Tax Incentives for Innovative Energy-Efficient Technologies

Howard Geller

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1001 Connecticut Avenue, NW, Suite 801, Washington, DC 20036
(202) 429-8873 phone, (202) 429-2248 fax, http://aceee.org Web site

EXECUTIVE SUMMARY

As part of his Climate Change Technology Initiative (CCTI), President Clinton has proposed a set of tax credits to stimulate the commercialization and sales of innovative energy efficiency and renewable energy 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 Clinton Administration as well as by members of Congress, and estimates the potential carbon savings that could result from the proposed tax credits.

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 for residential conservation and renewable energy measures including insulation, storm windows and doors, weatherstripping, and furnace modifications. During 1978-85, there were about 30 million claims for the residential tax credit, amounting to nearly $5 billion in lost revenues for the U.S. Treasury. Studies indicate that most of the energy efficiency measures probably would have been installed anyway, meaning a very 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 during 1978-82. Due primarily to the small magnitude, the credit had little effect on corporate decision making. Again, most of the measures probably would have been installed anyway. Both of these tax credits applied to conventional efficiency measures and therefore did not 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, we suggest adopting the following principles in crafting new energy efficiency tax incentives. These principles are meant to yield the greatest "bang per buck," assuming that the funds “available” for these tax credits is limited.

- 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"
- Allow adequate time

Review of Administration and Congressional Energy Efficiency Tax Incentive Proposals

The Clinton Administration has followed some but not all of these principles in the set of energy efficiency tax credits it has proposed, which were introduced in Congress by Rep. Matsui and 20 co-sponsors (H.R. 2380).

Vehicles

Cars and light trucks are an obvious target for tax credits since innovative, fuel-efficient vehicles are under active development worldwide. Manufacturers have announced plans to introduce these vehicles but market acceptance is uncertain and first cost could be a barrier. The Administration has proposed extending the current credit for electric and fuel cell vehicles (10 percent up to a maximum of $4,000) through 2006. In addition, Rep. Collins has proposed extending the tax credit for electric and fuel cell vehicles through 2008 and making it a flat $4,000 (H.R. 1108). Sen. Rockefeller has proposed tax credits to promote alternative fuels as well as extending the credit for electric and fuel cell vehicles through 2010 (S. 1003). The Rockefeller bill also increases the maximum credit to $5,000 for electric vehicles with an extended range. We support these proposals, including the increased incentive for vehicles with extended range.

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. After discussions with the "Big 3" automakers, the Administration proposed tax credits for hybrid vehicles starting in 2003 without any fuel efficiency or emissions thresholds. Instead, the credits are based on the capacity of the energy storage system and the amount of braking energy recovery from the regenerative braking system. In our view this proposal is flawed. We believe tax credits for hybrid vehicles should include: (1) minimum fuel economy thresholds reflecting significant efficiency improvements relative to typical vehicles in any size class; (2) requirements that criteria emissions at least meet the prevailing standards for gasoline-fueled cars; and (3) eligibility beginning in 2000 or 2001.

New Homes

The Administration has proposed a tax credit to encourage construction of very energy-efficient new homes. The credit would equal $1,000, $1,500, and $2,000 for new homes that are 30, 40, and 50 percent more energy efficient, respectively, than the 1998 International Energy Conservation Code (IECC). A number of issues need to be addressed, however, in order to make the new homes tax credit practical and prevent a high level of free riders and other unintended consequences such as promotion of homes with electric resistance heating. These issues include definition of prescriptive paths to compliance and fuel-neutral performance tradeoff procedures, and language to prevent overstatement of the energy savings in new homes containing an electric heat pump.

Besides the Administration's proposal, Rep. Thomas has introduced a bill (H.R. 1358) that provides a flat $2,000 credit for new homes 30 percent more efficient than the 1998 IECC. The Thomas bill proposes that the builder be eligible for the credit, which is reasonable as long as legitimate compliance is demonstrated. But the Thomas bill allows self-certification by builders, which could lead to high levels of fraud and abuse. Also, many of the issues that need to be addressed with the Administration's proposal also need to be addressed with the Thomas bill. In addition, we believe the multi-tier approach is preferable because it would encourage and reward higher levels of energy performance.

Building Equipment

The Administration has proposed 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. This tax credit could 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. The Administration also proposed a 20 percent credit up to $1,000 for natural gas-fired heat pumps—systems that provide both heating and cooling using an engine-driven or absorption cycle. After years of research and development (R&D), gas-fired heat pumps are poised for commercialization. We support both of these proposals.

The Administration has proposed tax credits for both highly efficient electric and gas-fired water heaters. In the case of electric water heaters, a 20 percent credit up to $500 is proposed for heat pump water heaters (HPWHs). HPWHs have been manufactured on a limited basis for around 20 years but have never caught on due to high first cost, limited availability, and reliability problems. In the case of natural gas water heaters, the Administration has proposed 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. Very few gas water heaters are sold with an Energy Factor of 0.65 or greater today due in large part to their first cost. We support the HPWH proposal and recommend that the gas water heater credit be extended to high-efficiency water heaters in integrated space and water heating systems.

Fuel Cell Cogeneration Systems

The Administration has proposed a 20 percent credit up to a maximum of $500 per kilowatt (kW) for fuel cell cogeneration systems installed in buildings. Fuel cells are a very promising distributed generation technology offering very low emissions and high electrical conversion efficiencies. The 20 percent tax credit could be valuable for promoting early adoption and helping to move the technology "down the learning curve." But since relatively small fuel cell cogeneration systems might be used in households, we suggest lowering the minimum size threshold from 5 kW to 2 kW.

Combined Heat and Power (CHP) Systems

The Administration has proposed an 8 percent investment tax credit for qualifying CHP systems adopted by businesses. We suggest increasing the credit amount and restricting eligibility to smaller systems (under 50 megawatts [MW][1]). Specifically, we recommend a 10 percent credit for units 10 to 50 MW, a 15 percent credit for units 1 to10 MW, and a 20 percent credit for units 50 kW to 1 MW. This should reduce the level of free riders and do more to stimulate the adoption of CHP systems that are relatively costly today.

Other Potential Energy Efficiency Tax Incentives

There are other innovative buildings technologies besides air conditioners, heat pumps, water heaters, and fuel cells that conceivably could be promoted through tax credits. If there is interest in expanding the package, we view high-efficiency refrigerators, ground-source heat pumps, and transformers as the next most logical products for which to offer tax credits.

Targeted tax credits also could help to stimulate the introduction of energy-saving innovations in some of the most energy-intensive industrial processes. We see the opportunity for tax credits in the paper and pulp, steel, and aluminum industries, where major innovations are now available or on the horizon. In this case, eligibility could be based on achieving a minimum level of efficiency or reducing energy intensity below some threshold.

Potential Impacts

The Treasury Department estimates that the energy efficiency tax credits will cost the federal government $8.3 billion and renewable energy credits $1.2 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 Department also estimates that consumers and businesses will realize energy savings worth $22-33 billion.

[1] In our discussions of fuel cell cogeneration and combined heat and power, MW and kW refer to electric output only.

The Energy Information Administration (EIA) estimates that the energy efficiency tax credits will only cut carbon emissions 1.6 MMT in 2010. The EIA analysis appears to understate carbon emissions reductions from some of the technologies. Also, the EIA analysis does not take into account the synergistic effects of technology research, development, and demonstration (RD&D), deployment efforts, and tax credits. And the EIA's modeling tool has other serious deficiencies including overstated costs for new and improving technologies, limited technology "learning effects," and the inability to adequately model new technologies.

Both the Treasury Department and EIA analyses consider only the direct effects of the tax credits—impacts from measures actually receiving credits. But economies of scale, technology learning, and market development could lead to indirect impacts many times greater than the direct impacts, as the Treasury Department and the U.S. Department of Energy (DOE) acknowledge. While very speculative, we offer some estimates of plausible indirect effects assuming that the credits along with RD&D and related deployment efforts are successful in stimulating introduction of and growing markets for the various advanced energy-efficient technologies.

We estimate that all units qualifying for the energy efficiency tax credits would reduce carbon emissions by about 4.0 MMT per year (i.e., the direct impact). It should be noted that this estimate includes reductions from any free riders. With growing adoption of the advanced technologies following the phase-out of the credits, the avoided carbon emissions could reach around 14 MMT per year by 2010 and 29 MMT per year by 2015. The latter value is equivalent to 2 percent of U.S. carbon emissions at the present time. Also, we estimate that the cumulative reduction during 2000-2015 could reach approximately 160 MMT.

Conclusion

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, highly efficient heating and cooling systems, and very efficient new homes. The Clinton Administration has made a constructive proposal that includes tax credits for a variety of innovative energy efficiency technologies. However, we recommend that certain modifications be made to the Administration's proposals in order to maximize the benefits while minimizing the potential for free riders and other adverse effects.

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.

We urge policy makers to test this theory in the real world independent of concerns about the rate of climate change or the Kyoto Protocol to limit future greenhouse gas (GHG) emissions. Put simply, tax credits for innovative energy efficiency and renewable energy technologies could 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 package of tax cuts and incentives enacted in the near future.

INTRODUCTION

President Clinton has proposed a set of tax credits to stimulate the commercialization and sales of innovative energy efficiency and renewable energy technologies as part of his Climate Change Technology Initiative. It's estimated that the set of tax credits will to cost the U.S. Treasury about $1 billion per year on average in foregone tax revenues over the next decade (DOT 1999b). This cost is a relatively small considering that U.S. energy expenditures are around $500 billion per year and total federal outlays are around $1,500 billion per year. Nonetheless, the tax credits could foster technological innovation and help consumers and businesses reduce greenhouse gas emissions while benefitting the economy.

Since the amount of money "available" for these tax credits appears to be relatively limited, it is critical that the credits be designed in ways that provide a high "bang per buck." This means stimulating the development and deployment of new technologies that might not otherwise be implemented, rather than mainly subsidizing actions that would occur even if the tax credits were not provided. It also means using the credits to leverage private sector investments on a large scale in order to maximize the GHG emissions reductions and other benefits over the long run.

The next section of this report reviews previous experience with tax incentives for energy efficiency measures since this experience presents some lessons that should be heeded today. Following this review, we recommend some general principles that should be followed when designing new tax incentives for energy efficiency measures. After that, we review and comment on the specific energy efficiency tax credit proposals made by the Clinton Administration as well as similar proposals made by members of Congress. Next, we suggest some other advanced energy efficiency technologies that we believe are good candidates for tax credits. Finally, we review analyses of the impacts of the tax credits and provide our own estimates of impacts.

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 U.S. Treasury.

Studies of the net benefits of the residential tax credit were inconclusive at best (OTA 1992). This was due in part to a variety of policy and market changes occurring simultaneously.

But there is some evidence 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 anyway (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 anyway, meaning 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 energy efficiency improvements. The credits were relatively small in percentage terms while eligibility was limited to widely available and commonly adopted efficiency measures. Consequently, the free rider levels probably were very high.

PRINCIPLES FOR NEW ENERGY EFFICIENCY TAX INCENTIVES

Based on the past experience with tax credits as well as the current policy, market, and technological context, we suggest adopting the following principles when crafting new energy efficiency tax credits. These principles are meant to yield the greatest "bang per buck."

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

3. **Pay substantial incentives**—make the incentives large enough to influence corporate decision making; and cover a sizable fraction of the incremental cost 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 (i.e., Industries of the Future, Partnership for a New Generation of Vehicles, and buildings research programs) and the ENERGY STAR® labeling programs in order to "jump start" the market for emerging technologies; also coordinate with the Consortium for Energy Efficiency and other market transformation efforts; and steer away from technologies that will be adopted via other means (e.g., efficiency standards or from labeling and promotion programs).

7. **Select priorities but "hedge bets"**—select priorities based on potential impact, cost-effectiveness (e.g., dollars per ton of avoided carbon), 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 a few years before qualifying technologies are commercialized and perhaps a few more years before incentives are fully used. It would be preferable to consider this a ten-year rather than five-year effort.

REVIEW OF ADMINISTRATION AND CONGRESSIONAL ENERGY EFFICIENCY TAX INCENTIVE PROPOSALS

The Clinton Administration has followed some but not all of these principles in its proposed energy efficiency tax credits. The Administration's proposal has been introduced in

Congress by Rep. Matsui and 20 co-sponsors (H.R. 2380). Below we review and comment on each of the Administration's tax credit proposals along with similar proposals made by other members of Congress. However, we limit our review to energy efficiency tax credits and do 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. And even if they are, it is unclear whether the vehicles will be successful in the marketplace since incremental first cost is likely (at least initially) to be substantial. Given this uncertainty and risk, it is logical to provide financial incentives to encourage mass production and support initial sales of innovative vehicles.

Fuel Cell and Electric Vehicles

The Administration has proposed extending the current credit for electric and fuel cell vehicles (10 percent up to a maximum of $4,000) through 2006. This proposal is included in Rep. Matsui's bill (H.R. 2380). In addition, Rep. Collins has proposed extending the tax credit for electric and fuel cell vehicles through 2008 and making it a flat $4,000 (H.R. 1108). Sen. Rockefeller has proposed tax credits to promote alternative fuels as well as extending the credit for electric and fuel cell vehicles through 2010 (S. 1003). The Rockefeller bill also increases the maximum credit to $5,000 for electric vehicles with an extended range. We support these proposals including the increased incentive for vehicles with extended range. This will encourage the commercialization of electric vehicles with advanced batteries as well as fuel cell vehicles, where high costs initially are a major barrier. However, we recommend that tax credits for hybrid vehicles be added to the Collins and Rockefeller proposals.

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 hybrid car in Japan and announcements by Toyota as well as Honda of plans to start selling highly efficient, low-emissions hybrid vehicles in the United States in late 1999 or 2000. Toyota has sold over 25,000 Prius models in Japan (about 1,500 per month) since its introduction in late 1997 (Gibbs 1999).

However, tax incentives as well as subsidies provided by Toyota reduce the additional first cost to $2,000-$3,000—a level acceptable to Japanese purchasers (Ing 1999).

In early 1999, the Clinton Administration proposed tax credits for hybrid vehicles on a sliding scale depending on the level of efficiency improvement (DOT 1999a):

MPG = 1.33 X or greater—$1,000 credit, 1/1/03-12/31/04
MPG = 1.67 X or greater—$2,000 credit, 1/1/03-12/31/06
MPG = 2.00 X or greater—$3,000 credit, 1/1/04-12/31/06
MPG = 3.00 X or greater—$4,000 credit, 1/1/04-12/31/06

In this formulation "MPG" is miles per gallon and "X" is the average fuel economy of a comparable vehicle in any particular size class. Also, all vehicles receiving credits would have to meet emissions requirements applicable to gasoline-powered automobiles.

However, after discussions of this proposal with the "Big 3" automakers, the Administration revised its proposal, removing the fuel efficiency and emissions requirements. Instead, the credits are based only on the capacity of the energy storage system and the amount of braking energy recovery from the regenerative braking system (see Table 1). There are no energy efficiency thresholds and no requirements with respect to environmental performance—in principle, credits could go to a 15-20 MPG sports utility vehicle with a limited amount of energy storage and a polluting diesel engine. And the credits do not start until 2003.

Table 1. Clinton Administration's Proposed Energy Efficiency Tax Credits for Vehicles

Electric and fuel cell vehicles	10% credit up $4,000	01/01/2002-12/31/2006
Hybrid vehicles	Main credit based on energy storage system capacity: 5-10% of maximum power, $500 credit 10-20% of maximum power, $1,000 credit 20-30% of maximum power, $1,500 credit > 30% of maximum power, $2,000 credit	01/01/2003-12/31/2006
	Additional credit for regenerative braking: 20-40% braking energy recovery, $250 credit 40-60% braking energy recovery, $500 credit > 60% braking energy recovery, $1,000 credit	

In our view, this proposal, due to modifications insisted upon by one or more of the U.S. automakers, is flawed. We believe tax credits for hybrid vehicles should include: (1) minimum fuel economy thresholds reflecting significant efficiency improvements relative to typical vehicles in any size class; (2) requirements that criteria emissions at least meet the prevailing standards for gasoline-fueled cars; and (3) eligibility beginning in 2000 or 2001. Including these elements will reward innovation and ensure energy and environmental benefits.

We support the Administration's earlier proposal but think it could be improved in a number of respects. First, two manufacturers (Toyota and Honda) indicate they will introduce hybrid vehicles in North America in late 1999 or 2000. The tax credits should reward early adopters and accelerate innovation, rather than reward laggards. Therefore, we urge that the availability of the hybrid vehicle credits be moved up to 2000 or 2001 at the latest.

Second, there are other promising paths to higher vehicle efficiency, including reducing vehicle weight through much greater use of aluminum and other advanced materials (DeCicco 1999). Therefore, we recommend that tax credits be extended to other high-efficiency vehicles that are not necessarily powered by fuel cells or hybrid drivetrains. Specifically, we suggest that credits start for vehicles that are at least 50 percent more efficient than typical new vehicles in the same 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).

Third, the Administration's earlier proposal only required vehicles to meet prevailing federal emissions standards for gasoline-fueled cars in order to qualify for tax credits. While this provides some protection against stimulating the sale of relatively dirty vehicles (e.g., light trucks employing a diesel engine), in our view it does not go far enough, in part because of the delays in and uncertainty surrounding the recently proposed "Tier 2" federal emissions standards. 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 meet the 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 are already meeting (DeCicco and Thomas 1999).

Fourth, the issue of how to treat non-gasoline fueled vehicles needs to be addressed either in the legislation or subsequently by the U.S. Environmental Protection Agency (EPA). We recommend setting fuel economy thresholds 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 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 if fuel economy thresholds are included. As part of developing a tax credit proposal for hybrid vehicles, there has been difficulty defining what is meant by a "comparable vehicle in its size class." In 1998, the Clinton Administration proposed a baseline scheme that included vehicle type and 0-60 MPH 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 (as was the case in the Administration's original proposal), a less complex baseline determination may be acceptable for credits targeted specifically to hybrid vehicles.

Alternative Fuels and Alternative Fuel Vehicles

The Rockefeller bill also contains a $0.50 per gallon of gasoline-equivalent credit to sellers of alternative fuels including natural gas, liquid propane gas (LPG), hydrogen, and methanol. Since existing legislation (EPAct) already requires 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 gaseous-fueled vehicles will be sold annually by 2005, with natural gas and methanol consumption by vehicles reaching about 0.35 quads that year (EIA 1998). This is equivalent to 3.1 billion gallons of gasoline. Since the level of free riders and the cost to the Treasury from this part of the Rockefeller bill could be quite substantial, we question the merit of extending tax credits to alternative fuels.

New Homes

The Administration has proposed a tax credit to encourage construction of very energy-efficient new homes. The original proposal made in 1998 was a tax credit for homes 50 percent more energy efficient than "good practice," as defined by the 1998 International Energy Conservation Code, formerly known as the Model Energy Code (MEC). Based on comments from the housing industry, energy efficiency advocates, and others, the Administration has modified its proposal and is now proposing credits of $1,000, $1,500, and $2,000 for new homes that are 30, 40, and 50 percent, respectively, more energy efficient than the 1998 IECC. The credit would be available for longer at the higher efficiency thresholds (see Table 2). We support this change and think it is reasonable balance between stimulating innovation on the one hand and making the credit more accessible on the other.

Table 2. Clinton Administration's Proposed Energy Efficiency Tax Credits for New Homes

30% more efficient than 1998 IECC standard	$1,000 credit	01/01/2000-12/31/2001
40% more efficient than 1998 IECC standard	$1,500 credit	01/01/2000-12/31/2002
50% more efficient than 1998 IECC standard	$2,000 credit	01/01/2000-12/31/2003

Note: The 1998 IECC standard is the 1998 International Energy Conservation Code published by the International Code Council.

A number of details need to defined either as part of the legislation or through a subsequent rulemaking in order to make the new homes tax credit practical. Also, it is critical to include certain provisions to prevent a high level of free riders and/or unintended consequences such as promotion of homes with electric resistance heating. We recommend including these details in the legislation to the maximum extent possible in order to remove uncertainty and speed up implementation.

1. We recommend defining the term "x percent more efficient than the 1998 IECC" as meaning x percent primary energy savings (or carbon emissions savings) for space heating and cooling compared to a reference home just meeting the IECC with the same heating fuel and a reference heating and cooling system.

2. 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.

3. Sets of component-based requirements should be defined 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. In both cases, the objective 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." This principle is included in the Matsui bill.

4. Heating and cooling equipment in a qualifying house should be required to meet the ENERGY STAR specifications, with credit provided for energy savings relative to the ENERGY STAR performance thresholds (i.e., a "reference heating system" would be ENERGY STAR compliant).

5. No credit should be allowed for an electric heat pump unless it exceeds ENERGY STAR specifications and credit only would be given for savings relative to the ENERGY STAR efficiency level. In other words, a home where a heat pump is installed should not get credit for the energy savings compared to the same home with electric resistance heating since about half of new electrically heated homes already utilize heat pumps.

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

Besides the Administration's proposal, Rep. Thomas has introduced a bill (H.R. 1358) that provides a flat $2,000 credit for new homes "certified to exceed by 30 percent or more the applicable standards for energy efficiency, based upon energy use or building component performance established by comparable dwellings under the 1998 IECC." The Thomas bill proposes that the builder be eligible for the credit, which is reasonable as long as legitimate compliance is demonstrated. But unlike the Administration's new homes credit proposal, the

Thomas proposal allows self-certification by builders. In our view, this could lead to high levels of fraud and abuse. Thus, we recommend requiring third-party certification as specified in the Matsui proposal. Also, the six issues discussed in the previous paragraph need to be clarified in order to: (1) remove uncertainty in the Thomas proposal; (2) limit the number of potential free riders; and (3) prevent other adverse effects.

Besides these clarifications and definitions, we believe the multi-tier approach is preferable because it would encourage and reward higher levels of 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.[2] A total of 20,000 ENERGY STAR Homes are expected to be built by the end of 1999 and the program has a goal of 100,000 homes per year by 2002 (EPA 1999). DOE's Building America program is demonstrating 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), initiated by the Clinton Administration, is targeting a 50 percent reduction in energy use in new homes.

The Thomas bill also provides a 20 percent tax credit not to exceed $2,000 for improvements to existing homes that are "certified to improve the annual energy performance by at least 30 percent." By requiring a 30 percent improvement, the Thomas bill takes a significant step towards 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. But this proposal as written is quite vague and raises many questions such as: What end uses are included? What is the base period? Is qualification based on modeling or actual energy use? Should weather be taken into account in the analysis or not? According to the Thomas bill, certification shall be made by the contractor, a local building regulatory authority, or qualified energy consultant. Since the contractor in particular will have an incentive to inflate energy savings, this credit could be subject to widespread fraud if it is not more carefully defined. The best way we can see to protect against such fraud is to require demonstration of energy savings through pre-retrofit and post-retrofit energy bill analysis using established techniques such as the Princeton Scorekeeping Model (PRISM). 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 efforts are underway to promote the adoption of energy efficiency measures in residential and commercial buildings, including state and local building codes, appliance and

[2] The ENERGY STAR Homes program promotes the construction of homes that exceed the IECC model code by 30 percent.

equipment efficiency standards, and labeling and promotion efforts such as the EPA/DOE ENERGY STAR labeling program. The Clinton Administration has structured its proposed tax credits for building equipment to complement rather than duplicate these other important efforts (see Table 3). The credits would be available to both individuals and businesses. In some cases, an additional efficiency and incentive tier was added to the proposal this year in order to promote a greater range of products but without greatly inflating free riders and the cost to the government.

Table 3. Clinton Administration's Proposed Energy Efficiency Tax Credits for Building Equipment

Central air conditioners and electric heat pumps		
SEER ≥ 13.5	10% credit up to $250	01/01/2000-12/31/2001
SEER > 15.0	20% credit up to $500	01/01/2000-12/31/2003
Natural gas heat pumps		
Heating COP ≥ 1.25 Cooling COP ≥ 0.70	20% credit up to $1,000	01/01/2000-12/31/2003
Electric heat pump water heaters		
Energy Factor ≥ 1.7	20% credit up to $500	01/01/2000-12/31/2003
Natural gas water heaters		
Energy Factor ≥ 0.65	10% credit up to $250	01/01/2000-12/31/2001
Energy Factor ≥ 0.80	20% credit up to $500	01/01/2000-12/31/2003
Building fuel cell systems		
Electric generation efficiency ≥ 35%	20% credit up to $500 per kW	01/01/2000-12/31/2003

Note: SEER is the Seasonal Energy Efficiency Ratio; COP is the Coefficient of Performance.

Air Conditioners and Heat Pumps

The Administration has proposed a 10 percent credit up to $250 for central air conditioners and heat pumps with a seasonal energy efficiency rating 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. For comparison, the average central air conditioner and heat pump sold in 1998 had a SEER of 11.0 (Leland 1999). While air conditioner and heat pump manufacturers would prefer a slightly lower minimum efficiency requirement (SEER of 13.0), we believe the cooling efficiency thresholds proposed by the Administration are reasonable.

Approximately 1.1 percent of units shipped as of 1998 had a SEER of 13.5 or greater and approximately 0.2 percent had a SEER of 15.0 or greater (Leland 1999). These high-efficiency air conditioners and heat pumps have a relatively high first cost premium in part because they are produced in small quantity. The 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. Currently, the federal standard is a minium SEER of 10.0. DOE has started a rulemaking to set new standards that are expected to take effect around 2005. The new standard could require a minimum SEER in the range of 12.5-13.5.

For electric heat pumps, the Administration also has proposed a minimum heating efficiency (HSPF) of 9.0 for both the lower and higher credits. This heating efficiency threshold is consistent with the SEER of 15.0 cooling requirement and therefore is reasonable for the 20 percent credit. But we suggest that a slightly lower HSPF threshold of 8.5 would be reasonable for qualifying for the lower credit, consistent with the lower cooling efficiency requirement.

The Administration's tax credit package includes a 20 percent credit up to $1,000 for natural gas-fired heat pumps—systems that provide both heating and cooling using an engine-driven or absorption cycle. After years of R&D, gas-fired heat pumps are poised for commercialization. One company has 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. 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 using no hydrochlorofluorocarbons or hydrofluorocarbons. Commercialization of the GAX heat pump is expected in the next two years. The GAX heat pump is projected to sell for an installed price of about $5,500 once it is established in the marketplace, with price drops as sales grow (Ryan 1997). A 20 percent tax credit up to $1,000 could be very useful as the GAX heat pump and possibly other gas-fired heat pumps are commercialized, especially if combined with incentives provided by some gas utilities.

Water Heaters

The Administration has proposed tax credits for both highly efficient electric and gas-fired water heaters. In the case of electric water heaters, a 20 percent credit up to $500 is proposed for heat pump water heaters with an Energy Factor of at least 1.7. HPWHs 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 around 20 years but have never caught on due to high first cost, limited availability, and reliability 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 major water heater or air conditioner manufacturers have expressed renewed interest in making the product. A 20 percent tax credit could help to stimulate production of and demand for this promising technology but other concerns such as reliability, consumer satisfaction, and installer training also need to be addressed (Nadel et al. 1998).

In the case of natural gas water heaters, the Administration has proposed 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 being developed by DOE are likely to raise the average Energy Factor for gas water heaters to around 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 (Nadel et al. 1998). We recommend that the gas water heater tax credit 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.

Fuel Cell Cogeneration Systems

A wide range of advanced cogeneration 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. In principle, "technology neutral" tax incentives could be offered, based on meeting energy efficiency and possibly other performance criteria, in order to support commercialization of advanced cogeneration technologies of various types. But each type of technology is at a different stage of development, with different efficiency levels and targets as well as different cost levels and targets. Therefore, we support establishing separate incentive schemes for one or more of the advanced cogeneration technologies.

The Administration has proposed a 20 percent credit up to a maximum of $500 per kW for fuel cell systems 5 kW or greater installed in buildings applications during 2000-2004. 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 (35-70 percent). 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. Other types of fuel cells such as molten carbonate, solid oxide, and proton exchange membrane are nearing commercialization and promise even higher efficiencies (Greene, Gupta, and Bryan 1997).

High capital cost is a problem for all types of fuel cells. Currently available PAFC systems cost around $3,000/kW, 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, the 20 percent federal tax credit could be valuable for stimulating initial sales and helping to move the technology "down the learning curve." But since fuel cell cogeneration systems less than 5 kW of electric capacity might be used in households, we suggest changing the minimum size threshold for a tax credit to 2 kW.

As mentioned earlier, other types of technologies such as internal combustion engines and microturbines can be used for cogeneration in residential and commercial buildings. But these technologies are more mature and do not have as high a capital cost as first generation fuel cells. Therefore, it is reasonable to exclude them from the tax incentives package.

Combined Heat and Power Systems

The Administration has proposed an 8 percent investment tax credit for qualifying CHP systems in excess of 50 kW in electrical capacity (see Table 4). Qualifying systems must produce at least 20 percent of their useful energy as electrical or mechanical power and 20 percent as thermal energy. Qualifying systems greater than 50 MW must have an overall efficiency of at least 70 percent; those 50 MW and under must have an overall efficiency of at least 60 percent. Also, the proposal includes other eligibility criteria related to depreciation.

Table 4. Clinton Administration's Proposed Energy Efficiency Tax Credits for Combined Heat and Power (CHP) Systems

Total Efficiency > 70%	CHP systems > 50 MW	8% credit	01/01/2000-12/31/2002
Total Efficiency> 60%	CHP systems ≤ 50 MW	8% credit	01/01/2000-12/31/2002

We have a number of concerns and suggestions for improving this proposal.

1. An 8 percent tax credit is not very significant and does not generate much enthusiasm from CHP manufacturers or vendors.

2. The proposal is broad-based and not focused on state-of-the-art or innovative technologies like most of the other tax credit proposals.

3. The first cost is not necessarily the key barrier inhibiting the adoption of CHP systems, especially for large capacity systems (Elliott and Spurr 1999).

In order to address these concerns, we suggest increasing the credit amount and restricting eligibility to smaller systems (under 50 MW). These systems have a higher installed cost per kW than larger systems and consequently cost-effectiveness is a bigger issue. Also, systems 50 MW or larger comprise 80 percent or more of CHP capacity now being installed (Elliott and Spurr 1999).

Specifically, we recommend a 10 percent credit for units 10-50 MW, a 15 percent credit for units 1-10 MW, and a 20 percent credit for units 50 kW to 1 MW. This should reduce the level of free riders and do more to stimulate the adoption of CHP systems that are relatively costly today. Also, the Administration has proposed making this credit available to systems installed during 2000-2002. But systems entering in service in 2000 are probably under development or construction already and therefore would be free riders. We recommend limiting eligibility to systems that begin operating in 2001, with the credit available through 2003 or 2004.

General Issues

One problem that applies to a number of the proposed credits is the fact that non-profit organizations, municipalities, universities, and other public sector organizations are not subject to federal income taxes. Thus, they would not be eligible for tax credits as the credits are now proposed. A solution to this problem has been suggested, specifically 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). The employees would not be penalized; in effect the Treasury would make up the difference in income tax withholding. This would make public sector organizations eligible for the same tax credits as private businesses and individuals, thereby increasing participation and impacts.

Another issue is the extent to which businesses will be able to use 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 credits may be somewhat limited. Therefore, if possible, we recommend that these tax credits not be subject to AMT restrictions and/or provided as tax rebates to companies not paying income taxes. 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.

OTHER POTENTIAL ENERGY EFFICIENCY TAX INCENTIVES

Buildings Sector

There are other innovative buildings technologies besides air conditioners, heat pumps, water heaters, and fuel cells that conceivably could be promoted through tax credits. Oregon has enacted a state tax credit for buyers of high-efficiency appliances, ground-source heat pumps, heating and cooling duct sealing treatment, solar systems, and alternative fuel vehicles (OOE 1999). We discuss the pros and cons of providing tax credits for highly efficient appliances, ground-source heat pumps, and a few other building technologies below.

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.

Regarding refrigerators, manufacturers have made great strides in improving efficiency due to market forces, utility incentive programs, and minimum efficiency standards. As of 1997, the average new refrigerator consumed 670 kilowatt-hour per year (kWh/yr), down from 1450 kWh/yr 20 years ago. When the new DOE refrigerator efficiency standard goes into effect in 2001, the average energy use of new refrigerators will decline to approximately 500 kWh/yr. Still, substantial additional efficiency improvements are possible. Oak Ridge National Laboratory and a consortium of refrigerator manufacturers developed a prototype refrigerator/freezer that uses only 340 kWh/year, 38 percent less than the 2001 standard (Vineyard and Sand 1998). One detailed technical analysis concluded that "it may be possible to produce a super-efficient refrigerator/freezer with energy consumption as low as 200 kWh/year" (EPA 1993).

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 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.

A federal tax credit for refrigerators could function in the same manner, stimulating introduction of some advanced models and thereby setting the stage for the next round of standards that would take effect in 2006 or later. If tax credits for very efficient refrigerators are pursued, we recommend that eligibility for such a credit be set at 25 percent energy savings relative to the 2001 efficiency standard. A 20 percent tax credit implies about a $100 incentive for a typical top-mount refrigerator-freezer. This is roughly the incremental retail cost expected for achieving a 25 percent energy savings relative to the new standards (EPA 1993; Vineyard and Sand 1998).

Concerning clothes washers, resource-efficient, ENERGY STAR clothes washers use 40-60 percent less energy and 30-40 percent less water than standard clothes washers. But a number of new ENERGY STAR clothes washers are now available and widely marketed. Sales of ENERGY STAR clothes washers are increasing rapidly in spite of a substantial first cost premium, due in part to promotion at the national and regional levels as well as incentives provided by numerous utilities. The market share for ENERGY STAR clothes washers reached 8 percent by the end of 1998 according to one estimate (Suozzo and Thorne 1999). Furthermore, DOE is planning to set new efficiency standards for clothes washers in 2000 with the standards taking effect most likely around 2005. These new standards could require all new clothes washers to achieve ENERGY STAR performance, thereby completing the market transformation. For these reasons, we recommend that tax credits NOT be extended to resource-efficient clothes washers.

Ground-Source Heat Pumps

The Administration's tax credits package includes credits for ordinary air-source heat pumps but not ground-source heat pumps (GSHPs). GSHPs have been available for around 20 years although a number of improvements in the technology occurred in recent years. GSHPs are actively promoted by numerous electric utilities as well as the Geothermal Heat Pump Consortium (L'Ecuyer and Sachs 1998). Sales were around 40,000 units per year as of 1997-98 and are increasing 10-20 percent per year (L'Ecuyer 1999). If tax credits are extended to include GSHPs, minimum efficiency thresholds should be set so that only the most efficient GSHPs sold today qualify. Doing so would encourage "best practice," maximum energy savings and emissions reductions, and maximum "bang for the buck." Following this logic, we suggest a minimum cooling efficiency of EER=15 and a minimum heating efficiency of COP=3.4 in order for GSHPs to qualify for tax credits.

Lighting

Halogen torchiere floor lamps of 300-500 watts have become very popular due to their bright light, dimming capability, and low cost. However, these light fixtures are inefficient and also a fire hazard. In response, compact fluorescent lamp (CFL)-based torchieres have been developed and commercialized over the past two years. CFL torchieres cost three to eight times as much as halogen torchieres but consume about 75 percent less electricity. Sales of CFL torchieres are increasing but still relatively low (Geller and Thorne 1999). Thus, they seem like a reasonable candidate for tax credits. However, the retail cost for a CFL torchiere is only $50-

$150 and costs are dropping as sales increase. With a 20 percent tax credit, the value of the credit is only $10-$30. This does not seem substantial enough to merit a specific tax credit. Instead of tax credits, the federal government could actively promote bulk purchases by institutions such as colleges or military bases, as well as encourage utility and regional promotion programs.

A similar concern applies to other innovative lighting technologies such as improved CFLs or metal halide lamps. While the technologies may be very beneficial, individually they are not costly enough to warrant establishing and administering tax credits. However, some of the advanced lighting technologies for commercial buildings such as electrodeless lamps, advanced daylighting devices, and integrated lighting fixtures and controls might be better suited to tax credits since the products would purchased in quantity and their high first cost is considered a market barrier (Nadel et al. 1998).

Transformers

Distribution transformers are used to reduce electricity voltage to 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 available that can reduce electricity losses in the transformer by 15-30 percent. There is an industry-based standard (NEMA standard TP-1) that denotes higher-efficiency transformers as well as minimum efficiency requirements in Canada. But the NEMA standard is not very stringent and is currently met by many products (Nadel et al. 1998). It would be reasonable to provide tax credits to stimulate the market for very efficient transformers since first cost is a barrier but efficiency thresholds significantly higher than those in TP-1 need to be developed in order to minimize free riders and promote state-of-the-art efficiency levels.

Industrial Sector

The industrial sector is complicated due to the great diversity of industries and processes. However, we think that targeted tax credits could help to stimulate the introduction of major energy efficiency and emissions-reducing innovations for some of the most important industrial processes. A few of the advanced technologies being developed under DOE's Industries of the Future program look particularly promising in this regard. Following we present proposals for the paper and pulp, steel, and aluminum industries. Similar schemes might be possible for other industries such as the chemical, glass, and petroleum refining industries.

Paper and Pulp Industry

Black liquor and residual biomass gasification and combined cycle power production are advanced technologies under development for the paper and pulp industry with substantial support forthcoming from DOE as part of the Forest Products Vision Initiative. The integrated gasification and combined cycle (IGCC) technology increases electricity production by a factor of two to three compared to current cogeneration technology used by the paper and pulp industry, thereby allowing paper and pulp mills to be net electricity exporters. The IGCC technology also provides environmental advantages, operating cost reductions, and other benefits. The technology would be especially attractive when existing recovery boilers in paper mills need to be replaced and many are nearing the end of their lifetime.

High capital cost is a barrier inhibiting commercialization of the biomass-based IGCC technology. It is estimated that the capital cost for initial biomass-based IGCC plants will be in the range of $2,500-$3,000/kW but the capital cost could be reduced as much as 40 percent (to $1,500/kW) by construction of the fifth unit (CEES 1997). The technology is expected to be competitive in many paper and pulp mills at this latter price. Thus, a financial incentive such as a 20 percent investment tax credit for a limited period of time could help offset the high cost of initial plants and allow the learning needed to reduce costs. We suggest that the credit be provided for IGCC plants installed during 2001-2004, which should limit the use of the credit to 5-10 plants and the cost to the government to no more than $150 million. Regarding performance criteria, requirements for minimum electrical conversion efficiency could be used, perhaps in the range of 29-32 percent, which could be met by biomass-based IGCC technologies of various types and sizes.

Steel Industry

Major technological advances are possible for both iron ore-based integrated steel mills and scrap-based electric mini-mills. For integrated mills, smelt reduction is the advanced technology offering major energy, environmental, and possibly cost benefits. Smelt reduction involves replacing the blast furnace and coke ovens with a coal-based smelter and direct reduction of iron oxides. At least seven different smelt reduction processes are under development worldwide, including one sponsored by the American Iron and Steel Institute. One process (COREX) is commercially available but costly; a few other processes are operating at the pilot-plant scale (de Beer, Worrell, and Blok 1998).

Rather than specifying a particular technology or process, eligibility could be based on meeting certain performance criteria, namely the specific energy consumption (SEC) for a given type of steel mill. The SEC for existing integrated ore-based steel mills averages about 24 gigajoule (GJ) per metric tonne while well-designed new mills consume about 19 GJ per tonne (de Beer, Worrell and Blok 1998). Smelt reduction processes offer the potential to reduce SEC to 13-17 GJ per tonne. Tax incentives could be offered for new or refurbished steel mills with a SEC equal to or less than, say, 17 GJ per tonne net (i.e., taking into account any excess electricity generated from waste gases). Such an incentive could motivate commercialization of one or more smelt reduction processes but manufacturers would be able to pursue other advanced technologies such as strip or spray casting that could help achieve this goal.

Interest in smelt reduction steel processes is higher in Europe, Japan, and countries such as South Korea and South Africa, where steel output is growing more rapidly than in the United States. We suggest offering tax credits during 2000-2004 to help overcome the barriers such as investment cost, risk, and resistance to technical change that are limiting interest in this innovative technology in the United States. Tax credits could be offered either as a fraction of the investment cost or per tonne of steel produced.

Similarly, tax credits could be offered to stimulate commercialization of advanced technologies in scrap-based mini-mills. Although the energy intensity of electric arc furnaces (EAFs) has steadily declined over the past 20 years, a number of advanced EAF technologies are under development, including scrap preheating and melting using both electricity and fossil fuel. A well-designed new mini-mill has a primary energy intensity of about 5 GJ per tonne, while use of advanced technologies could reduce this value to 3.5 GJ per tonne or less (de Beer, Worrell, and Blok 1998). Again, tax credits could be offered to new or refurbished mills that are below this energy intensity threshold, either as an investment credit or production-based incentive.

Aluminum Industry

Primary aluminum smelting is highly electricity-intensive and electricity is a major component of the cost of aluminum. U.S. primary aluminum producers consume about 15.2 kWh per kilogram (kg) on average, with state-of-the-art producers consuming about 13 kWh per kg. Further energy intensity improvements are possible and the aluminum industry has set a target of achieving 11 kWh per kg in new smelters (Aluminum Association 1997).

New anodes and cathodes (i.e., inert anodes and wettable cathodes) are under development for the electrolytic cells used in aluminum smelting. These technologies could reduce electricity use by up to 27 percent and also would eliminate carbon emissions associated with the production and use of carbon anodes (IWG 1997). But considerable R&D is still required on the new anodes and cathodes, and consequently they are a major focus of DOE's Aluminum Industry Vision program. Commercialization is not expected for at least five years.

If the inert anode and/or wettable cathode technologies can be perfected, they could have difficulty entering the marketplace due to high initial capital cost and/or limited willingness of manufacturers to invest in new technology in the United States where total aluminum capacity is stable or declining (i.e., aluminum manufacturing has been moving overseas). Financial incentives for early adopters may be helpful for commercializing and diffusing the technologies in the United States. In this case, we suggest providing tax credits in the 2004-2008 time frame with eligibility based on energy intensity as well as other criteria such as reducing direct carbon and perfluorocarbon emissions.

POTENTIAL IMPACTS

How much will carbon dioxide emissions be reduced as a result of the energy efficiency tax credits proposed by the Clinton Administration? This is a logical question given that the credits are part of the Administration's Climate Change Technology Initiative. At the same time, it is important to examine other impacts including cost to the government and impacts on consumers. These are by no means easy questions to answer since the proposed tax credits are intended to stimulate the development and commercialization of advanced technologies. It is unclear whether some of the technologies such as gas-fired heat pumps or fuel cell vehicles can be perfected and whether they will have costs and other characteristics that are attractive to consumers. Therefore, any estimate of potential impacts is highly uncertain.

Only experience can reveal whether the tax credits will be successful both in terms of use of the credits themselves and 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 carbon emissions reductions due to these units) and indirect impacts (i.e., impacts from sales and use of the technologies after the credits are phased out) should be considered in a comprehensive impacts analysis. In this section, we present and comment on analyses of the potential direct impacts of the energy efficiency tax credits and present some of our own estimates of the possible direct and indirect impacts.

Impacts Estimated by Clinton Administration

Two branches of the Clinton Administration—the Treasury Department and the Energy Information Administration—have conducted analyses of the potential direct impacts of the Administration's climate technology tax credits. As shown in Table 5, the Treasury Department estimates that the energy efficiency tax credits will cost the federal government $3.2 billion during 2000-2004 and $8.3 billion during 2000-2009 (DOT 1999b). In addition, the renewable energy tax credits included in the package are estimated to cost the government $0.4 billion during 2000-2004 and $1.2 billion during 2000-2009. As shown in Table 5, the Treasury Department projects that the credits for building equipment will cost the most during the early period but that the vehicle credits will dominate after 2004 and will account for nearly two-thirds of the total cost over the 10-year period.

Table 5. Estimates of Revenue Effects and Direct Carbon Emissions Reductions from Climate Change Technology Tax Incentive Proposals

	Revenue Loss 2000-2004 (billion $)	Revenue Loss 2000-2009 (billion $)	Carbon Emissions Reduction (a) (MMT)
New Homes	0.4	0.5	7-10
Building Equipment	1.5	1.5	28-42
Vehicles	0.9	6.0	36-54
CHP 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 & Biomass Power	0.3	0.8	15-23
RENEWABLE ENERGY SUBTOTAL	0.4	1.2	17-26
TOTAL	3.6	9.5	100-150

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

Table 5 also includes Treasury's estimates of the avoided carbon emissions due to equipment for which credits are claimed during 2000-2009. The estimates are based on avoided emissions over the lifetime of these products. The total estimated reduction in emissions is 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 1,485 MMT of carbon from fossil fuel consumption as of 1998 (EIA 1999b). The Treasury analysis notes 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 1999b).

Regarding other impacts, the Treasury Department estimates 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 does 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).

The Energy Information Administration released a study of the CCTI that includes its assessment of the tax incentives package using the NEMS model, EIA's main energy forecasting tool (EIA 1999a). As shown in Table 6, EIA estimates that the tax credits (including renewables credits) will cut carbon emissions 3.1 MMT in 2010 but the energy efficiency tax credits will only account for 1.6 MMT of this total. EIA does not present cumulative carbon emissions reductions over the lifetime of the measures receiving credits. EIA's estimates exclude 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 is projected to be very high for the CHP, advanced vehicles, and renewable energy credits. This is why EIA estimates substantial revenue loss but very little energy savings and avoided carbon emissions for these particular credits.

The EIA analysis has a number of flaws and has been criticized by others. First, the analysis appears to understate carbon emissions reductions from advanced vehicle technologies, estimating 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 as a result of the vehicles credit. Second, as pointed out by DOE and EPA, the EIA tax credits analysis does not take into account the synergistic effects of technology RD&D, deployment efforts, and tax credits (Gardiner 1999; Reicher 1999). Efforts like the Partnership for a New Generation of Vehicles (PNGV), 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, along with the financial incentive provided by the tax credits. The EIA model is overly conservative in how it treats (or doesn't treat) these synergistic market transformation efforts (e.g., the model fails to recognize the potential to reduce or remove non-cost market barriers through activities such as education, information, and regulatory reform). Third, the NEMS model has 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).

Table 6. Climate Technology Tax Credit Impacts in 2010 Estimated by the Energy Information Administration

Tax Credit	Energy Savings (TBtu)	Avoided Carbon Emissions (MMT)	Cumulative Revenue Loss (a) (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, & Hybrid Vehicles	0.8	<0.01	2.0
Wind & Biomass	71.9	1.5	0.8
TOTAL	103.5	3.1	3.5 (b)

Notes:
(a) Revenue loss over 2000-2004 in 1998 dollars.
(b) Total excluding revenue loss from tax credits on building equipment.
Source: EIA 1999a.

Potential Longer Term Impacts

Both the Treasury Department and EIA analyses consider only the direct effects of the tax credits–impacts from measures actually receiving credits. But economies of scale, technology learning, and market development could lead to indirect impacts many times greater than the direct impacts, as the Treasury Department and DOE acknowledge. While very speculative, we offer some estimates of plausible indirect effects, assuming that the credits along with RD&D and related deployment efforts are successful in stimulating introduction of and growing markets for the various advanced energy-efficient technologies. Our estimates, shown in Table 7, are not meant to be predictions of what will occur. Rather they are indicative of what could happen if the tax credits, other policies, and private sector efforts in combination are successful.

Table 7 shows the estimated number of installations of each technology receiving tax credits (labeled "direct") along with the total number of installations by 2010 and 2015. We believe that the number of installations by 2015 could equal four to twenty times the number of installations qualifying for the credits, depending on the product type. The total revenue loss consistent with these estimates is $7.6 billion, similar to the Treasury Department's estimate of $8.3 billion.[3]

Table 7. Climate Technology Tax Credit Impacts Estimated by ACEEE

	Cumulative Installations (million)			Avoided Carbon Emissions (MMT/yr)			Total Revenue Loss (million$)
Tax Credit	Direct	2010	2015	Direct	2010	2015	
New Homes (a)	0.50	1.7	3.6	0.4	1.5	3.1	750
Central AC/HP (b)	2.0	9.0	19.0	0.3	1.2	2.5	800
Gas heat pumps (c)	0.1	0.5	1.0	0.06	0.3	0.6	100
El. water heaters (d)	1.0	3.1	5.1	0.35	1.1	1.8	200
Gas water heaters (e)	2.0	4.8	7.8	0.1	0.3	0.5	300
Fuel cell cogen. (MW) (f)	200	2000	4000	0.2	1.8	3.6	80
El./fuel cell vehicles (g)	0.6	1.8	3.5	0.6	1.7	3.2	2100
Hybrid vehicles (h)	1.2	3.6	7.4	1.0	3.0	6.2	3000
CHP (MW) (i)	2000	5000	8000	1.0	3.5	7.5	300
TOTAL	—	—	—	4.0	14.4	29.0	7630

Notes:
(a) Assumes 500,000 homes qualify for credits during 2000-2004; 200,000 new homes built per year during 2005-2010 are energy-efficient; and 375,000 new homes built per year during 2011-2015 are energy-efficient. Energy-efficient homes save 40 MBtu of primary energy on average.
(b) Assumes 2 million new central air conditioners and heat pumps qualify for credits during 2000-2003; 1 million per year on average are energy-efficient during 2004-2010; and 2 million per year on average are energy-efficient during 2011-2015. Energy and carbon savings equal 545 kWh/yr and 101 kg of carbon per year for a qualifying central air conditioner and 1920 kWh/yr and 356 kg of carbon per year for a qualifying heat pump.
(c) Assumes 100,000 gas-fired heat pumps qualify for credits during 2000-2003; 50,000 per year on average are sold during 2004-2010; and 100,000 per year on average are sold during 2011-2015. Energy savings equal 18 MBtu/yr of gas and 2300 kWh/yr of electricity. Carbon savings equal 650 kg of carbon per year for a qualifying gas-fired heat pump.
(d) Assumes 1 million heat pump water heaters qualify for credits during 2000-2003; 300,000 per year on average are sold during 2004-2010; and 400,000 per year on average are sold during 2011-2015.

[3] The difference in estimated revenue loss is caused in part by different assumptions concerning the design of two of the tax credit proposals.

Energy and carbon savings equal 1900 kWh/yr of electricity and 350 kg of carbon per year per heat pump water heater.
(e) Assumes 2 million gas water heaters qualify for credits during 2000-2003; 400,000 sold per year during 2004-2010 are energy-efficient; and 600,000 sold per year during 2011-2015 are energy-efficient. Energy and carbon savings equal 4.5 MBtu of natural gas and 65 kg of carbon per year per qualifying gas water heater.
(f) Assumes 200 MW of fuel cell cogeneration systems qualify for credits during 2000-2003; 1800 MW are sold during 2004-2010; and 2000 MW are sold during 2011-2015. Fuel cells cogeneration systems operating on natural gas would provide a net energy savings of 42 MBtu/yr per kW installed and 900 kg of avoided carbon emissions per year per kW installed.
(g) Assumes 0.6 million electric and fuel cell vehicles qualify for credits during 2003-2006, mostly in California and the Northeast; 300,000 per year on average are sold during 2007-2010; and 500,000 per year on average are sold during 2011-2015. The avoided carbon emissions are 925 kg per year per electric or fuel cell vehicle, about half the emissions of a typical new gasoline vehicle.
(h) Based on hybrid vehicle tax credits proposed by the Clinton Administration in February 1999. Assumes 1.2 million hybrid vehicles qualify for credits during 2003-2006; 600,000 per year on average are sold during 2007-2010; and 1 million per year on average are sold during 2011-2015. The avoided carbon emissions are 840 kg per year per hybrid vehicle, about 45 percent less than the emissions of a typical new gasoline vehicle.
(i) Based on modified tax credits for CHP systems 50 MW or less; see text. Assumes 2000 MW of CHP systems qualify for credits during 2001-2004; 3000 MW are sold during 2005-2010; and 3000 MW are sold during 2011-2015. Qualifying CHP systems operating on natural gas are assumed to cut carbon emissions by 500 kg/yr per kW of installed capacity.
Source: American Council for an Energy-Efficient Economy.

Regarding direct emissions impact, we estimate that all units qualifying for the energy efficiency tax credits would reduce carbon emissions by about 4.0 MMT per year. It should be noted that this estimate includes emissions reductions from any free riders. With growing adoption of the advanced technologies following the phase-out of the credits, the avoided carbon emissions could reach around 14 MMT per year by 2010 and 29 MMT per year by 2015. The latter value is equivalent to 2 percent of U.S. carbon emissions at the present time. The cumulative reduction during 2000-2015 could reach approximately 160 MMT. 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 incentives phase-out. And the avoided carbon emissions should continue to rise after 2015 as market penetration grows.

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. greenhouse gas 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, highly efficient heating and cooling systems, and very efficient new homes.

The Clinton Administration has made a constructive proposal that includes tax credits for a variety of innovative energy efficiency technologies. However, we recommend that certain modifications be made to the Administration's proposals in order to maximize the benefits while minimizing the potential for free riders and other adverse effects. Also, we recommend that tax credits be expanded to cover a wider range of energy uses and technologies including important industrial processes such as making steel, aluminum, and paper and pulp.

Given that the amount of money available for climate change technology tax credits is likely to be limited, perhaps on the order of $10 billion over a decade, then it is important to get the maximum "bang per buck." This means 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. We believe 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. We theorize that this type of response is possible from tax credits and suggest how large the indirect impact might be (at least through 2015). 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."

We urge policy makers to try this experiment independent of concerns about the rate of climate change or the Kyoto Protocol to limit future greenhouse gas emissions. Put simply, tax credits for innovative energy efficiency and renewable energy technologies could have positive impacts on U.S. businesses, consumers, air quality, and public health, as well as help to reduce greenhouse gas emissions and global warming. They should be included in any broad-based package of tax cuts and incentives enacted in the near future.

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