the Future, Partnership for a New Generation of Vehicles [PNGV], and buildings research programs) and the ENERGY STAR labeling programs in order to "jump start" the market for emerging technologies; coordinate with the Consortium for Energy Efficiency and other market transformation efforts; and generally steer away from technologies that will be adopted via other means (e.g., efficiency standards or labeling and promotion programs).

7. *Select priorities but "hedge bets":* select priorities based on potential impact, cost-effectiveness (e.g., dollars per million Btus of energy saved), private sector interest and support, and likelihood of success but offer incentives in a variety of areas in order to increase the likelihood that some succeed.

8. *Allow adequate time* if the focus is on advanced technologies—remember that it may take several years before qualifying technologies are commercialized and perhaps a few more years before incentives are fully used. It would be preferable to consider tax credits a 10-year rather than a 5-year effort.

REVIEW OF ADMINISTRATION AND CONGRESSIONAL ENERGY EFFICIENCY TAX INCENTIVE PROPOSALS

The Bush Administration, in the NEP, followed some, but certainly not all of these principles in its proposed energy efficiency tax credits. Each of the Administration's tax credit proposals is reviewed below, along with similar proposals introduced in Congress. However, this review is limited to energy efficiency tax credits and does not address the renewable energy tax credits proposed by the Administration or members of Congress.

Vehicles

Cars and light trucks are an obvious target for tax credits since the global vehicle industry is spending a large amount of money to research and develop innovative, fuel-efficient vehicles. However, the average fuel economy of new passenger vehicles is not rising at the present time, and hybrid, fuel cell, and electric vehicles are not yet widely available in the United States. It is unclear if the innovative vehicles under development will be mass-produced and vigorously marketed in the near term. And it is unclear whether the vehicles will be successful in the marketplace because incremental first cost is likely (at least initially) to be substantial. Given this uncertainty and risk, financial incentives are necessary to encourage mass production and support initial sales of innovative vehicles.

Hybrid Vehicles

Hybrid vehicles combine an energy storage system, such as a battery, and an internal combustion engine, thereby overcoming the range problem inherent in all-electric vehicles. Hybrid vehicles are a very promising approach to both high fuel efficiency and low criteria emissions, as evidenced by the initial success of the Toyota Prius and Honda Insight hybrid automobiles in Japan and the United States. Toyota has sold about 1,500 Prius models per month in Japan since its introduction in late 1997 (Gibbs 1999). In Japan, where Prius models were first introduced, tax incentives and manufacturer subsidies helped to lower the additional first cost by $2,000–$3,000—a level acceptable to Japanese purchasers (Ing 1999). In the United States, Prius models are selling at the rate of 1,300 vehicles per month; Insights are selling at the rate of 300 vehicles per month (Automotive News 2001). U.S. manufacturers have also announced plans to introduce hybrid models soon. In November 2002, Ford will begin selling a small hybrid version of the Escape SUV and Dodge will introduce a hybrid variant of its Durango series of light trucks. Ford has also announced it will begin selling a hybrid version of its Explorer SUV in the 2004 timeframe.

Fuel Cell and Electric Vehicles

Transportation fuel cells, which provide electric power by the catalyzed oxidation of atmospheric oxygen with an organic fuel, have long been viewed as a promising breakthrough technology because of the potential for zero emissions and absence of efficiency barriers inherent in combustion-based processes. For these reasons, fuel cell technology development has been a consistent element of the federally supported PNGV. However, with constituent materials produced at relatively low volume, costs remain high. Nevertheless, manufacturers are also committing to introducing fuel cell technologies in limited applications in coming years. In August 2001, General Motors announced plans to introduce both a stationery proton exchange membrane (PEM) fuel cell and later a transportation version incorporating an advanced on-board gasoline reformer (GM 2001). The announcement was accompanied by the demonstration of a fuel cell-powered pickup truck that was equipped with an on-board gasoline-to-hydrogen reformer. DOE has also selected 16 contractors to receive an estimated $70 million for research in advanced fuel cells and high-efficiency, low-emission automotive engines. The contracts will support development of fuel cell technologies for use in buildings as well as vehicles (USCAR 1999).

Alternative Fuels and Alternative Fuel Vehicles

Since existing legislation (EPAct) already requires the adoption of alternative fuel vehicles by vehicle fleet owners, use of compressed natural gas, LPG, and methanol is expected to increase significantly in the next 5–10 years. EIA projects that, without any financial incentives, about 500,000 natural gas-fueled vehicles would be sold annually by 2005, with natural gas and methanol consumption by vehicles reaching about 0.25 Quads that year (EIA 2001). This is equivalent to 2.2 billion gallons of gasoline.

Tax Incentives for Hybrid and Fuel Cell Vehicles

In the United States, several auto manufacturers have announced plans to introduce vehicles incorporating hybrid-electric, fuel cell, or electric drivetrain technologies, but market acceptance is uncertain and first cost is a barrier. Recognizing both these opportunities and barriers, the NEP recommended creation of an income tax credit for the purchase of hybrid and fuel cell vehicles to promote fuel-efficient vehicles.

Also this year, Senator Hatch (R-UT) introduced S. 760, the ‘‘Clean Efficient Automobiles Resulting from Advanced Car Technologies (CLEAR Act) of 2001.” Representative Camp (R-MI) then introduced the CLEAR Act in the House of Representatives as H.R. 1864. The CLEAR Act sets tax credits for efficient fuel cell, hybrid, electric, and alternative fuel vehicles, as well as alternative fuel supplies and infrastructure. For hybrid vehicles, the CLEAR Act proposes tax credits on a sliding scale depending on the weight and level of efficiency of the vehicle, in relation to a model year 2000 vehicle in the same weight class. These incentives are listed in Table 1. In addition to a base-level credit for qualifying technology implementations, both passenger and light-truck hybrid vehicles could earn tax credits for improved fuel efficiency, in comparison to the model year 2000 vehicle in the similar weight class. Table 2 lists the efficiency credits. Vehicles would have to also meet emissions requirements at minimum equivalent to non-hybrid vehicles. In the case of heavy-duty vehicles, a third credit is also available for accelerated emissions performance. Table 3 lists the emissions credits for hybrid heavy-duty vehicles.

Table 1. CLEAR Act Tax Credits for Qualifying Hybrid Vehicles

Maximum Power of Hybrid System*	Amount of Credit			
	Passenger Cars and Light Trucks	Heavy-Duty Vehicles		
		Through 14,000 lbs.	From 14,000 to 26,000 lbs.	Over 26,000 lbs.
5–10%	$250	n/a	n/a	n/a
10–20%	$500	n/a	n/a	n/a
20–30%	$750	$1,500	$4,000	$6,000
30–40%	$1,000	$1,750	$4,500	$7,000
40–50%	$1,000	$2,000	$5,000	$8,000
50–60%	$1,000	$2,250	$5,500	$9,000
60% and greater	$1,000	$2,500	$6,000	$10,000

* Relative to performance of model year 2000 base vehicle in similar weight class.

The combined incentive impact of these three credits is significant, especially for qualifying low-emission heavy-duty vehicles. Nevertheless, after discussions of the CLEAR Act with major automakers, the House of Representatives removed emissions requirements, added a fourth tax credit for lifetime fuel savings, and increased the levels of efficiency-based financial incentives by $500. With no requirements with respect to environmental performance, credits in H.R. 4 could go to a 15 miles per gallon (mpg) sport utility vehicle with a limited amount of hybrid power and a polluting diesel engine.

Table 2. CLEAR Act Tax Credits for Hybrid Vehicle Efficiency Improvements

Efficiency Increase* ➔	125–150%	150–175%	175–200%	200–225%	225–250%	at least 250%
Tax Credit ➔	$500	$1,000	$1,500	$2,000	$2,500	$3,000

* Relative to performance of model year 2000 base vehicle in similar weight class.

Table 3. CLEAR Act Credits for Heavy-Duty Hybrid Vehicle Emissions Improvements

Model Year	Gross Vehicle Weight		
	Through 14,000 lb.	From 14,000 to 26,000 lb.	Greater Than 26,000 lb.
2002	$3,500	$9,000	$14,000
2003	$3,000	$7,750	$12,000
2004	$2,500	$6,500	$10,000
2005	$2,000	$5,250	$8,000
2006	$1,500	$4,000	$6,000

The CLEAR Act also includes base-level credits for fuel cell vehicles. Table 4 lists the applicable credits for vehicles meeting program definitions for the vehicles. In addition, as is the case for hybrid vehicles, the CLEAR Act also includes a second set of credits for efficiency improvements of fuel cell vehicles in comparison to model year 2000 vehicles in comparable weight classes. Table 5 lists the efficiency-based credits.

Table 4. CLEAR Act Tax Incentives for Qualifying Fuel Cell Vehicles

Gross Vehicle Weight ➔	through 8,500 lb.	from 8,500 to 14,000 lb.	from 14,000 to 26,000 lb.	greater than 26,000 lb.
Tax Credit ➔	$4,000	$10,000	$20,000	$40,000

Table 5. CLEAR Act Tax Credits for Fuel Cell Vehicle Efficiency Improvements

Efficiency Increase ➔	150–175%	175–200%	200–225%	225–250%	250–275%	275–300%	at least 300%
Tax Credit ➔	$1,000	$1,500	$2,000	$2,500	$3,000	$3,500	$4,000

The CLEAR Act provides incentives for alternative fuel motor vehicles. The credit is equal to 50 percent of incremental cost plus an additional 30 percent if the vehicle meets additional emissions criteria. Credits are capped at $5,000 for vehicles up to 8,500 lbs.; $10,000 for vehicles between 8,500 and 14,000 lbs.; $25,000 for vehicles between 14,000 and 26,000 lbs.; and $40,000 for vehicles over 26,000 lbs. Also, a significant proportion of alternative fuel vehicles are duel-fuel capable and run on gasoline. For dual-fuel vehicles, the credit is pro-rated to the proportion of use of alternative fuel. These proportions are set at unrealistically high levels of alternative fuel use (e.g. 75 percent and up) with the result that substantial tax credits will be awarded for vehicles that use little alternative fuel. We recommend that dual-fuel vehicles not be eligible for credits.

Electric vehicles are also provided incentives in the CLEAR Act. For qualifying vehicles, ten percent of the cost of the vehicle up to $4,000 can be credited (for 100 mile range and 1,000 lb. payload, the maximum is $6,000). For heavy-duty electric vehicles, credits rise to $6,000 for vehicles up to 8,500 lbs., $10,000 for vehicles from 8,500 to 14,000 lbs., $20,000 for vehicles from 14,000 to 26,000 lbs., and $40,000 for vehicles weighing at least 26,000 lbs.

The modifications inserted into H.R. 4 by several U.S. and foreign automakers are flawed. In addition, even the original CLEAR Act should be improved. First, tax credits for hybrid vehicles should include minimum fuel economy thresholds reflecting significant efficiency improvements relative to typical vehicles in any size class. Such requirements are included in CLEAR for the most part but are significantly weakened in the House-passed bill, allowing substantial credits to be awarded to inefficient vehicles.

Second, credits for hybrid vehicles should include requirements that criteria emissions at least meet the prevailing standards for gasoline-fueled cars. Such a provision is included in CLEAR but was deleted in the House bill. While the provision in CLEAR provides some protection against stimulating the sale of relatively dirty vehicles (e.g., light trucks employing a diesel engine), it does not go far enough, in part because of the delays in and uncertainty surrounding the recently proposed "Tier 2" federal emissions standards for cars and trucks. The tax credits should take a forward-looking view regarding both vehicle emissions and fuel economy. At a minimum, all vehicles should be required to exceed Tier 2 emissions standards in order to be eligible for a tax credit, even if the new standard for that vehicle type isn't yet in effect nationwide. To be truly forward-looking, it may be desirable to go even further than this and require vehicles to comply with tougher emissions standards such as the California ultra-low-emissions vehicle (ULEV) standards that a number of vehicles have been meeting for several years.

Third, there are other promising paths to higher vehicle efficiency, including reducing vehicle weight through much greater use of aluminum and other advanced materials (DeCicco, An, and Ross 2001). Therefore, tax credits should be extended to other high-efficiency vehicles that are not necessarily powered by fuel cells or hybrid drivetrains. Specifically, credits should begin for vehicles that are at least 50 percent more efficient than model year 2000 vehicles in the same weight class. The credits should be performance-based, with higher credits for vehicles that achieve even higher levels of energy efficiency (e.g., 100 or 150 percent more efficient than typical vehicles in the same class).

Fourth, the issue of how to treat non-gasoline fueled vehicles needs to be addressed either in the legislation or subsequently by EPA. Fuel economy thresholds should be set for vehicles running on compressed natural gas, ethanol, methanol, or fuel blends on the basis of equivalent full fuel cycle carbon emissions. This would provide credit for, and some incentive to use, fuels with less carbon intensity than gasoline. So-called "flex fuel vehicles" should be assumed to operate on gasoline alone, since this is normally the case; they would be eligible for credits if they meet the fuel efficiency and emissions requirements for gasoline vehicles.

Fifth, the issue of "baselines" must be resolved. As part of developing the CLEAR Act for hybrid vehicles, there was some difficulty defining a "comparable vehicle." In 1998, the Clinton

Administration proposed a baseline scheme that included vehicle type and 0–60 miles per hour acceleration time in the determination of baseline fuel economy for cars, and vehicle type and weight in the determination of baseline fuel economy for light trucks. While a scheme of this sophistication makes sense if the credits are not targeted to specific types of technologies, a less complex baseline determination is far preferable for credits targeted to hybrid vehicles. A weight-class criteria is more readily implemented than a “similar vehicle” criteria; newer vehicles are never exactly similar, presenting a significant gray area for dispute and lengthy negotiation.

The NEP recommended creation of an income tax credit for the purchase of hybrid and fuel cell vehicles to promote fuel-efficient vehicles. The language of the CLEAR Act as introduced goes beyond the NEP recommendation to include explicit performance criteria for vehicles with extended range. The credit would encourage the commercialization of electric vehicles with advanced batteries as well as fuel cell vehicles, where high costs initially are a major barrier.

Unfortunately, the version of the CLEAR Act passed in the House, contained in H.R. 4, is also overburdened with auto industry-requested, low-yield financial advantages that needlessly increase the cost of the programs beyond both the President’s plan and the original language in the CLEAR Act as introduced. We estimate that changes made to CLEAR in the House (i.e., eliminating emissions requirements and adding a new category of credits for vehicles that do not meet efficiency requirements) would increase the costs to the Treasury by about 25 percent (i.e., nearly $1 billion) while providing few additional benefits. We recommend that the original CLEAR provisions be restored in order to increase energy savings and environmental benefits and reduce costs.

Alternative Fuels as Motor Fuels

The CLEAR Act also contains tax credits to sellers of alternative fuels including natural gas, liquid propane gas (LPG), hydrogen, and methanol. Since the level of free riders and the cost to the Treasury from this part of the CLEAR Act could be quite substantial, the merit of extending tax credits to alternative fuels, rather than for other priorities, is questionable.

Buildings

Various tax incentives to help reduce energy use in new and existing homes and new commercial space have been offered this year in Congress. The legislation regarding home relies on a per-residence efficiency improvement criteria, whereas the commercial incentives are provided on a “per square foot” basis. No incentives are offered for existing commercial space.

New Homes

Several of the comprehensive energy bills introduced this year have included tax credits for new homes that are 30–50 percent more energy efficient than the 1998 International Energy Conservation Code (IECC).

H.R. 4 includes tax credits for new homes (as well as existing homes and commercial buildings). For new homes, the tax credit is 20 percent of the upgrade cost up to a maximum of $2,000. The $2,000 applies to homes certified to achieve at least a 30 percent improvement in energy efficiency relative to the model code. The credit in this case is set too high because the incremental costs of qualifying for the credits are expected to range from $750–1,500 per home. Typically, the costs of energy efficiency measures for buildings are high at the outset, then with experience costs fall. Therefore, we recommend a tax credit of about $1,000 for homes that achieve 30 percent savings. Another option, to allow for builder learning effects, would be a credit of $1,500 for the first 2-3 years, followed by a credit of $750 for the next 2-3 years.

Another problem with the House bill is that new home credits are set are for a single tier. A multi-tier approach is preferable because it would encourage and reward higher levels of energy performance. Thousands of new homes are already being built that are 30 percent more efficient than the 1998 IECC, stimulated in part by EPA's ENERGY STAR Homes program that explicitly targets the 30 percent savings level. Due to the substantial number of homes being build today with 30 percent savings, a credit at this level would reward a substantial number of free riders. DOE's Building America program has demonstrated innovative new home designs that reduce space conditioning energy use by up to 45 percent and these designs are starting to be widely replicated (Geller and Thorne 1999). Also, the Partnership for Advanced Technology in Housing (PATH) targeted a 50 percent reduction in energy use in new homes. DOE's Office of Building Technology, State and Community Programs (BTS) has set a strategic goal of reducing energy use "by 50 percent in 4.8 million of the anticipated 18.4 million new homes by 2010 used annually" (DOE 2000). Based in part on these developments, S. 207 sponsored by Senator Bob Smith (R-NH) provides a credit of $750 for 30 percent improvement and $2,000 for 50 percent improvement in home energy efficiency relative to the model code. A similar two-tier approach is included S. 596 by Senator Bingaman (D-NM) and in several House bills. We believe this would be a useful addition to the H.R. 4 language.

In addition to these major issues, a number of details need to be defined either as part of the legislation or through a subsequent rulemaking in order to make the new homes tax credit practical and effective. Following are descriptions of some of the details.

- Certification of savings measures should be performed by third-party professionals who have completed adequate training. Self-certification by builders could invite abuse. These details should be addressed in the legislation to the maximum extent possible in order to remove uncertainty and speed up implementation. H.R. 4 calls for third-party certification but would permit local building officials to do the certification without any training. We recommend that a provision be included directing DOE, working in concert with the states, to develop training and certification programs for third-party certifiers.

- The objective of energy efficiency tax credits should be to enable the same energy efficiency measures to qualify a home regardless of the type of heating system, in order to remain "fuel neutral." To achieve this objective, efficiency improvements should be defined as meaning the percent of primary energy savings for space heating and cooling compared to a reference home just meeting the IECC model code with the same heating fuel and a reference heating and cooling system.

- Any credits for air leakage or duct leakage reductions should be based on on-site diagnostic testing.

- A new home should not be allowed to qualify in part by saying it would have used a different type of heating fuel than it actually uses.

- DOE should be directed to develop sets of component-based requirements by climate zone to enable compliance through a prescriptive approach.

- At the same time, rules and procedures for performance tradeoffs should be established to enable performance-based compliance.

Another issue is who receives the credit—the builder or the homebuyer. H.R. 4 also proposes that the builder be eligible for the credit, which is reasonable as long as legitimate compliance is demonstrated. Paying the builder gives it a stronger incentive to design and build complying homes. However, the homebuyer should be informed that the builder is receiving the credit, so that the credit can factor into price negotiations. In addition, a permanent label should be put on the homes that receive the credit, so that future purchasers of each home know that it is efficient (this last provision is included in S. 596).

New Commercial Buildings

New commercial buildings could be made substantially more efficient through improved design and equipment, resulting in buildings that save 30–50 percent relative to current model building codes (Johnson and Nadel 2000). Given the great range in building sizes and energy use, most approaches to commercial building energy efficiency have been based on energy intensity, or energy use measured on a per square foot basis; reducing that intensity is the goal of efforts to provide tax incentives for energy efficiency in commercial buildings. Following the per square foot formula, for example, H.R. 4 set a commercial buildings tax deduction of $2.25 per square foot for buildings certified to achieve at least 50 percent in projected energy savings relative to a 1999 model building code developed by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Similar provisions are included in bills introduced in the Senate by Senators Bob Smith (S. 207) and Bingaman (S. 596).

Although ambitious, the 50 percent objective is achievable (Wright 1999). However, to broaden participation, it might make sense to also include a lower deduction for buildings that achieve 30 percent savings as only a few buildings are being constructed at this savings level. Tax deductions for large improvements in commercial building efficiency would challenge architects and engineers to design for these efficiency levels, and would result in long-term changes in building practices, since even when the deductions expire, building designers will know how to design highly efficient buildings for the lowest possible cost. Also, once these savings levels are demonstrated in large numbers of new buildings, some states may tighten their building codes to require at least the 30 percent savings level.

Existing Homes

H.R. 4 also includes tax credits for existing homes, providing a credit of 20 percent of the upgrade cost up to a maximum of $2,000 for meeting a 20 percent savings criteria. H.R. 4 limits the credit to "building envelope components," such as insulation and new windows that are "tried and true" and not advanced efficiency measures. As such, while this credit will promote increased sales of windows and efficiency windows, it is unlikely to have much impact on the long-term market for these products once the credits expire.

To qualify for the existing home credits in H.R. 4, homeowners must achieve a 20 percent energy improvement. This provision takes steps toward avoiding a repeat of the 1970s experience where tax credits subsidized many incremental improvements that probably would have been made even if the credits were not available. However, the 20 percent level is relatively easily achievable with window retrofits or an insulation package and thus this credit is likely to also have a substantial number of free riders. To address this problem, we recommend that the savings threshold be increased to 30 percent, or a two-tier credit could be established, with a maximum credit of $1,000 for 20 percent savings and $2,000 for 30 percent savings. Savings at this level could be achieved in many, if not most, homes via a package of retrofit measures (Nadel et al. 1997). Furthermore, rather than basing credits on a percentage of cost, credits should be for fixed amounts. Basing credits on costs encourages contractors to raise prices higher than needed.

In addition, the legislation also raises many questions. Only certain applications are qualified, such as insulation and windows, whereas all efficiency measures that meet the target goals should be permitted. Questions regarding covered end-uses, identification of base period, and consideration of climate zones remain open as well and will need to be clarified in either the legislation or in implementing regulations. Also, since the contractor particularly will have an incentive to inflate energy savings, this credit should be subject to third-party certification of savings, as discussed above for new homes tax credits. And once again, the credit should be fuel neutral and not encourage undesirable measures such as conversion from gas to electric resistance heating.

Building Equipment

Many policies support the production and purchase of energy-efficient equipment in residential and commercial buildings, including state and local building codes, appliance and equipment efficiency standards, and labeling and promotion efforts such as the EPA/DOE ENERGY STAR labeling program. Federal tax credits for building equipment should complement rather than duplicate these important efforts by focusing on emerging technologies. The credits should be available to both individuals and businesses, and should include central air conditioners and electric heat pumps (including natural gas-fired heat pumps), advanced water heaters, furnaces (including furnace blowers), distribution transformers, and building fuel cells.

This year, energy-efficient tax incentives were introduced for building equipment in several bills, including S. 596 (introduced by Senator Bingaman), H.R. 2392 (introduced by Representative Inslee [D-WA]), and S. 207 (introduced by Senator Bob Smith). In H.R. 4, fuel cells for buildings are included, but other promising technologies are not listed.

Air Conditioners and Heat Pumps

In the Senate, S. 586 introduced by Senator Bingaman and S. 207 introduced by Senator Bob Smith include tax credits for energy-efficient air conditioners and heat pumps, proposing a 10 percent credit up to $250 for central air conditioners and heat pumps with a SEER of at least 13.5 and a 20 percent credit up to $500 for central air conditioners and heat pumps with a SEER of at least 15.0.

The tax credits for SEER 13.5 and 15 would help to increase the market share and reduce the first cost premium for high-end units that currently have only approximately a 1 percent market share. For comparison, the average central air conditioner and heat pump sold since 1998 had a SEER of about 11.0. A new minimum-efficiency standard for air conditioners and heat pumps will be set by DOE at a SEER of 12 or 13 level, and thus tax incentives should begin at higher levels. Even if a SEER 12 standard is ultimately adopted, sales of SEER 13 products will become common, just as SEER 11 is the average efficiency today even though the current standard is only SEER 10.

Just over 1 percent of units shipped as of 1998 had a SEER of 13.5 or greater and less than 1 percent had a SEER of 15.0 or greater. These high-efficiency air conditioners and heat pumps have a relatively high first cost premium in part because they are produced in small quantities. Tax credits should help to increase sales and thereby reduce the first cost premium. Also, the tax credits could help smooth the transition to tougher efficiency standards for central air conditioners and heat pumps. For example, under the law, DOE should start a new rulemaking in a few years to set a standard to be finalized in 2006 and take effect in 2011.

For electric heat pumps, a minimum heating efficiency (HSPF) of 9.0 was proposed by the Clinton Administration for tax incentives. This heating efficiency threshold is consistent with the SEER of 15.0 cooling requirement and therefore is reasonable for a 20 percent credit. However, for SEER 13.5 heat pumps, a slightly lower HSPF threshold of 8.5 would be consistent with the lower cooling efficiency requirement.

Natural gas-fired heat pumps provide both heating and cooling using an engine-driven or absorption cycle. After years of R&D, gas-fired heat pumps have been recently introduced to the market. A generator-absorber heat exchange (GAX) heat pump, developed through R&D funded in large part by DOE, is twice as efficient for heating compared to a highly efficient gas furnace. Also, it runs on an ammonia cycle, thereby avoiding gases such as hydro-chlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs) that contribute to global warming and ozone depletion in the upper atmosphere. In the late 1990s, one company produced an engine-driven system for residential and small commercial applications but the unit is no longer produced due to high first cost and limited demand. Since then, attention has shifted to the GAX due to its higher efficiency and potential for lower costs. GAX chillers are currently being produced by Robur (based in Indiana) and a consortium of businesses, including Goettl and ITT Technologies, are testing a prototype GAX heat pump for possible future market introduction. Three companies are planning or considering developing GAX (or "GAX-related," as some are using variants of the original GAX design) units for field testing in late 2001 (Schafer 2001). A federal tax credit could help bring some of these products into the market and spur initial sales.

Water Heaters

Heat pump water heaters (HPWH) use a compressor to extract heat from the surrounding air in order to raise the temperature of water. They are two to three times more efficient for heating water than a conventional electric resistance water heater. HPWHs have been manufactured on a limited basis for about 20 years but have never caught on due to high first cost, limited availability, and technical problems. In the early 1990s, EPRI sponsored the development of an improved residential HPWH, which is now produced on a limited basis by one manufacturer (Nadel et al. 1998). Two other manufacturers are producing HPWHs on a small scale and several heating system and air conditioning system manufacturers have expressed renewed interest in making the product. For example, DOE and a consortium of electric utilities have been working with ECR International to develop and field test a heat pump water heater that directly replaces a current 50-gallon electric hot water heater. Current plans are to introduce the product to the market in 2002. A 20 percent tax credit would help to stimulate production of and demand for this promising technology.

In the case of natural gas water heaters, tax credits have been proposed in recent years for a 10 percent credit up to $250 for units with an Energy Factor of at least 0.65 and 20 percent credit up to $500 for units with an Energy Factor of at least 0.80. The average gas water heater sold today has an Energy Factor of approximately 0.56; very few units are sold with an Energy Factor of 0.65 or greater. New efficiency standards recently set by DOE take effect in January 2004 and raise the average Energy Factor for gas water heaters to approximately 0.58–0.61. The proposed tax credit could help to stimulate the development and introduction of even more efficient gas water heaters where high first cost is a major barrier.

One of the most viable approaches to high-efficiency water heating is through an integrated space and water heating system. Such systems use a high-efficiency water heater or boiler to meet both hot water and domestic space heating needs. A number of systems are on the market, some with a water heating efficiency of 0.80 or greater. But high first cost is one of the main barriers limiting their adoption (Thorne 1998). The gas water heater tax credit should be extended to high-efficiency water heaters in these integrated systems, with the minimum efficiency requirement of either 0.65 or 0.80 applied to the water heater Energy Factor (C_{EF}) or combined annual efficiency (CAE) of the integrated system.

Furnaces and Furnace Fan Motors

Furnaces and furnace fan motors are significant sources of potential savings due to continuing advances in furnace and blower-motor design. In particular, improvements in motors used to distribute conditioned air present an attractive opportunity for significant savings to homeowners. Also, since most of these motors are components of central air conditioning systems, improving the motors will also reduce peak power demand, lessening the stresses on utilities. S. 596 (introduced by Senator Bingaman) and H.R. 954 (introduced by Representative

Inslee) include credits for advanced natural gas furnaces that achieve a 90 percent annual fuel utilization efficiency and have seasonal electricity use of less than 300 kWh per year. Already, furnaces with AFUE ratings of 90 and higher are achieving significant market share. Heating systems combining high AFUE ratings with fan motor requirements calling for a variable speed fan motor lead to much greater energy savings and greatly reduce free riders.

Transformers

Distribution transformers are used to reduce electricity voltage from tens of thousands of volts down to the levels used by consumers. Liquid-immersed transformers are used by utilities while dry-type transformers are used in commercial buildings and by industries. In both cases, higher-efficiency transformers are now commercially available that reduce losses by an average of about 30 percent. There is one industry-based standard (NEMA Standard TP-1) that denotes higher-efficiency transformers, as well as the minimum-efficiency requirement in Canada. But the NEMA standard is not very stringent and is now easily matched by many products (Nadel et al. 1998). Tax credits for a higher level of very efficient transformers are now appropriate, since efficiency criteria significantly higher than those in TP-1 are needed. We recommend that tax credits be offered for transformers with efficiencies 0.5 percent higher than the TP-1 efficiency values; such an increase may appear small, but since transformers are energized every hour of the year, savings would be substantial. A 15 percent tax credit for distribution transformers at these levels is included in H.R. 2392, introduced by Representative Inslee.

Fuel Cell Cogeneration Systems

H.R. 4 includes a 10 percent credit up to a maximum of $1,000/kW for fuel cell cogeneration systems installed in buildings. Fuel cells are a very promising distributed generation technology offering the potential to cogenerate electricity and useful thermal energy with very low emissions and high electrical conversion efficiencies. Fuel cells also are compact, modular, and flexible with respect to fuels. Various types of fuel cells are under development. Phosphoric acid fuel cells (PAFCs) are the most mature technology and are commercially available in the 200 kW size range, with an electrical conversion efficiency of about 35 percent. Proton exchange membrane fuel cells are also available commercially for small applications. Other types of fuel cells such as molten carbonate and solid oxide are in early commercialization and promise even higher efficiencies.

All types of fuel cells are still burdened with high capital costs. PAFC systems cost about $3,000/kW (Onsite Energy Corporation 2001), similar to the expected market entry cost for other types of fuel cells. As manufacturing volume increases, installed costs are expected to decline to approximately $1,500/kW or even lower (Moore 1997). Therefore, a 10 percent federal tax credit could be valuable for stimulating initial sales and helping to move the technology "down the learning curve."

Appliances

Among the various household appliances, two types stand out as candidates for tax credits—refrigerators and clothes washers. In both cases, large energy savings are technically feasible and cost-effective on a life-cycle cost basis.

Refrigerators

Manufacturers have made great strides in improving efficiency due to market forces, utility incentive programs, and efficiency standards. As of 1997, the average new refrigerator consumed 670 kWh per year, down from 1,450 kWh per year 20 years ago. A new refrigerator efficiency standard went into effect in July 2001 that reduces the average energy use of new refrigerators to approximately 500 kWh per year. Still, substantial additional efficiency improvements are certainly possible. In 1998, Oak Ridge National Laboratory and a consortium of refrigerator manufacturers developed a prototype refrigerator/freezer that uses only 340 kWh per year, 38 percent less energy than the 2001 standard (Vineyard and Sand 1998). One detailed technical analysis concluded: "it may be possible to produce a super-efficient refrigerator/freezer with energy consumption as low as 200 kWh/year." (EPA 1993). Also, as of January 2001, the ENERGY STAR labels are awarded to refrigerators using 10 percent less energy than the 2001 standard, and the criteria will fall to 15 percent less energy as of 2004.

There is ample precedent for using financial incentives to stimulate innovation in refrigerators. In 1993, a consortium of utilities issued a Request for Proposals to refrigerator manufacturers, offering up to $30 million to the manufacturer that could produce and sell the most efficient chlorofluorocarbon-free refrigerator. The winning bid in this Super-Efficient Refrigerator Program (SERP) consisted of a series of models that exceeded the 1993 efficiency standard by 30–40 percent. Likewise, the New York Power Authority (NYPA) issued a Request for Proposals in 1995 for a highly efficient small refrigerator-freezer appropriate for public housing in New York City. The winning bid in that case was for a unit using 30 percent less energy than the prevailing efficiency standard. The SERP and NYPA programs had substantial influence on the 2001 refrigerator efficiency standards.

S. 686, introduced by Senator Lincoln (D-AR), and H.R. 1316, introduced by Representative Nussle (R-IA), provide $50 and $100 credits for refrigerators that save 10 and 15 percent, respectively, over the standard. Credits for higher-efficiency levels should also be considered (i.e., 20 and/or 25 percent savings). A federal tax credit for refrigerators could effectively stimulate the introduction of advanced models and thereby set the stage for the next round of standards that would take effect in 2006 or later.

Clothes Washers

Clothes washers also provide substantial opportunities for energy savings. Current ENERGY STAR clothes washers use 40–60 percent less energy and 30–40 percent less water than standard clothes washers. These units have been promoted for many years by utilities and state programs, often including financial incentives. In early 2001, DOE published final new minimum-efficiency standards for clothes washers that make the current ENERGY STAR level a mandatory national standard as of 2007. DOE also announced that the ENERGY STAR level will increase about 13 percent as of 2004.

S. 686 (introduced by Senator Lincoln) and H.R. 1316 (introduced by Representative Nussle) provide $50 credits for clothes washers that obtain a 1.26 Modified Energy Factor (MEF), the current ENERGY STAR level, or $100 credits for clothes washers that obtain a 1.42 MEF, the ENERGY STAR level as of 2004. Credits for even higher-efficiency levels should also be considered (there are now several machines on the market with MEFs of about 1.5, including at least one at 2.2).

Combined Heat and Power Systems

A wide range of advanced CHP technologies is under development for supplying electricity and useful heat in buildings applications. These technologies include engine-based, gas turbine-based, and fuel cell-based systems, operating on natural gas or other fuels. “Technology neutral" tax incentives should be offered, based on meeting energy efficiency and possibly other performance criteria, in order to support commercialization of advanced CHP technologies of various types. Credits are needed for CHP to overcome several barriers, including technology and interconnection costs and bureaucratic and regulatory burdens. If these challenges were addressed, CHP could provide an estimated 50,000 MW of power capacity to U.S. consumers by 2010.

In the NEP, the Administration proposed either investment tax credits or shorter depreciation periods for qualifying CHP systems. Following the release of the NEP, several bills were introduced in Congress that proposed a 10 percent investment tax credit for qualifying CHP systems. Among these bills are H.R. 1945, the “Combined Heat and Power Act of 2001,” and S. 596 and S. 389 by Senators Bingaman and Murkowski (R-AK), respectively. According to the language in all of these bills, qualifying systems would need to produce at least 20 percent of their useful energy as electrical or mechanical power and at least 20 percent as thermal energy. In addition, eligible systems must have an overall efficiency of at least 60 percent (up to 70 percent in the case of a system with electrical capacity in excess of 50 MW and mechanical energy capacity in excess of 67,000 horsepower, or an equivalent combination of electrical and mechanical energy capacities).

The House bill this year, H.R. 4, includes a 10 percent investment tax credit for qualifying CHP systems adopted by businesses, coupled with a longer 22-year depreciation schedule for systems earning the credit. Input and output infrastructure (i.e., fuel pipes and heat and electrical distribution networks) are excluded. Output piping in many cases is part of a district energy system or local thermal energy distribution system closely associated with the CHP system, and therefore merits inclusion. The 10 percent credit should be adopted, but the longer depreciation period is problematic and should be deleted.

Depreciation is complicated. Under current law, depreciation periods for CHP systems range from as little as 5 years to as many as 39 years depending on system type and ownership. Most CHP equipment currently sold has a life of 7–10 years before major maintenance must be preformed. For this reason, 7–10 year depreciation periods make sense. Another option might be to split the schedules, with 7–10 year schedules for industrial applications (where run times are often longer and equipment lives shorter) and 15 years for building applications. None of the bills now pending before Congress address depreciation. On the other hand, H.R. 4, with a 22-year depreciation period for systems taking advantage of tax credits, is a step in the wrong direction.

This year, the NEP recommended either tax credits or depreciation simplification for CHP incentives. Congress has expressed a preference for the tax credits approach, as included in H.R. 4. The language in H.R. 4 could be improved and simplified by removal of the increased-depreciation clause and elimination of restrictions on small systems (the House bill only applies to systems larger than 50 kW). Small systems have a higher installed cost per kilowatt than larger systems and consequently cost-effectiveness is a bigger issue. In order to focus CHP tax incentives on innovative CHP technologies and installations needing assistance, size restrictions should not be set.

Several factors have influenced the debate over the preferred means to provide federal incentives to foster CHP. On one hand, a 10 percent tax credit does not generate as much enthusiasm from CHP manufacturers or vendors as does 7–10 year depreciation. On the other hand, CHP tax credits are broad-based and not focused on state-of-the-art or innovative technologies, as are most of the other tax credits. Also, first cost is not necessarily the key barrier inhibiting the adoption of CHP systems, especially for large capacity systems (Elliott and Spurr 1999), hence tax credits may not act as powerfully to promote CHP as other technologies. For this reason, the NEP and many of the Congressional bills include provisions to address other barriers to CHP such as widely varying interconnection requirements and environmental permitting regulations that do not reward efficiency (USCHPA 2001). Adoption of these other provisions, combined with establishment of tax incentives or shorter depreciation periods, would be a powerful spur to increased CHP development.

General Issues

One problem that applies to a number of the proposed credits is the fact that nonprofit organizations, municipalities, universities, and other public sector organizations are not subject to federal income taxes. Thus, nonprofit organizations would not be readily eligible for tax credits as the credits are currently proposed. A solution to this problem could be to allow these public sector entities to reduce their personal income withholding taxes on employees' wages by the amount of the tax credit (Osann 1999). Employee tax payments would not be affected; only the employer portion of shared tax payments would be reduced by the amount of the credits. This would make public sector organizations eligible for the same tax credits as private businesses and individuals, thereby increasing participation and impacts. One limitation to this approach is that it would work well for non-residential properties since the credit would be for the employer, but not in general. Another solution, included in S. 207 (introduced by Senator Bob Smith), would "allow the allocation of the deduction to the person primarily responsible for designing the property in lieu of the public entity which is the owner of such property," and treat that person as the taxpayer for purposes of the deduction or credit.

Another impediment is the extent to which businesses would be able to make use of the tax credits. With some companies not making profits (particularly small entrepreneurial companies) and others subject to the alternative minimum tax (AMT), the value of the business-oriented credits may be somewhat limited. Therefore, if possible, these tax credits should not be subject to AMT restrictions. Also, in the case of a business not paying income taxes due to inadequate profitability, credits should nevertheless be available. Similar tax treatment was provided for certain tax deductions available to the oil and gas industry in recent years; energy efficiency and renewable energy tax credits should receive equivalent treatment.

POTENTIAL IMPACTS

To what extent would energy usage, energy costs, and emissions of criteria pollutants and carbon dioxide be reduced with the implementation of the energy efficiency tax credits discussed in this report? Also, what would be the component costs to the government and consumers? These questions are difficult to answer, since the proposed tax credits are intended to stimulate the development and commercialization of advanced technologies that have uncertain market acceptance. It is unclear at this time which technologies will be perfected and whether they will have costs and other features ultimately attractive to consumers. Therefore, any estimate of potential impacts is inherently speculative.

Only time and experience will reveal whether tax credits for certain technologies will be successful, both in terms of use of the credits themselves and their assistance in establishing viable new technologies in the marketplace. This latter point is critical—even if the credits are widely used, they will be a failure if the technologies can't "stand on their own" once the credits are phased out. Thus, both direct impacts of the credits (i.e., number of participants, energy savings, and emissions reductions due to these units) and indirect impacts (i.e., impacts from sales and use of the technologies beyond the credits' timeframe and budgets) should be considered in a comprehensive analysis of impacts. This section presents and reviews analyses of the potential direct impacts of the energy efficiency tax credits as well as some of our own estimates of the possible with: *direct impacts* (directly incentivized by a tax credit) and *indirect impacts* (resulting from subsequent market changes created by the earlier tax credit).

Impacts Estimated by the Federal Government

Over the past several years, members of Congress have drafted a host of bills containing various energy efficiency tax credits and depreciation modifications. In order to be able to judge the merit of these bills, Congress and the Administration have requested estimates of the revenue effects. Although the Department of Treasury has participated in formulating such "scorekeeping" for the Executive branch, Congress relies principally on scorekeeping analyses produced by staff of the Joint Committee on Taxation. There is considerable variation in scorekeeping estimates among the various entities. These inconsistencies reflect differences in assumptions and methods, but also the difficulty in long-term forecasting of participation levels and other associated inputs to the estimates.

In July 2001, JCT provided Congress with the estimated revenue effects of both the energy efficiency and supply-side tax provisions of H.R. 4 (JCT 2001). Included in the scorekeeping report were revenue estimates for individual energy efficiency titles in the bill. Table 6 lists the estimates for energy efficiency tax credits for the years 2002, 2005, 2010, and the entire period through 2011. The total estimated revenue impact of the efficiency provisions was estimated to be approximately $5.4 billion, with the advanced vehicles and new homes provisions accounting for three-quarters of the total impacts.

Table 6. JCT Revenue Estimates for Selected Energy Efficiency Provisions Contained in H.R. 4 for the Years 2002, 2005, 2010, and Cumulatively to 2011

Tax Credit	Revenue Estimate ($Millions)			
	2002	2005	2010	cumulative to 2011
Fuel cells	4	88	6	447
Advanced vehicles	47	430	17	2,395*
Energy-efficient appliances	50	53	0	292
New and existing homes	84	308	0	1,558
Commercial buildings	75	80	0	387
Combined heat & power	6	72	7	357
TOTAL	266	1,031	30	5,436

* This estimate is for the original CLEAR bill and does not include adjustments due to changes made in the House.

In September 2001, JCT provided revenue reduction estimates for the tax provisions in S. 596. These estimates are summarized in Table 7. The efficiency provisions have a total cost of $4.4 billion, but this figure does not include vehicles since vehicles are not included in S. 596.

Table 7. JCT Revenue Estimates for Selected Energy Efficiency Provisions Contained in S. 596 for the Years 2002, 2005, 2010, and Cumulatively to 2011

Tax Credit	Revenue Estimate ($Millions)			
	2002	2005	2010	cumulative to 2011
Energy-efficient business property	95	224	197	1,987
Commercial buildings	49	79	0	549
Energy-efficient appliances	70	42	0	295
New homes	56	21	0	160
Existing homes	107	302	0	1,380
TOTAL	377	668	197	4,371

In 2001, the Department of Treasury estimated the revenue impacts for selected energy proposals contained in the President's National Energy Plan. Table 8 lists the Treasury forecasts for the two efficiency tax credits included in the NEP. There are large differences between the Treasury and JCT estimates, due in part to different analysis approaches and assumptions but also due to differences between the tax proposals being analyzed. For example, the Treasury estimate for CHP systems is based on accelerated depreciation while the JCT estimate is based on a tax credit. On the other hand, the Treasury estimate for advanced vehicles is based on a more limited credit than that contained in the CLEAR bill, let alone the more expansive credit contained in H.R. 4.

Table 8. The Treasury's 2001 Estimates of Revenue Effects for Advanced Vehicle and CHP Tax Credit Programs, and Differences from JCT Estimates listed in Table 6

Tax Credit	Revenue Estimate ($Millions)			
	2002	2005	2010	cumulative to 2011
Combined heat & power	22	358	126	3,512
Advanced vehicles	119	212	5	1,106

The Bush Administration has not developed estimates of the cost of other efficiency tax credits, nor estimated the benefits of any of the efficiency provisions. However, the Treasury and EIA conducted analyses of the potential direct impacts of a specific set of energy efficiency technology tax credits during the Clinton Administration

Table 9 lists the estimates of revenue effects and emissions reductions from the climate change technology tax incentive proposals in 1999. As shown in Table 8, the Treasury estimated that the set of energy efficiency tax credits would cost the federal government $8.3 billion during 2000–2009 including $3.2 billion during 2000–2004 (DOT 1999). In addition, the Treasury estimated that the renewable energy tax credits included in the package would cost the government $1.2 billion during 2000–2009, including $0.4 billion during 2000–2004. As shown in Table 9, the Treasury projected that the credits for building equipment would have greatest impacts during the early period, then the vehicle credits would dominate after 2004 and account for nearly two-thirds of the total cost to the Treasury over the 10-year period.

Table 9. The Treasury's 1999 Estimates of Revenue Effects and Direct Carbon Emissions Reductions from Climate Change Technology Tax Incentive Proposals

Tax Credit	Revenue Loss 2000–2004 (billion $)	Revenue Loss 2000–2009 (billion $)	Carbon Emissions Reduction[a]
New homes	0.4	0.5	7-10
Building equipment	1.5	1.5	28-42
Vehicles	0.9	6.0	36-54
Combined heat & power systems	0.3	0.4	12-18
ENERGY EFFICIENCY SUBTOTAL**	3.2	8.3	83-124
Solar systems	0.1	0.4	2-3
Wind and biomass power	0.3	0.8	15-23
RENEWABLE ENERGY SUBTOTAL	0.4	1.2	17-26
TOTAL**	3.6	9.5	100-150

* Cumulative reduction in carbon emissions over the lifetime of equipment purchased through 2009. ** Total may not add due to rounding. Source: DOT (1999)

Table 9 also includes the Treasury's estimates of the avoided carbon emissions due to equipment for which credits could be claimed through 2009. The estimates were based on avoided emissions over the lifetime of these products. The total estimated reduction in emissions was 100–150 MMT of carbon (including the renewable energy credits), with about one-third of the reduction coming from advanced vehicles that receive credits. For comparison, the United States emitted about 1,558 MMT of carbon from fossil fuel consumption as of 2000 (EIA 2001). The Treasury report noted that its estimates "do not take into account the incentives' long-term effects on markets for energy saving items" and therefore its estimates are likely to be understated (DOT 1999).

Regarding other impacts, the Treasury estimated that the credits will produce energy savings for consumers and businesses of $22–33 billion over the lifetime of items receiving the credits (expressed as net present value). But the Treasury did not provide further details of how these numbers were obtained or what the **net** economic impacts might be (i.e., the energy bill savings minus the additional capital cost paid by consumers and businesses).

In 1999, EIA released a study of the Climate Change Technology Initiative (CCTI) that included its assessment of the tax incentives package using the National Energy Modeling Systems (NEMS) model, EIA's main energy forecasting tool (EIA 1999). As shown in Table 10, EIA estimated that the tax credits (including renewables credits) will cut carbon emissions 3.1 MMT in 2010 but the energy efficiency tax credits would only account for 1.6 MMT of this total. EIA did not present cumulative carbon emissions reductions over the lifetime of the measures receiving credits. EIA's estimates excluded energy savings and emissions reductions due to projected free riders—measures expected to be installed even if the incentives were not offered. The free rider level was projected to be very high for the CHP, advanced vehicles, and renewable energy credits. This is why EIA estimated substantial revenue loss but very little energy savings and avoided carbon emissions for these particular credits.

Table 10. Climate Technology Tax Credit Impacts in 2010 Estimated by EIA

Tax Credit	Energy Savings (TBtu)	Avoided Carbon Emissions (MMT)	Cumulative Revenue Loss* (billion $)
Building equipment	24.4	1.2	NA
New homes	6.4	0.2	0.5
Rooftop solar	<0.01	<0.01	0.1
Combined heat & power	NA	0.15	0.08–0.12
Electric, fuel cell, and hybrid vehicles	0.8	<0.01	2.0
Wind and biomass	71.9	1.5	0.8
TOTAL	103.5	3.1	3.5**

* Revenue loss in 1998 dollars. ** Total excluding revenue loss from tax credits on building equipment. Source: EIA (1999)

The EIA analysis had a number of flaws that earned substantial criticism. First, the analysis apparently underestimated carbon emissions reductions from advanced vehicle technologies, calculating a very small increase in sales of hybrid, fuel cell, and electric vehicles in the next decade and almost no carbon emissions reduction in 2010 due to the vehicles credit. Second, as pointed out by DOE and EPA, the EIA tax credits analysis did not take into account the synergistic effects of technology R&D, deployment efforts, and tax credits (Gardiner 1999; Reicher 1999). Programs such as the Partnership for a New Generation of Vehicles, DOE's Building America new homes program, ENERGY STAR equipment and new homes promotion, CHP Challenge program, etc. will help to develop and deploy new technologies in tandem with the financial incentive provided by the tax credits. The NEMS model had other major deficiencies including overstated costs for new and improving technologies, limited technology "learning effects," and inability to adequately model new technologies (ASE et al. 1997).

ACEEE Estimates of Potential Longer-Term Impacts

Only the direct effects of the tax credits—impacts from measures actually receiving credits—were considered by both Congress's (JCT) and the Administration's (Treasury and EIA) analyses. But economies of scale, technology learning, and market development also lead to indirect impacts. These additional indirect effects can be many times greater than the direct impacts, as the Department of Treasury and DOE have acknowledged.

Participation in Tax Credit Programs

In order to include both direct and indirect impacts of proposed tax credits measures, ACEEE undertook an assessment of the plausible indirect effects, assuming that the credits along with R&D and related deployment efforts will be successful in stimulating introduction of, and growing markets for, the various advanced energy-efficient technologies. While ACEEE's estimates are invariably speculative, they are indicative of what could happen if the tax credits, other policies, and private sector efforts are effectively applied. Our estimates are based on our recommended tax credits and not some of the more generous proposals that have been suggested such as the vehicles and new and existing homes provisions in H.R. 4.

Table 11 lists ACEEE's estimate of the number of installations of each technology receiving tax credits (labeled "direct") along with the total number of installations every 5 years through to 2020. The number of installations by 2020 could equal five to thirty times the number of installations qualifying for the credits, depending on the product type.

The results listed in Table 11, as well as the subsequent calculations described later in this section, rely on an extensive set of assumptions, which are listed in the appendix. The participation estimates are based on tax credits alone in isolation from other policies (i.e., the estimates are not adjusted to avoid double counting of savings that may occur as a result of other policies such as stronger codes or interconnection standards for CHP and other distributed generation systems).

Table 11. ACEEE Estimates of Participation in Tax Credit Programs

Tax Credit	Program Participants (millions)				
	Direct	2005	2010	2015	2020
New homes	0.5	0.5	1.5	3.5	5.5
Central air/heat pumps	2.0	2.0	7.0	14	24
Natural gas heat pumps	0.1	.10	.35	.85	1.4
Heat pump water heaters	1.0	1.0	2.5	4.5	7.5
Natural gas furnaces	1.2	1.2	3.7	7.5	12
Energy-efficient appliances	5.0	10	24	31	41
New commercial buildings (billion sq. ft.)	1.4	1.4	3.4	6.4	10
Fuel cell cogeneration (MW)	200	200	1,200	3,200	6,200
Electric/fuel cell vehicles	0.06	0.04	0.17	0.44	0.84
Hybrid vehicles	0.4	0.25	1.2	3.34	7.0
Combined heat & power (thousands of MW)	8	8	18	33	53
Transformers (kVA)	19	19	66	136	230

Energy Savings Estimates

The installation rates listed in Table 11 were used as a basis to calculate energy savings provided by the tax credits each year, using the assumptions for energy savings potential listed in the appendix. Table 12 below lists the resulting estimated energy savings at selected 5-year intervals from 2005 through to 2020. Annual energy savings (in TBtus) from the listed tax incentives are impressive: 440 in 2005; 1,100 in 2010; 2,100 in 2015; and 3,200 in 2020.

Table 12. Estimated Energy Savings Resulting from Energy Efficiency Tax Incentives

Tax Credit	Energy Savings			
	2005	2010	2015	2020
New homes	E: 0.8 G: 6	E: 2.5 G: 18	E: 5.8 G: 42	E: 9.2 G: 6
Central air/heat pumps	E: 0.8	E: 2.7	E: 5.7	E: 9.6
Natural gas heat pumps	E: 0.3 G: 1.8	E: 0.9 G: 0.3	E: 2.2 G: 15	E: 3.5 G: 24
Heat pump water heaters	E: 1.9	E: 4.8	E: 8.6	E: 14
Efficient natural gas furnaces	E: 0.6 G: 4.8	E: 1.8 G: 15	E: 3.8 G: 30	E: 0.2 G: 50
Appliances	E: 1.3 G: 3.7	E: 2.6 G: 4.9	E: 3.8 G: 0.2	E: 5 G: 4.8
Commercial buildings	E: 4.6 G: 15	E: 11 G: 37	E: 21 G: 70	E: 34 G: 114
Fuel cell cogeneration	G: 8.4	G: 50	G: 134	G: 260
Electric/fuel cell vehicles	G: 1.5	G: 0.4	G: 16	G: 31
Hybrid vehicles	G: 9.3	G: 45	G: 124	G: 260
Combined heat & power	G: 280	G: 20	G: 1,100	G: 1,800
Transformers	E: 0.2	E: 0.9	E: 1.8	E: 3.0
CUMULATIVE (TBtu)*	440	1,100	2,100	3,200

* E = electricity (in TWh) and G = natural gas equivalent (in TBtu); assuming an average heat rate of 10,600 Btu/kWh in 2005, 10,200 Btu/kWh in 2010, 9,900 Btu/kWh in 2015, and 9,600 Btu/kWh in 2020 based on EIA (2001) across all years beginning in 2002.

Cost Savings and Economic Impacts of Tax Credit Plan

ACEEE estimated potential economic impacts as a result of the technology adoption resulting from the tax incentives. Using the expected participation rates, the tax credit amounts listed in legislative proposals and energy price forecasts by EIA, costs to the Treasury and consumers, and savings to consumers were estimated and compared. These estimates take into account the costs and savings from both direct and indirect impacts through 2020.

Table 13 lists the participation levels and lost revenue estimates for each tax credit. The most prominent measures are the tax credits for hybrid, electric, and fuel cell vehicles, followed by new commercial buildings. The total estimated revenue loss to the Treasury is about $6 billion.

In addition to costs, we estimated the benefits of each of the measures. The energy savings in each year were monetized for measures installed from 2002 through 2020, resulting in total net present value energy savings of about $200 billion. Comparing this estimate for the present value of lifetime energy savings with the present value of federal costs yields a benefit-cost ratio of about 30 to 1. Similarly, the present value of lifetime costs associated with the credits (federal costs plus consumer costs) was estimated by ACEEE to be approximately $87 billion through 2020. Comparing the present value of total costs to total benefits yields an overall benefit-cost ratio of about 2.3 to 1. Net benefits are about $190 billion from the federal perspective and $110 billion overall.

Table 13. Estimated Participation Rates for the Years 2002 through 2005 Plus Associated Cost per Measure and Total Cost to the Treasury

Qualifying Measure	Tax Credits* ($)	Direct Participants	Lost Revenue ($million)
New homes	1,500	620,000	940
Central air/heat pumps	400	2,500,000	1,000
Gas heat pumps	1,000	125,000	125
Heat pump water heaters	200	1,250,000	250
Gas furnaces	500	1,500,000	750
Appliances	70	6,250,000	438
Commercial buildings (10^9 ft^2)	770	1,750,000	1,350
Fuel cell cogeneration (per kW)	400	250,000	100
Electric/fuel cell vehicles	5,000	58,000	290
Hybrid vehicles	2,000	380,000	760
Combined heat & power (per MW)	100	10,000,000	1,000
Transformers (per kVA)	5	57,500,000	290
TOTAL DIRECT COST			$7,300

* Cost to the Treasury per participant.

Table 14 lists the estimated cost premiums for each of the credits. For each tax credit, the cost premium was then multiplied by the number of participants to estimate the total amount spent on that particular measure. Table 15 lists the total investments in energy efficiency measures incentivized by the credits.

Table 14. Estimated Cost Premiums for Tax Credits

Premium (2002 dollars)	Cost Premium ($)			
	–2005	2006–10	2011–15	2016–20
New homes	3,000	2,500	2,000	1,500
Central air/heat pumps	400	330	270	200
Gas heat pumps	3,000	2,500	2,000	1,500
Heat pump water heaters	800	670	530	400
Gas furnaces	800	670	530	400
Appliances*	115	70	40	30
Commercial buildings	1.3	1.1	0.9	0.7
Fuel cell cogeneration (per kW)	3,500	3,100	2,700	2,300
Electric/fuel cell vehicles	14,500	10,250	7,500	6,000
Hybrid vehicles	3,990	3,730	2,960	2,184
Combined heat & power (per kW)	970	920	880	830
Transformers (per kVA)	5	4	4	3

*Appliance numbers are based on refrigerators accounting for two-thirds and clothes washers for one-third of participants

Table 15. Total Efficiency Investments ($Billion) for Each Tax Credit

Tax Credit	Total Efficiency Investment (billion $)			
	–2005	2006–10	2011–15	2016–20
New homes	1.5	2.7	4.4	3.4
Central air/heat pumps	0.8	1.8	2.2	2.3
Gas heat pumps	0.3	0.7	1.1	0.9
Heat pump water heaters	0.8	1.1	1.2	1.4
Gas furnaces	1.0	1.8	2.2	2.3
Appliances	0.9	1.2	0.8	0.6
Commercial buildings	1.9	2.4	2.9	3.1
Fuel cell cogeneration	0.7	3.3	5.7	7.4
Electric/fuel cell vehicles	0.6	1.5	2.2	2.6
Hybrid vehicles	1.0	3.6	6.9	9.0
Combined heat & power	7.9	9.4	13	17
Transformers	0.1	0.2	0.3	0.3
TOTAL	17	30	43	50

Tables 16 and 17 summarize the key results of our economic analyses. In Table 16 we compare the different credits in terms of cost to the Treasury, energy savings, and energy savings per federal dollar. This last measure is a useful metric to compare tax credits. Since federal funds are tight, it makes sense to target tax credit dollars to those technologies and practices with the largest savings per federal dollar invested.

The five measures with the *highest* savings per federal dollar are fuel cell cogeneration, CHP systems, commercial buildings, heat pump water heaters, and gas heat pumps. The five measures with the *lowest* savings per federal dollar are electric and fuel cell vehicles, residential central air conditioners and heat pumps, appliances, gas furnaces, and transformers. On the other hand, even for the lower ranked measures, tax credits could lay the groundwork for stronger minimum efficiency requirements, which would dramatically increase the energy savings achieved (four out of five of these products are covered by existing or pending federal standards).

Table 17 lists the benefit-cost ratios for each of the tax credits. The list is ranked, with the highest benefit-cost ratio at the top. Commercial buildings tops the list with a 5.4 to 1 benefit-cost ratio. Only one of the credits (electric and fuel cell vehicles) has a benefit-cost ratio less than one and a negative net benefit. This is a case where tax incentives should be used to advance technology, rather than simply for bulk energy savings. In this case, the federal costs will be a useful, long-term investment in moving the technology further down the cost curve. The payoff will hopefully be in the long term, beyond the time-span of our analysis.

Table 16. ACEEE Estimates of Direct Costs, Cumulative Energy Savings, and Energy Savings per Dollar of Federal Spending from Selected Tax Credits

Tax Credit	Direct Cost ($million)	Cumulative Energy (Quads)	Energy per Federal Dollar (mmBtu/$)	Rank
Fuel cell cogeneration	100	4.2	42	1
Combined heat & power	1,000	29	29	2
Commercial buildings	1,400	18	13	3
Heat pump water heaters	250	2.2	8.9	4
Gas heat pumps	130	0.9	7.5	5
New homes	940	6.3	6.8	6
Hybrid vehicles	760	3.1	4.1	7
Transformers	290	0.9	3.1	8
Gas furnaces	750	2.3	3.1	9
Appliances	440	0.8	1.8	10
Central air/heat pumps	1,000	1.5	1.5	11
Electric/fuel cell vehicles	290	0.4	1.3	12
TOTAL	7,300	70	9.6	

Notes: Direct costs are the cost to the Treasury. Energy savings are lifetime savings for measures installed through 2020.

Table 17. Summary Economic Data for Proposed Tax Credits, including Costs, Savings, and Benefit-Cost Ratios

Tax Credit	NPV of Total Costs ($billions)	Cumulative Savings ($billions)	Benefit-Cost Ratios	Rank	Net Benefits ($billions)
Commercial buildings	6.7	36	5.4	1	30
Transformers	0.5	2.1	3.9	2	1.6
Combined heat & power	30	92	3.1	3	62
Heat pump water heaters	2.9	7.4	2.5	4	4.5
New homes	7.6	12	1.6	5	4.7
Gas heat pumps	1.8	2.9	1.6	6	1.1
Gas furnaces	4.6	6.6	1.4	7	2.0
Central air/heat pumps	4.5	6.4	1.4	8	2.0
Hybrid vehicles	12	16	1.3	9	3.9
Appliances	2.4	3.0	1.2	10	0.5
Fuel cell cogeneration	10	12	1.2	11	2.1
Electric/fuel cell vehicles	4.2	1.9	0.5	12	(2.2)
TOTAL	87	200	2.3		110

Note: NPV = net present value.

Emissions

Emissions of selected criteria pollutants are also reduced along with reductions in costs and energy usage. Emissions of SO_2, NOx, and carbon were estimated using factors relating emission rates as a function of energy use. The carbon factors are derived from EIA's *Annual Energy Outlook* (EIA 2001) and are based on average national emissions per kilowatt-hour from fossil fuel power plants. The SO_2 and NOx factors were derived by the Tellus Institute (Tellus 2001) from national emissions data. Table 18 lists the annual emissions improvements resulting from implementation of the energy efficiency tax incentives. By 2020, the tax incentives have the potential to reduce annual NOx emissions by 370 thousand metric tons per year and annual SO_2 emissions by approximately 120 thousand metric tons per year.

Table 18. Annual Reductions in Carbon, SO_2, and NOx Emissions from Energy Efficiency Tax Credits

Combined Emissions Reductions	2005	2010	2015	2020
Carbon (MMT)	9	22	41	60
NOx (thousand metric tons)	58	137	254	370
SO_2 (thousand metric tons)	18	44	81	120

Regarding direct impact on carbon emissions, we estimate that all equipment directly qualifying for the energy efficiency tax credits would reduce carbon emissions by about 9 MMT per year by the year 2005. It should be noted that this estimate includes emissions reductions from any free riders. With growing adoption of the advanced technologies following the phaseout of the credits, avoided carbon emissions could reach around 22 MMT per year by 2010 and 60 MMT per year by 2020. The cumulative reduction during 2000–2020 would be over 500 MMT. This is equivalent to about 4 months of U.S. carbon emissions at the current rate. Thus, the credits could help to establish technologies that would have a modest but non-trivial impact on U.S. carbon emissions within a decade after the incentive phaseout. And the avoided carbon emissions should continue to rise after 2020 as market penetration grows.

Ranking the Credits

In recognition of the fact that federal funds are tight and that there might not be sufficient money to fund all the tax credits discussed in this report, as part of our analysis we also ranked the different credits on several criteria. These results are summarized in Table 19. First, the different tax credits were compared in terms of energy savings per dollar of federal spending. The five measures with the *highest* savings per federal dollar are: fuel cell cogeneration, CHP systems, new commercial buildings, heat pump water heaters, gas heat pumps, and new homes. The five measures with the *lowest* savings per federal dollar are electric and fuel cell vehicles, residential central air conditioners and heat pumps, appliances, gas furnaces and transformers. On the other hand, even for the lower ranked measures, tax credits could lay the groundwork for stronger minimum-efficiency requirements, which would dramatically increase the energy savings achieved (all five of these products are covered by existing or pending federal standards).

Table 19. Ranking the Different Tax Credits Based on Three Criteria

Tax Credit	Overall Benefit-Cost Ratio	Rank	Total Savings (Quads)	Rank	Energy per Dollar (Btu/$)	Rank	Average Rank	Rank
Combined heat & power	3.1	3	29	1	29	2	2.0	1*
Commercial buildings	5.4	1	18	2	13	3	2.0	1*
New homes	1.6	5	6.3	3	6.8	6	4.7	3
Heat pump water heaters	2.5	4	2.2	7	8.9	4	5.0	4
Fuel cell cogeneration	1.2	11	4.0	4	42	1	5.3	5
Gas heat pumps	1.6	6	0.9	10	7.5	5	6.7	6*
Transformers	3.9	2	0.9	11	3.1	8	6.7	6*
Hybrid vehicles	1.3	9	3.1	5	4.1	7	7.0	8
Gas furnaces	1.43	8	2.3	6	3.1	9	7.7	9
Central air/heat pumps	1.44	7	1.5	9	1.5	11	8.7	10
Appliances	1.2	10	0.8	8	1.8	10	9.3	11
Electric/fuel cell vehicles	0.5	12	0.4	12	1.3	12	12.0	12
OVERALL	2.3		70		9.6			

* Tied with other credits.

Second, we ranked the different tax credits on the basis of overall benefit-cost ratios. The five measures with the best (highest) benefit-cost ratios are commercial buildings, transformers, CHP systems, heat pump water heaters, and new homes. Measures ranked highly under this criteria overlap heavily with measures ranked highly under the previous criteria, although there are differences. Measures with the lowest benefit-cost ratios are electric and fuel cell vehicles, fuel cell cogeneration, appliances, hybrid vehicles, and furnaces. The lower-ranked measures involve either cutting-edge technologies such as fuel cells for which time is needed for costs to decline and sales to increase or technologies such as appliances and furnaces where substantial energy savings have already been achieved and remaining savings are more expensive.

Third, we compared measures on total energy savings, since an objective of a federal energy bill is to reduce national energy use and thus measures with high savings should be favored. By this measure, the highest ranked measures are CHP systems, commercial buildings, new homes, fuel cell cogeneration, and hybrid vehicles.

Across the three sets of rankings, two measures are consistently high on the list—CHP systems and commercial buildings (top 5 on all three measures). Other measures are ranked high on some criteria and low on others. To help show overall trends, in the final column of Table 19 we calculated average rank across all three criteria. Using this overall average, the top five measures are CHP systems, commercial buildings, new homes, heat pump water heaters, and fuel cell cogeneration. Of course there are other ways to rank measures and thus these results should be considered indicative rather than definitive.

CONCLUSION

A number of studies have shown that the development and widespread adoption of innovative energy efficiency and renewable energy technologies are essential in order to significantly reduce U.S. GHG emissions over the long run without harming economic growth (Bernow, Duckworth, and DeCicco 1998; IWG 1997). Tax credits, if properly structured, could play a valuable role in stimulating the introduction and initial sales of important energy efficiency technologies such as hybrid and fuel cell vehicles, and very efficient heating and cooling systems and new homes and commercial buildings.

This year, there is wide bipartisan support in Congress for energy efficiency tax incentives, as well as support for some credits from the Bush Administration. Given that the amount of money available for energy efficiency technology tax credits is likely to be limited (perhaps on the order of $7 billion over a decade), then it is important to get the maximum return on investment. This will necessitate focusing on state-of-the-art and advanced technologies, and carefully selecting technologies, performance thresholds, and credit levels so that these technologies are commercialized, established in the market, and able to compete and gain market share on their own once the credits phase out. These criteria can be met with tax credits along the lines suggested here, assuming complementary R&D and non-incentive-based deployment programs are continued.

Since the funds available for tax credits are limited, so will be the direct impact on emissions from the adoption of products qualifying for credits. But that is not an appropriate way to look at the potential impacts. If the credits along with complementary policies and programs are successful, than the sales and market penetration of the advanced technologies will grow after the incentives phase out, leading to indirect emissions reductions many times greater than the direct reductions. This type of response is possible from tax credits and this report suggests how large the indirect impact might be (at least through 2020). However, the only way to test this theory is to adopt the tax credits and let technologies and market forces play out "in the real world."

Our economic analysis of the impacts of the proposed tax incentives, when taking into account both direct and indirect impacts, demonstrates that the credits are both cost-effective (net present value over $100 billion and overall benefit-cost ratio of about 2.3 to 1) and environmentally beneficial, with up to 540 MMT of cumulative carbon emission avoidance through to 2020. Put simply, tax credits for innovative energy efficiency technologies would have positive impacts on U.S. businesses, consumers, air quality, and public health, as well as help to reduce GHG emissions and global warming. These credits should be included in any broad-based energy legislation enacted in the near future.

REFERENCES

[ASE] Alliance to Save Energy. 1983. *Industrial Investment in Energy Efficiency: Opportunities, Management Practices, and Tax Incentives.* Washington, D.C.: Alliance to Save Energy.

[ASE et al.] Alliance to Save Energy, American Council for an Energy-Efficient Economy, Natural Resources Defense Council, Tellus Institute, and Union of Concerned Scientists. 1997. *Energy Innovations: A Prosperous Path to a Clean Environment.* Washington, D.C.: American Council for an Energy-Efficient Economy.

Automotive News. 2001. "U.S. Car Sales, August and YTD." *Automotive News,* September 10: 42.

Bernow, S., M. Duckworth, and J. DeCicco. 1998. "Climate Strategy for the United States: Bottom-Up Analyses of CO_2 Reductions, Costs, and Benefits." *Energy Policy 26* (5). Special Issue.

DeCicco, John, Fen An, and Marc Ross. 2001. *Technical Options for Improving the Fuel Economy of U.S. Cars and Light Trucks by 2010–2015.* ACEEE Report Number T012. Washington, D.C.: American Council for an Energy-Efficient Economy.

[DOT] U.S. Department of Treasury. 1999. *General Explanation of the Administration's Revenue Proposals.* Washington, D.C.: U.S. Department of Treasury.

[EIA] Energy Information Administration. 1986. *Residential Energy Consumption Survey: Housing Characteristics 1984*. DOE/EIA-0314(84). Washington, D.C.: U.S. Department of Energy, Energy Information Administration.

———. 1999. *Analysis of the Climate Change Technology Initiative*. SR/OIAF/99-01. Washington, DC.: U.S. Department of Energy, Energy Information Administration.

———. 2001. *Annual Energy Outlook 2001, with Projections to 2020.* DOE/EIA-0383(2001). Washington, D.C.: U.S. Department of Energy, Energy Information Administration.

Elliott, R.N. and M. Spurr. 1999. *Combined Heat and Power: Capturing Wasted Energy*. ACEEE Report Number IE983. Washington, D.C.: American Council for an Energy-Efficient Economy.

[EPA] U.S. Environmental Protection Agency. 1993. *Multiple Pathways to Super-Efficient Refrigerators*. EPA-430-R-93-008. Washington, D.C.: U.S. Environmental Protection Agency, Office of Atmospheric and Indoor Air Programs.

[GAO] U.S. General Accounting Office. 1985. *Business Energy Investment Credit*. GAO/GGD-86-21. Washington, D.C.: U.S. General Accounting Office.

Gardiner, David M. 1999. "Testimony of the Assistant Administrator for Policy, U.S. Environmental Protection Agency before the Subcommittee on Energy and Environment of the Committee on Science, U.S. House of Representatives," Washington, D.C., April 14.

Geller, H. and J. Thorne. 1999. *U.S. Department of Energy's Office of Building Technologies: Successful Initiatives of the 1990s*. ACEEE Report Number A991. Washington, D.C.: American Council for an Energy-Efficient Economy.

Gibbs, E. 1999. "Toyota Keeps Options Open on Green Cars." *Reuters.* July 1.

[GM] General Motors. 2001. "GM Fuel Cells Power the Future—Size, Speed Power Mark GM Progre*ss*." August 7th Press Release. www.gm.com/cgi-bin/pr_display.pl?2403.. Detroit, Mich.: General Motors.

Ing, C. (Toyota Government Affairs). 1999. Personal communication to Howard Geller. July.

[IWG] Interlaboratory Working Group. 1997. *Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy Technologies by 2010 and Beyond.* LBNL-40533 and ORNL/CON-444. Berkeley, Calif.: Lawrence Berkeley National Laboratory and Oak Ridge, Tenn.: Oak Ridge National Laboratory.

[JCT] Congressional Joint Committee on Taxation. 2001. *Estimated Revenue Effects of a Chairman's Amendment in the Nature of a Substitute to the "Energy Tax Policy Act of 2001" Scheduled for Markup by the Committee on Ways and Means on July 18, 2001, for Fiscal Years 2002-2011.* Washington, D.C.: Congressional Joint Committee on Taxation.

Johnson, Jeff and Steven Nadel. 2000. "Commercial New Construction Programs: Results from the 90's, Directions for the Next Decade." In *Proceedings from the ACEEE 2000 Summer Study in Buildings.* Washington, D.C.: American Council for an Energy-Efficient Economy.

Moore, T. 1997. "Market Potential High for Fuel Cells." *EPRI Journal*, May/June: 6-17.

Nadel, S., S. Laitner, M. Goldberg, R.N. Elliott, J. DeCicco, H. Geller, and R. Mowris.1997. *Energy Efficiency and Economic Development in New York, New Jersey, and Pennsylvania.* ACEEE Report Number E971. Washington, D.C.: American Council for an Energy-Efficient Economy.

Nadel, S., L. Rainer, M. Shepard, M. Suozzo, and J. Thorne. 1998. *Emerging Energy-Saving Technologies and Practices for the Buildings Sector*. ACEEE Report Number A985. Washington, D.C.: American Council for an Energy-Efficient Economy.

Onsite Energy Corporation. 2001. *The Market and Technical Potential for Combined Heat and Power in the Commercial/Industrial Sector*. (Revision 1). Prepared for the U.S. Energy Information Administration. Washington, D.C.: Onsite Energy Corporation.

Osann, E. 1999. *Tax Incentives for the Untaxed: Attracting New Investors to New Technology.* Washington, D.C.: Potomac Resources, Inc..

[OTA] Office of Technology Assessment. 1983. *Industrial Energy Use*. Washington, D.C.: U.S. Congress, Office of Technology Assessment.

———. 1992. *Building Energy Efficiency*. Washington, D.C.: U.S. Congress, Office of Technology Assessment.

Reicher, Dan. 1999. "Testimony of the Assistant Secretary for Energy Efficiency and Renewable Energy, U.S. Department of Energy before the Subcommittee on Energy and Environment of the Committee on Science, U.S. House of Representatives." Washington, D.C., April 14.

Schafer, Jennifer (Cascade Associates). 2001. Personal communication with Steve Nadel, September.

[Tellus Institute] S. Bernow, W. Dougherty, and A. Bailie. 2001. Personal communication to P. Quinlan. September.

Thorne, Jennifer. 1998. *Integrated Space Conditioning and Water Heating Systems: One System Is Often Better than Two.* ACEEE Report Number A982. Washington, D.C.: American Council for an Energy-Efficient Economy.

[USCAR] 1999. *Powering the 21st Century: Projects Selected by DOE for PNGV Fuel Cell and Combustion Research and Development.* http://www.uscar.org/techno/fcsolicitation.htm. Southfield, Mich.: U.S. Consortium for Automotive Research.

[USCHPA] United States Combined Heat and Power Association. 1999. "Administration Restructuring Proposal Attempts to Eliminate Barriers for Combined Heat and Power (CHP)." April 19th Press Release. http://www.nemw.org/uschpa/eliminatebarriers.htm. Washington, D.C.: United States Combined Heat and Power Association.

Vineyard, E.A. and J.R. Sand. 1998. "Fridge of the Future: Designing a One Kilowatt-Hour/Day Domestic Refrigerator-Freezer." In *Proceedings of the ACEEE 1998 Summer Study on Energy Efficiency in Buildings*. Washington, D.C.: American Council for an Energy-Efficient Economy.

Wright, R. 1999. *California Non-Residential New Construction Baseline Study: Final Report.* Sonoma, Calif.: RLW Analytics, Inc. As cited in Johnson, Jeff and Steven Nadel. 2000. "Commercial New Construction Programs: Results from the 90's, Directions for the Next Decade." In *Proceedings from the ACEEE 2000 Summer Study in Buildings.* Washington, D.C.: American Council for an Energy-Efficient Economy.

APPENDIX: ASSUMPTIONS USED TO ESTIMATE PARTICIPATION LEVELS AND ENERGY SAVINGS LEVELS FOR EACH OF THE TAX INCENTIVES

Listed below are participation and energy savings assumptions, based on tax credits applied in isolation from other policies—i.e., the estimates are not adjusted to avoid double counting of savings that may occur as a result of other policies, such as stronger codes and standards. These assumptions were used to develop subsequent economic and emissions analyses for each measure.

New homes: The new homes credit analyses assume that 500,000 homes qualify for credits during the years 2002–2005, 200,000 new homes per year during 2006–2010, and 400,000 new homes per year during 2011–2020. Savings average 1,665 kWh of electricity and 12 mmBtu of natural gas per new home, based on a 40 percent average reduction for space heating and cooling.

Central air conditioners and heat pumps**:** The analysis assumes two million new central air conditioners and heat pumps qualify for credits during the years 2002–2005, 1 million per year on average during 2006–2010,1.5 million per year during 2011–2015, and 2 million per year on average during 2016–2020. Energy savings average 300 kWh per year for a qualifying central air conditioner and 750 kWh per year for a qualifying heat pump. Assuming that about three-fourths of qualifying units are air conditioners, then an average for both appliances is about 392 kWh per year.

Natural gas heat pumps**:** The analysis assumes 100,000 gas-fired heat pumps qualify for credits during the years 2002–2005, 50,000 per year on average during 2006–2010, and 100,000 per year on average during 2011–2020. Energy savings equal 18 mmBtu per year of gas and 2,624 kWh per year of electricity.

Heat pump water heaters: The analysis assumes 1 million heat pump water heaters qualify for credits during the years 2002–2005. 300,000 per year on average during 2006–2010, 400,000 per year during 2011–2015, and 600,000 per year during 2016–2020. Energy savings equal 1900 kWh of electricity per year per heat pump water heater.

Gas furnaces: The analysis assumes 1.2 million gas furnaces qualify for credits during the years 2002–2005, 500,000 per year during 2006–2010, 750,000 per year during 2011–2015, and 1.0 million per year during 2016–2020. Energy savings equal 500 kWh per year and 4 mmBtu per year of natural gas per qualifying furnace (gas savings account for high free rider levels given current market share for condensing furnaces).

Appliances: The analysis assumes 2.5 million qualifying models are sold per year on average during 2002–2006 and 4 million per year during 2007–2020. Assumes 128 kWh per year of electricity savings and 3.67 mmBtu per year of natural gas savings from the average of qualifying refrigerators and clothes washers during 2002 through 2006, declining to 61 kWh and 0.67 mmBtu for 2007 through 2020.

New commercial buildings: The analysis assumes 10 percent of new commercial floor space constructed during the years 2002–2005 and an equal amount of renovated floor space qualify for the credit (1.4 billion square feet), a total of 2 billion square feet of floor during 2006–2010, 3 billion square feet during 2011–2015, and 4 billion square feet during 2016–2020. Energy savings average 3.25 kWh of electricity and 11,000 Btu of natural gas per square foot of floor area.

Fuel cell cogeneration: The analysis assumes 200 MW of fuel cell cogeneration systems qualify for credits during 2002–2005, 1,000 MW during 2006–2010, 2,000 MW during 2011–2015, and 3,000 MW during 2016–2020. Fuel cell cogeneration systems operating on natural gas would provide a net energy savings of 42 mmBtu per year per kilowatt installed.

Electric and fuel cell vehicles: The analysis assumes 170,000 electric and fuel cell vehicles qualify for credits during 2002–2010 (mostly in California and the Northeast), 11,000 per year on average during 2011–2015, and 21,000 per year on average during 2016–2020. Assumes an average gasoline savings equivalent to 37.5 mmBtu per year, net additional consumption of electricity, natural gas, methanol, or some other fuel.

Hybrid vehicles: The analysis is based on hybrid vehicle tax credits proposed in the CLEAR Act, beginning in 2002. Assumes 250,000 hybrid vehicles qualify for credits during 2002–2005, 19,000 per year on average during 2006–2010, 43,000 per year during 2011–2015, and 73,000 per year during 2016–2020. The average fuel savings are equivalent to 37.2 mmBtu per year per vehicle.

***Combined heat and power systems*:** The analysis assumes 8,000 MW of efficient CHP systems qualify for credits during 2002–2005, 10,000 MW during 2006–2010, 15,000 MW during 2011–2015, and 20,000 MW during 2016–2020. Each megawatt of CHP capacity displaces 5,400 MWh of purchased electricity consumption but leads to a net increase of 22,000 mmBtu per year of natural gas consumption, netting a decrease equivalent to approximately 34,700 mmBtu per year.

Transformers*:* Analysis assumes 5 percent of sales qualify for credits during 2002–2005 and that the market share of complying products increases to 10 percent in 2006–2010, 15 percent in 2011–2015, and 20 percent in 2016–2020. Analysis based on total annual distribution transformer sales of 94 million kilovolt-amperes (kVA). Energy savings estimated at 13 kWh annually per kilovolt-ampere of capacity. Incremental costs are 30 percent in the first 5 years ($5.25/kVA) and we assume this drops to 25 percent in 2006–2010, 20 percent in 2011–2015, and 15 percent in 2016–2020. Annual sales, kilowatt-hour savings, and current incremental costs all based on work by Oak Ridge National Laboratory for the U.S. Department of Energy.