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Analysis of Efficiency Standards for Air Conditioners, Heat Pumps, and Other Products (S. 1766 Section 921-929, H.R. 4 Section 124, 142, and 143)

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Introduction

On December 20, 2001, Sen. Frank Murkowski, the Ranking Minority Member of the Senate Committee on Energy and Natural Resources requested an analysis of selected portions of Senate Bill 1766 (S. 1766, the Energy Policy Act of 2002) and House Resolution 4 (the Securing America's Future Energy Act of 2001)[1]. In response, the Energy Information Administration (EIA) has prepared a series of analyses showing the impacts of each of the selected provisions of the bills on energy supply, demand, and prices, macroeconomic variables where feasible, import dependence, and emissions. The analysis provided is based on the *Annual Energy Outlook 2002*[2] (*AEO2002*) midterm forecasts of energy supply, demand and prices through 2020.

Because of the rapid delivery requested by Sen. Murkowski, each requested component of the Senate and House bills was analyzed separately, that is, without analyzing the interactions among the various provisions. Because of the approach taken:

- The combined impact of the individual policies cannot be determined by simply adding the individual policy impacts together. For example, a provision establishing a renewable portfolio standard (RPS) for electricity production, and one that establishes a bio-diesel program for transportation fuels, each increases the use of biomass. The simultaneous enactment of the two provisions would be likely to increase biomass costs because of the competition for land and other needed resources. The estimated fossil energy displaced will therefore be lower than the sum of the two individual policy impacts because of the higher resource costs. Stated another way, the impacts of multiple simultaneous policies are non-linear.

- Some policies will interact to increase the overall response while others may interact to mitigate the impacts of each other. For example, when two separate policies increase demand and, consequently, production of an advanced technology, the reductions in manufacturing costs expected from increased production are likely to be accelerated, making the technology even more attractive in later years. The total adoption of the advanced technology in this case could be greater than the sum of the parts.

In addition, the following should also be noted:

- Computation of expected benefits and costs of equipment installed at the end of the forecast horizon (e.g., 2020) requires estimates of costs and prices for a

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[1] Letter from Sen. Murkowski to Mary J. Hutzler, dated December 20, 2001. See Appendix A at the back of this report for a copy of the original letter.

[2] *Annual Energy Outlook 2002, With Projections to 2020,* U.S. Department of Energy, Energy Information Administration, DOE/EIA-0383(2002), December 2001.

number of years beyond this period. Since EIA does not project costs, prices or benefits past 2020, the estimates of the benefits after 2020 must be assumed for equipment installed by 2020. For example, analyzing consumer product standards for air conditioners through 2020 requires an estimate of the savings through 2036, because of the expected operating life of the new equipment that EIA projects to be installed through 2020. *AEO2002*, however, only produces projections through 2020. For the remaining years from 2021 to 2036, we have assumed the savings per unit remain constant at 2020 levels. Such estimates of savings are highly uncertain and could be higher or lower than this estimate.

- Some aspects of S.1766 and H.R.4 cannot be modeled because of lack of specificity. For example, several provisions require the Department of Energy (DOE) to evaluate the desirability of setting standards for stand-by power and other electronic devices. Because there is no statement about what the standards will be, EIA cannot quantitatively analyze them.

- Section 403(b) of Executive Order 13123, signed on June 3, 1999, requires Federal agencies to select ENERGY STAR and other energy-efficient products, where cost-effective, when acquiring energy using products. Current ENERGY STAR criteria for central air conditioners and air-source heat pumps specify a minimum efficiency of 12 SEER (seasonal energy efficiency ratio) in cooling mode and 7.6 HSPF (heating seasonal performance factor) in heating mode. The air conditioner and heat pump requirements for Federal agencies specified in Section 124 of H.R. 4 are not expected to provide any additional impact on energy consumption because Federal agencies are already mandated by E. O. 13123 to purchase equipment that meets the requirements set forth in H.R. 4. This analysis will present quantitative results from implementing a 12 SEER standard for all purchases, as a means of comparison with the 13 SEER standard proposed in S.1766.

EIA's projections are not statements of what will happen but what might happen, given known technologies, current technology and demographic trends, and current laws and regulations. Thus, the *AEO2002* provides a policy-neutral Reference Case that can be used to analyze energy policy initiatives, as has been done for each of these studies. EIA does not propose, advocate or speculate on future legislative or regulatory changes. Laws and regulations are assumed to remain as currently enacted or in force in the Reference Case; however, the impacts of emerging regulatory changes, when clearly defined, are reflected.

Models are simplified representations of reality because reality is complex. Projections are highly dependent on the data, methodologies, model structure and assumptions used to develop them. Because many of the events that shape energy markets are random and cannot be anticipated (including severe weather, technological breakthroughs, and geo-political disruptions), energy market projections are subject to uncertainty. Further, future developments in technologies, demographics, and resources cannot be foreseen with any degree of certainty. These uncertainties are addressed through analysis of alternative cases in the *AEO2002*.

This study addresses the provisions of H.R. 4 and S. 1766 that pertain to efficiency in the residential, commercial, and industrial sectors. The estimated effects of the provisions are presented below where quantitative analysis is feasible. Qualitative discussion is provided for the remaining standards-related provisions analyzed here.

Analysis Summary

Several provisions included in S.1766 and H.R.4 target appliance efficiency in the residential, commercial, and industrial sectors. In particular, S.1766 sets specific standards for residential-sized central air conditioners and heat pumps, torchiere lighting, illuminated exit signs, and low voltage dry-type transformers, while H.R.4 sets specific requirements for Federal purchases of residential-sized central air conditioners and heat pumps. Additionally, S.1766 allows for the Department of Energy (DOE) to enter into voluntary agreements with the goal of reducing industrial sector energy intensity 2.5 percent per year over the next 10 years. Both bills also require the DOE to investigate the applicability of efficiency standards for ceiling fans, furnace fans, commercial refrigerators and freezers, and stand-by power in numerous devices; however, given the lack of specificity in the level and timing of the standards for these four product categories, it is not possible to do an analysis of their effectiveness. A qualitative analysis is presented for illuminated exit signs and transformers, as these technologies are not explicitly represented in *AEO2002*. EIA does not currently have comprehensive data sources for estimating the quantity and efficiency levels of equipment in use, precluding quantitative analysis of the provisions in S.1766 that address efficiency standards for exit signs and transformers.

Table 1 summarizes the key results from the standards analyzed in S.1766. In order to analyze the proposed air conditioner and heat pump standards, a new baseline energy forecast for the buildings sector was created that uses a 10 SEER standard, rather than the 12 SEER standard that was included in the *AEO2002* Reference Case. This is the standard that was proposed by the DOE in the July 25, 2001 Federal Register, and proposed in H.R.4 for Federal purchases. As noted above, the guidelines for Federal purchases of air conditioners and heat pumps proposed in H.R.4 codifies Executive Order 13123, which requires Federal agencies to purchase ENERGY STAR air conditioners and heat pumps, if cost effective. Current ENERGY STAR requirements for air conditioners and heat pumps specify a minimum efficiency of 12 SEER, the same specifications proposed in H.R.4 for Federal facilities. In addition, the discount rate used by Federal facilities in determining cost effectiveness is based on long-term Treasury bond rates, which is consistent with the 10 year or less pay-back period specified in H.R.4. Although the NEMS modeling framework does not differentiate Federal purchases from other purchases, precluding a quantitative assessment of section 124 of H.R.4, the proposed provision mirrors the existing executive order, and the effects of implementation are projected to be negligible. However, as a means of comparison, the analysis below presents the standard proposed in S.1766 (13 SEER) with the standard currently proposed by DOE (12 SEER), assuming a reference case level of 10 SEER. Table 1, therefore, details the energy, carbon emissions, and energy bill savings, relative to a projection of energy demand assuming a 10 SEER standard for air conditioners and heat pumps.

Table 1. Summary of Projected Energy Savings from Selected Efficiency Standards Required in S.1766, Relative to a 10 SEER Baseline (cumulative over the life of equipment purchased through 2020) [1]

	12 SEER Standard	S.1766 13 SEER Standard	S.1766 Torchiere Standard
Electricity Savings (billion kWh)	592	799	138
Primary Energy Savings (trillion Btu) [2]	5,092	6,808	1,399
Carbon Savings (million metric tons)	79	105	23
Energy Bill Savings (billion $2001)	38	51	11
Net Present Value in 2002 (billion $2001) [3]	2.4	-0.6	N/A[4]

[1]Cumulative savings for torchiere lamps are provided through 2020, while savings for air conditioners and heat pumps are provided through the life cycle of units purchased through 2020. The last year for energy savings for air conditioners and heat pumps is 2036.
[2] Primary energy savings includes the direct use of all energy sources (measured at the point of use) plus the losses associated with generating and delivering electricity.
[3] Discounts future expenditures and savings at a 7 percent real discount rate (the DOE societal discount rate for computing net present value in its summary table in the Federal Register). Table 4 provides different net present value calculations based on different discount rate assumptions.
[4]A stock accounting framework does not exist for torchiere lamps in NEMS, thus a net present value calculation cannot be made.
Source: National Energy Modeling System.

The net present value calculations associated with the standards are the difference between the costs incurred by the consumer by purchasing more expensive equipment through 2020, and the projected annual energy bill savings for the life of the equipment. Since the National Energy Modeling System (NEMS) forecast horizon ends in 2020, the life-cycle savings for the 12 and 13 SEER standards are projected to 2036 by assuming that the 2020 energy bill savings decline linearly until all of the equipment purchased through 2020 has been retired. In Table 1, the projected costs and savings are discounted back to 2002 assuming a 7 percent real discount rate. Although the NEMS modeling framework incorporates an explicit representation of torchiere lighting electricity use, a detailed stock accounting does not exist, and therefore a cost/benefit or net present value calculation cannot be provided. For the torchiere standard proposed in S.1766, the electricity savings relative to the case with a 10 SEER baseline is provided through 2020, the last year of the NEMS projection period.

The results in Table 1 conclude that the standards analyzed here, and required in S.1766 (13 SEER) and proposed by DOE (12 SEER), provide energy and carbon savings over the forecast horizon. Due to the additional costs associated with the more stringent (13 SEER) air conditioner standard in S.1766, the net present value of costs and benefits for the 13 SEER standard yields a negative result, while the standard proposed by DOE (12 SEER) yields a positive net present value.

The sections below present quantitative analyses of the provisions outlined above in more detail and qualitative analyses of the provisions that cannot be captured in NEMS. The analysis of the air conditioning and heat pump standards focuses on the results in the residential sector, since relatively few residential-sized units are in use in the commercial sector, which is dominated by the use of large chillers and boilers.

Air Conditioning Efficiency Standards

S.1766 Sec. 927 - Energy Conservation Standards for Central Air Conditioners and Heat Pumps

Section 927 of S.1766 requires that the manufacture of all central air conditioners and heat pumps greater than 30,000 Btu of output meet the minimum efficiency standard of 13 SEER (seasonal energy efficiency ratio – Btu out/watt in) in cooling mode, and 7.7 HSPF (heating seasonal performance factor – Btu out/watt in) in heating mode. This standard represents the Final Rule issued by the DOE in the Federal Register on January 22, 2001, which the DOE subsequently proposed, in the Federal Register of July 25, 2001, to be replaced by a less strict standard (12 SEER).

H.R.4 Sec. 124 – Federal Central Air Conditioner and Heat Pump Efficiency

Section 124 of H.R.4 requires that Federal purchases of all central air conditioners and heat pumps less than 65,000 Btu of output meet the minimum efficiency of 12 SEER and 7.4 HSPF, if cost effective (defined by a 10 year pay-back period). These efficiency levels are the same as those announced by the Department of Energy as a manufacturing standard in the July 25, 2001 Federal Register, and included in the *AEO2002* Reference Case. As noted above, the proposed requirement in H.R.4 is a codification of Executive Order 13123, and represents a very small segment of the market for residential and commercial air conditioners and heat pumps. The NEMS modeling framework does not allow for a quantitative analysis of Federal purchases, however, the amount of energy savings that could be achieved through the implementation of Section 124 of H.R.4 is not expected to be significant due to the Executive Order already in place. For this analysis, however, the 12 SEER manufacturing standard proposed by DOE is compared with a 10 SEER standard for illustrative purposes.

Energy Implications of the12 SEER and 13 SEER Standards

In order to compare the different proposals for air conditioner and heat pump standards in S.1766 and the current DOE proposal, the *AEO2002* Reference Case was modified to reduce the 12 SEER standard in 2006 to the current standard of 10 SEER. This modification allows for a direct comparison of the two proposals. It should be noted, however, that the most recent update to the EIA technology forecast, completed in September 2001, was based on the assumption that the 12 SEER standard would become law. Although the 12 SEER standard was modified for this analysis, the impact of future technological progress of the more efficient air conditioners and heat pumps due to the implementation of the 12 SEER standard cannot be removed from the Reference Case, since the technological advances in 2010 and beyond are driven to some degree by the economies of scale experienced in prior years. To the extent that the market penetration of the most efficient units are driven by the implementation of the 12 SEER standard, this analysis may slightly underestimate the potential energy savings from both the 12 and 13 SEER standards. Since this issue is present in both the 12 and 13 SEER analyses, the relative effectiveness between the two standards should not be affected.

In the residential sector, the primary effect of both the 12 and 13 SEER standards is an increase in the stock efficiency of air conditioners and heat pumps over the projection period. As the capital stock turns over and new units are purchased, the average efficiency for heat pumps and air conditioners increases over time in all three cases (Table 2). As expected, however, the more strict the standard, the greater the increase in average stock efficiency over time. In the 13 SEER case, the stock efficiency of air conditioners increases to 13.3 SEER by 2020, a 22 percent increase over the stock efficiency projected for the 10 SEER case.

Table 2. Stock Efficiency of Residential Air Conditioners and Heat Pumps

		--2020 Under Various Standard Levels--		
	2000	**10 SEER**	**12 SEER**	**13 SEER**
Central Air Conditioners (SEER)	10.3	10.9	12.6	13.3
Heat Pump Cooling Mode (SEER)	10.5	11.1	12.9	13.5
Heat Pump Heating Mode (HSPF)	7.1	7.2	7.9	8.1

Source: National Energy Modeling System.

The secondary effect of the stricter standards, however, is to cause a shift away from heat pumps as a main heating source, relative to the 10 SEER case. As the price to purchase new heat pumps rises due to the standard, more homes choose to heat with competing technologies, which have no price increases associated with the implementation of the standard. The shift toward gas heating is most pronounced in the 13 SEER case (Table 3), as the cost of heat pumps in this case increases most. Although the shift is modest, the increase in the number of gas furnaces, relative to heat pumps, yields a 69 trillion Btu (1.1 percent) increase in natural gas consumption in 2020, relative to the 10 SEER case. Figure 1 shows the projected residential consumption of natural gas and electricity in 2020 due to the implementation of the different air conditioning and heat pump standards.

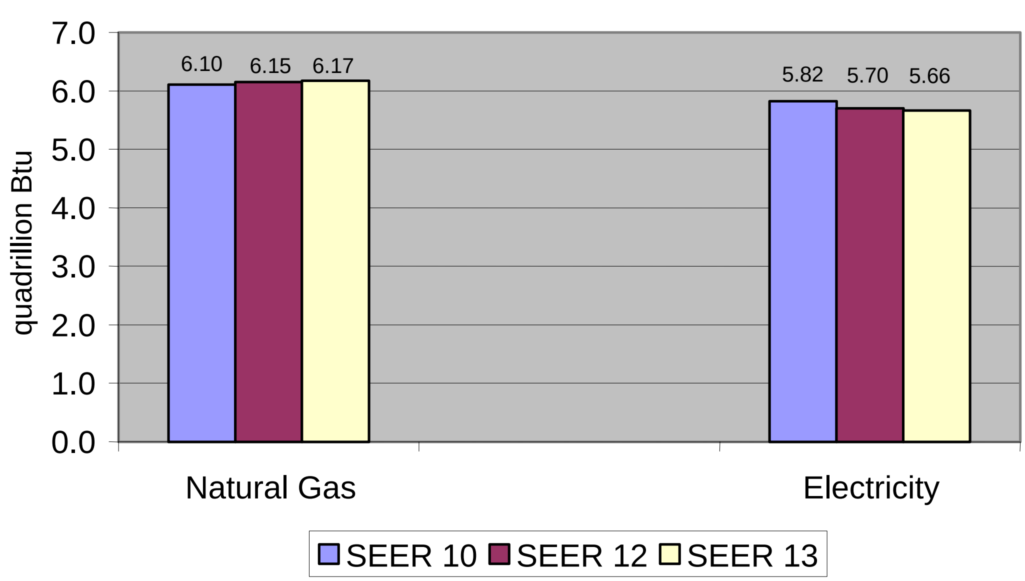
Table 3. Stock of Various Residential Heating and Cooling Technologies (millions)

		--2020 Under Various Standard Levels--		
	2000	**10 SEER**	**12 SEER**	**13 SEER**
Central Air Conditioners	42.1	59.5	60.3	60.8
Electric Air-Source Heat Pumps	10.2	15.7	14.8	14.4
Natural Gas Heating (all types)	55.8	71.2	71.9	72.2

Source: National Energy Modeling System.

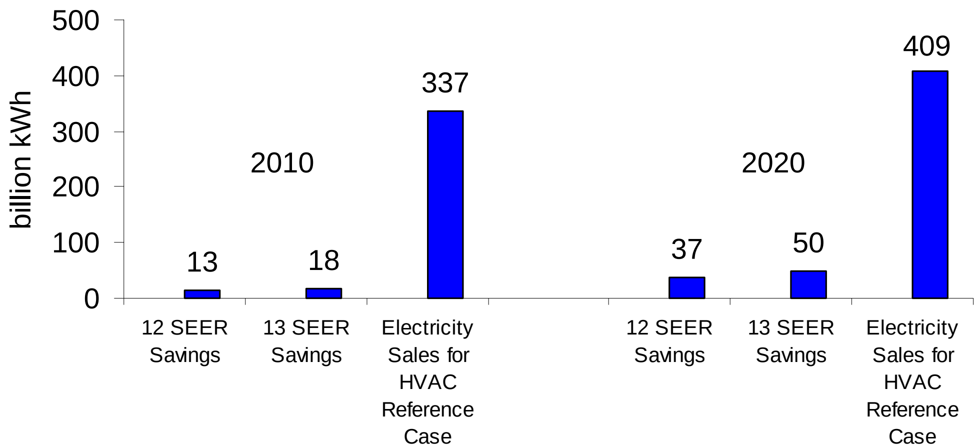
Figure 1 shows that the projected decrease in electricity consumption due to the implementation of the standards outweighs the projected increase in natural gas consumption, yielding a net energy savings. The projected electricity savings from the proposed air conditioner and heat pump standards in 2010 and 2020, relative to the baseline (SEER 10) projection of electricity consumed for heating and cooling in the residential sector, is shown in Figure 2. By 2020, it is projected that the 12 and 13 SEER standards could save 9 and 12 percent of the electricity required for heating and cooling, respectively, relative to the current 10 SEER standard. In terms of total residential electricity consumption, the savings from the standards in 2020 amounts to 2 and 3 percent for the 12 and 13 SEER standards, respectively.

Figure 1. Residential Sector Natural Gas and Electricity Consumption under Various Standards, 2020 (quadrillion Btu)



Source: National Energy Modeling System.

Figure 2. Baseline Electricity Sales for Heating and Cooling and Savings from Current DOE Proposal (SEER 12) and S.1766 (13 SEER), 2010 and 2020



Source: National Energy Modeling System.

Economic Implications of the 12 and 13 SEER Standards

Although the air conditioner and heat pump standards proposed in S.1766 and by DOE are projected to decrease energy use over the projection period, consumers will have to pay more in up-front costs for the more efficient technologies to achieve these savings. While consumers save money on their monthly electric bills over many years, they must also pay a higher retail cost for these savings. In order to compare the cost effectiveness of each standard, the costs and savings associated with the standard must be appropriately discounted over time, to account for the time value of money. Depending on the analysis, low and high discount rates are used to capture the cost-effectiveness of different investments. Low discount rates (3-4 percent) are generally used to capture a "societal" cost or benefit of a particular investment, while high rates (10-15 percent) are used to capture what a typical consumer might pay for purchases made on credit.

Given the controversy surrounding the value for the "appropriate" discount rate, a range of discount rates has been used to analyze the cost effectiveness, in terms of net present value, of both proposed standard levels. Since energy bill savings accrue over many years and the cost of the investment occurs in the first year, higher discount rates yield smaller net present values for both the 12 and 13 SEER standards. As shown in Table 4, the value assumed for the discount rate has a significant effect on the economic benefit of the standard. In this analysis, any discount rate higher than 11.7 percent will yield a negative net present value for both standards.

Table 4. Net Present Value of Costs and Benefits of 12 and 13 SEER Air Conditioner and Heat Pump Standards under Various Discount Rates (billion $2001)

	SEER 12	S.1766 SEER 13
0 Percent Discount Rate	18.1	16.2
3 Percent Discount Rate	8.2	5.2
7 Percent Discount Rate	2.4	-0.6
10 Percent Discount Rate	0.6	-2.2
15 Percent Discount Rate	-0.7	-2.8

Source: National Energy Modeling System.

Net Present Value Methodology

For this analysis, costs and savings are computed based on the number of units purchased through 2020, and the energy bill savings from these purchases, through the end of their useful life (in this case, 2036). In each year of the forecast, new air conditioners are purchased for both newly constructed homes and for replacement of retired units, through 2020. When a stricter standard is enforced, the installed cost for these units increases, while the annual operating cost decreases, all else equal. Energy bill savings per year is the difference in the amount of energy consumed per year in the case without the standard, less the amount of energy consumed per year in the case with the standard, multiplied by the applicable *AEO 2002* Reference Case energy price (Table 5). Likewise, the annual cost of the standard is the incremental amount of money needed to purchase the more efficient unit. To calculate the net present value of the standard, the total annual cost, less the total annual savings, is discounted back to 2002. It should be noted that the costs and benefits presented here capture only the direct (i.e., increased cost of the unit and decreased energy bill from using the unit) implications from regulating the new standard on the residential sector. Other societal benefits, such as fewer power plant emissions and less strain on the electricity grid, are not considered in the net present value calculation.

Table 5. Residential Sector Electricity Prices used to Calculate Net Present Value of Standards (cents/kWh)

	2006	2008	2010	2012	2014	2016	2018	2020
Electricity Price ($2001)	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.9

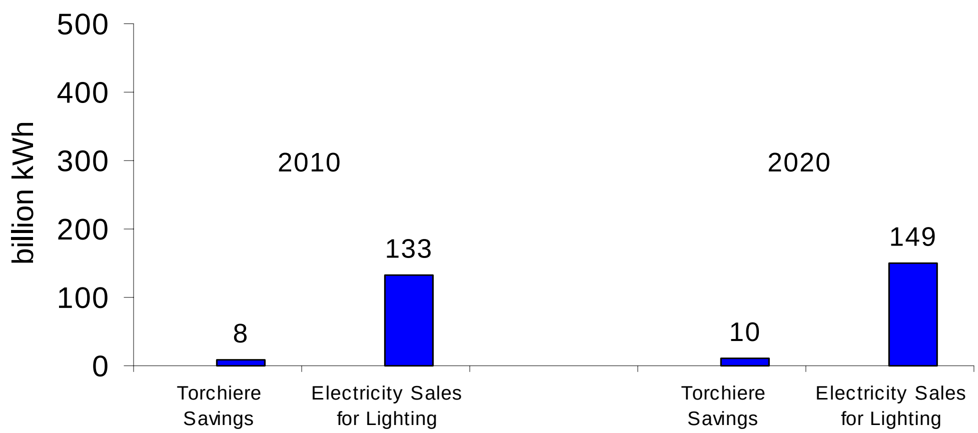
Source: Energy Information Administration, *Annual Energy Outlook 2002*, Washington, DC, December 2001.

Torchiere Standards

In addition to the air conditioner and heat pump standards described above, S.1766 includes standards for torchiere lamps. Torchiere lamps are widely used in the residential sector as an inexpensive source for high-wattage lighting applications. In the past, bulbs as high as 500 watts were sold, but fire safety concerns have caused manufacturers to reduce the maximum wattage to the point where 300 watts per bulb are now commonplace. The standard included in S.1766 requires torchiere lamps to reduce the maximum wattage to 190 watts per bulb by 2005. Because the NEMS modeling framework does not explicitly account for the stock of torchiere light bulbs, the analysis of this standard focuses on the impact on electricity sales to the residential sector. For torchiere lighting, the NEMS model assigns a portion of lighting use to torchiere lamps and applies growth rates and efficiency levels based on historical rates to project future electricity requirements. To the extent that the historical rate of growth does not accurately reflect the current and future rate of growth for torchiere lamps, this estimate may be subject to higher levels of uncertainty.

The impact on residential electricity sales due to the torchiere lamp standard in S.1766 is shown in Figure 3. The requirement to reduce the wattage of the bulbs in torchiere fixtures by 2005 reduces the amount of electricity needed to power these fixtures. Since sales of torchiere lamps are forecast to grow more rapidly in the early part of the projection period, relative to the latter part of the projection period, electricity savings accrue relatively quickly, especially when compared with appliances with much slower turnover rates. Figure 3 shows that baseline lighting electricity use can be reduced by 7 percent by 2020 if the torchiere standard specified in S.1766 is promulgated in 2005. This savings represents 0.6 percent of total residential electricity sales in 2020.

Figure 3. Baseline Residential Electricity Sales for Lighting and Savings from Torchiere Standards in S.1766, 2010 and 2020

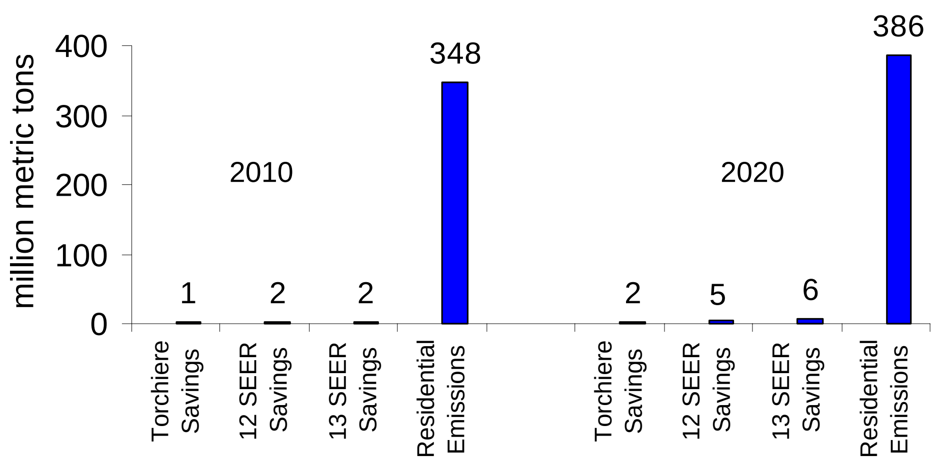


Source: National Energy Modeling System.

Environmental Benefits from Torchiere and Air Conditioner and Heat Pump Standards

The standards for both torchiere lamps in S.1766 and air conditioners and heat pumps in S.1766 provide carbon emission savings, relative to the baseline level of carbon emissions attributable to energy use in the residential sector. Given that the energy savings from the various standards result in electricity savings from 1 to 3 percent of total residential sales in 2020, carbon emission savings from these standards are projected to range from 0.4 percent for the torchiere standard to nearly 2 percent for the 13 SEER air conditioner and heat pump standard. Figure 4 details total residential carbon emissions and carbon emission savings from the three standards analyzed in this section.

Figure 4. Baseline Residential Sector Carbon Emissions and Savings from Standards in S.1766 and DOE 12 SEER Proposal, 2010 and 2020



Source: National Energy Modeling System.

Illuminated Exit Signs

Section 928(w) of S.1766 requires energy conservation standards for illuminated exit signs in accordance with the current Energy Star Program requirements for exit signs prescribed by the Environmental Protection Agency. Current Energy Star requirements specify exit signs that operate on five watts or less per face, while meeting specific visibility and reliability characteristics.

Five different light source technologies are commonly used to illuminate exit signs. Power demands range from under 1 watt for a few Light-emitting Diode (LED) technologies to about 40 watts for some incandescent or fluorescent light sources. Many existing exit signs that use incandescent lamps have a power demand ranging from 24 to 40 watts.[3] Exit signs typically operate 24 hours a day, 365 days a year, leading to annual energy savings of 160 to 300 kilowatthours of electricity if one incandescent exit sign that uses 24 to 40 watts is replaced by a sign meeting the 5-watt S.1766 conservation

[3]National Lighting Product Information Program, *Specifier Report: Exit Signs* (Troy, NY, January 1994, revised November 1994) and Supplements (March 1995 and March 1998).

standard.[4] Replacing 50 incandescent exit signs with signs that meet the S.1766 conservation standard would reduce the average annual electricity demand of a 100,000 square foot office building 0.4 to 0.8 percent.[5]

Exit signs are not explicitly represented in NEMS, precluding quantitative analysis of Section 928(w) of S.1766. The impact of this provision depends on the mix of light source technologies used in existing exit signs, the rate of sign replacement, and the rate of construction for new non-residential buildings. Exit signs can last upwards of 25 years, slowing the rate of replacement and limiting the near-term effects of the proposed standard on energy consumption in existing buildings.

Low Voltage Dry-type Transformers

Section 928(y) of S.1766 requires all low voltage dry-type transformers manufactured on or after January 1, 2005 to meet the Class I Efficiency Levels for low voltage dry-type transformers specified by the National Electrical Manufacturers Association (NEMA) in its *Guide for Determining Energy Efficiency for Distribution Transformers* (NEMA TP-1-1996). The proposed efficiency levels vary by transformer size and power specification and are presented in Table 6. The Energy Policy Act of 1992 directed the Department of Energy (DOE) to consider minimum efficiency standards for distribution transformers. In 1997, the DOE found that transformer standards appeared to be technically feasible and economically justified and initiated the process that could lead to minimum standards. The DOE is presently conducting the analysis necessary to support the formal standards rulemaking process. The NEMA efficiency levels specified in Section 928(y) of S.1766 comprise a voluntary standard published by manufacturers to move the market toward higher efficiencies in anticipation of potential mandated standards.

Commercial and industrial consumers use low voltage dry-type transformers to decrease the voltage of electricity received from the utility to the levels used to power lights, computers, and other electric-operated equipment. Although distribution transformers are already quite efficient - estimates of average stock efficiency for low voltage transformers range from just over 95 percent to over 97 percent - most transformers are in constant use, providing the potential for measurable savings from incremental efficiency improvements.

Distribution transformers are not explicitly represented in NEMS, precluding quantitative analysis of Section 928(y) of S.1766. The effects of minimum efficiency standards for low voltage dry-type transformers would be expected to accumulate gradually due to the slow rate of turnover in the stock of equipment in use. Distribution transformers have an

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[4] Ibid.

[5] Electricity consumption in office buildings averaged 18.9 kilowatthours per square foot in 1995 according to EIA's 1995 Commercial Buildings Energy Consumption Survey, Energy Information Administration, *A Look at Commercial Buildings in 1995: Characteristics, Energy Consumption, and Energy Expenditures*, DOE/EIA-0625(95) (Washington, DC, October 1998), web site www.eia.doe.gov/emeu/cbecs/contents.html.

estimated average useful life of 30 years; thus, new construction, expansions, and major renovations are the primary reasons for transformer purchases. In addition, a significant market exists for used equipment, further delaying the introduction of new transformers into the equipment stock. In the absence of a DOE standard, the NEMA standard has been adopted in Massachusetts and Minnesota as the minimum efficiency guideline for the installation of new equipment. Wisconsin requires distribution transformers installed for all new State facility construction and remodeling projects to meet the NEMA standard as well. These State initiatives reduce the potential energy savings that could be credited to S.1766.

Table 6. S.1766 Proposed Efficiency Levels for Low Voltage Dry-type Transformers

Single-phase		Three-phase	
Size (kVA)[a]	Efficiency (%)[b]	Size (kVA)[a]	Efficiency (%)[b]
15	97.7	15	97.0
25	98.0	30	97.5
37.5	98.2	45	97.7
50	98.3	75	98.0
75	98.5	112.5	98.2
100	98.6	150	98.3
167	98.7	225	98.5
250	98.8	300	98.6
333	98.9	500	98.7
		750	98.8
		1000	98.9

[a] Nameplate capacity of the transformer in kilovolt-amperes
[b] Transformer efficiency is the amount of usable electricity obtained as a percent of the electricity that enters the transformer.
Source: Oak Ridge National Laboratory, *Supplement to the "Determination Analysis" (ORNL-6847) and Analysis of the NEMA Efficiency Standard for Distribution Transformers*, ORNL-6925 (Oak Ridge, TN, September 1997).

Voluntary Agreements in the Industrial Sector

Section 921 of S.1766 requires the Department of Energy to enter into voluntary agreements with industrial sector entities that consume significant amounts of energy to reduce their energy intensity.[6] For these entities, the goal is to reduce primary energy intensity at an average rate of 2.5 percent per year over the period 2002-2012. Entities participating in the program "shall be eligible to receive ... a grant or technical assistance as appropriate to assist in the achievement of those goals." Energy intensity is defined as "primary energy consumed per unit of physical output in an industrial process."

[6]There are no industrial provisions in the sections of H.R.4 specified in the Committee's Letter of Request.

The proposed legislation does not specify the size of the potential grant or the nature of the technical assistance. However, there do exist Department of Energy Programs in the Office of Industrial Technologies that seem to have similar functions. Financial assistance is available in the Inventions and Innovations program and in the National Industrial Competitiveness through Energy, Environment, and Economics program. Technical assistance is available through the Industrial Assessment Centers program. It is not clear whether the proposed legislation is intended to change the participation requirements for these programs (e.g., pledge to reduce energy intensity by the specified amount or change the firm size allowed to participate).

As written, the proposed legislation seems to specify that the primary energy intensity reduction must be measured for a process. However, process is not defined, nor is primary energy. Generally, primary energy is defined to include the losses incurred in generating electricity. Primary energy intensity can decline due to improvements in electricity generating efficiency irrespective of changes at the plant or process. Presumably, the intent of the proposed legislation is to exclude efficiency improvements by electricity suppliers when calculating intensity improvements by industrial sector entities.

It is extremely difficult to quantify the impacts of voluntary programs. For the NEMS industrial model, we have assumed that these impacts are captured in our baseline assumptions regarding energy intensity improvements. As a practical matter, it is highly improbable that the industrial sector in aggregate could reduce energy intensity by 2.5 percent annually during 2002-2012, although some plants or industrial sub-sectors may be able to achieve that goal. In the *AEO2002* Reference Case projection, industrial primary energy intensity falls by 1.6 percent annually over this time period. Industrial primary energy intensity fell by 1.6 percent annually over the 1978-2000 period. Thus, the 2.5 percent goal is almost 60 percent higher than the intensity decline rate in the Reference Case and in recent history. If the 2.5 percent goal were met for the industrial sector, primary energy consumption in 2012 would be 9 percent or 3.6 quadrillion Btu lower than in the *AEO2002* Reference Case (Table 7). The *AEO 2002* also presents a High Technology Case, which assumes earlier availability, lower costs, and higher efficiency for more advanced equipment. In the High Technology Case, industrial primary energy intensity is projected to fall 1.8 percent per year. If the 2.5 percent goal were achieved for the industrial sector, primary energy consumption in 2012 would be 7 percent or 2.7 quadrillion Btu lower than projected in the *AEO2002* High Technology Case.

Table 7. Summary of Industrial Sector Energy Indicators in Various Efficiency Cases

	2002	2012		
Indicator	Reference	Reference	High Technology	2.5 Percent Goal
Primary Energy (quadrillion Btu)	35.0	40.8	39.9	37.2
Intensity (thousand Btu per dollar of Output)	6.86	5.85	5.72	5.33
Percent Change from Reference Case	N/A	N/A	6.9	8.9

Source: National Energy Modeling System.

Summary of the Impact of Industrial Sector Voluntary Agreements

The 2.5 percent goal is quite ambitious and not likely to be achieved for the industrial sector overall. Some individual plants or industrial sub-sectors may be able to meet that goal. The proposed legislation does not clarify the relationship(s) between Section 921 and existing Department of Energy programs, such as the Inventions and Innovations program, the National Industrial Competitiveness through Energy, Environment, and Economics program, and the Industrial Assessment Centers program. The proposed legislation requires an intensity indicator that would include efficiency gains by electricity suppliers, which does not seem reasonable for all industrial sub-sectors. Further, the indicator must be measured at the process level in physical terms. While "process" is undefined, this requirement seems to be unduly restrictive because energy intensity for the total plant has a larger impact on energy consumption. An alternative would be to measure intensity at the plant level and allow the indicator to be in dollar terms in appropriate cases, such as when a plant produces products that differ significantly from one production line to another. Overall, the proposed legislation is unlikely to have a measurable impact on overall industrial energy intensity.

Comparison of this Analysis to DOE's Standards Analysis

In January and July of 2001, DOE issued rules regarding appliance efficiency standards for air conditioners and heat pumps. In January, DOE published a Final Rule mandating a new standard of 13 SEER for air conditioners and heat pumps, effective in 2006. In July, DOE withdrew the January Final Rule and proposed a 12 SEER standard for air conditioners and heat pumps, also effective in 2006. A comparison of the summary of quantitative results from the DOE analysis and the analysis presented here is detailed in Table 8. While the level of savings resulting from the standards differs in the two analyses, the conclusion is the same: The 12 SEER standard yields a greater net present value than the 13 SEER standard when comparing residential consumers' costs and energy bill savings. When interpreting the results in Table 8, it is important to keep in mind the many input assumptions, such as the number of air conditioners purchased, the cost of air conditioners, the amount of electricity an air conditioner uses, and future electricity prices, differ in the two analyses, leading to different quantitative results.

Several important differences in the two analyses account for the differences found in Table 8. Since the EIA analysis assumes a shorter life expectancy for heat pumps and air conditioners, relative to the DOE analysis, more units are purchased through 2020 in the EIA analysis, creating a larger opportunity for energy savings. In addition, EIA assumes that the increase in the size of new construction that has occurred historically will continue through the end of the forecast horizon, requiring more electricity for space heating and cooling. In the DOE standards analysis, the space cooling intensity is not adjusted for this effect.

In computing the net present value of the standards, the unit costs for air conditioners assumed in each of the analyses explain the differences in the estimates. In the 13 SEER case, for example, the incremental cost of an air conditioner meeting the new standard is projected to be 18 percent higher in the EIA analysis, when compared to the DOE analysis. The higher cost of the standard in the EIA analysis results in a negative net present value, shown in Table 8.

Table 8. Quantitative Results from EIA and DOE Standards Analyses

	EIA 12 SEER Standard	**DOE 12 SEER Standard**	**EIA 13 SEER Standard**	**DOE 13 SEER Standard**
Primary Energy Savings (trillion Btu) [1,2]	4801	3000	6419	4200
Carbon Savings[3] (million metric tons)	43	24	56	33
Net Present Value in 1998 (billion $1998) [1,4]	2	2	-0.4	1

[1]Savings are cumulative through 2030, as specified by DOE in the Federal Register.
[2] Primary energy savings includes the direct use of all energy sources (measured at the point of use) plus the losses associated with generating and delivering electricity.
[3] Savings are cumulative through 2020, as specified by DOE in the Federal Register.
[4] Discounts future expenditures and savings at a 7 percent real discount rate.
Source: National Energy Modeling System, Federal Register, Part III, July 25, 2001, Supplementary Information Section IV.B.3., and Federal Register, Part XII, January 22, 2001, Section I.A.4.

Uncertainties in Estimating Program Effectiveness

In evaluating the effectiveness of any energy policy on future energy market trends, there exist uncertainties that can greatly impact the conclusions derived from the analysis. Future macroeconomic growth, energy crises, and rate of technological advances can significantly alter the conclusions of any analysis of energy policy. Other energy policies can also have a big impact on the results presented from this analysis. If, for example, a policy aimed at incorporating the social costs of energy and the impacts on the environment were introduced simultaneously to those presented here, the results could change dramatically. When comparing the analyses provided in this report with other analyses performed on the same subject matter, it is important to keep in mind that different input assumptions and future growth patterns can significantly affect the projected results of the policy in question.

In evaluating the air conditioner and heat pump standards, for example, input assumptions, economic growth forecasts, and modeling techniques all contribute to the variability in estimates of policy effectiveness across different analyses. In the NEMS residential energy demand module, factors such as increasing square footage in new construction and increasing saturation of central air conditioning over the forecast horizon both contribute to increasing demand for electricity for space heating and cooling. Variations in these factors, as well as changes in energy prices, can have a significant impact on the amount of energy demanded in the future.

The NEMS residential module also captures the concept known as the rebound, or take back effect. This concept theorizes that as consumers adopt a more efficient technology, they use it more intensively. In the case of air conditioners, a consumer may set the thermostat a few degrees cooler knowing that the increase in efficiency will offset the additional cooling requirement. The NEMS residential model assumes that 15 percent of the increase in efficiency is "taken back" by the consumer in the form of increased intensity. A recent literature review on the rebound effect in Energy Policy[7] reported that the rebound effect for space cooling is estimated at anywhere from 0 to 50 percent, depending on the study. The choice of 15 percent reflects the belief that most consumers will not opt to recapture all of the savings associated with increased efficiency.

[7] Greening, L.A., et. al., *Energy efficiency and consumption – the rebound effect – a survey*, Energy Policy 28, Elsevier Science Ltd., 2000.

Appendix A. Letter from Senator Frank Murkowski

United States Senate

COMMITTEE ON
ENERGY AND NATURAL RESOURCES

WASHINGTON, DC 20510-6150

ENERGY.SENATE.GOV

December 20, 2001

Dr. Mary Hutzler
Acting Administrator
Energy Information Administration
1000 Independence Avenue, SW
Washington, DC, 20585

Dear Acting Administrator Hutzler:

The Senate is considering comprehensive legislation to update U.S. national energy strategy in light of the volatility of energy markets in calendar year 2000 and the growing energy security concerns in light of recent events that highlight our dependence on foreign imported oil. To this end, there have been several legislative proposals introduced in the 107th Congress on the subject of national energy policy, and the Majority Leader has indicated that the Senate will debate energy policy early in the next session of Congress. Our decisions will benefit from an analysis of the strengths and weaknesses of the various energy policy proposals that have been introduced to date.

With that in mind, I request that the Energy Information Administration (EIA) analyze the potential costs and benefits of proposed legislation to update and revise our national energy strategy, namely, H.R. 4 as passed by the House of Representatives in August 2001, and S. 1766 as proposed by Senators Daschle and Bingaman earlier this month. I understand that EIA has the ability to conduct such analysis, including the use of both sectoral and economy-wide energy models. Using the most recent *Annual Energy Outlook 2002* as a reference case, I ask that EIA assess the impacts of these energy policy proposals on, at minimum:

- macroeconomic indicators (jobs, Gross Domestic Product, trade balance, etc.);
- energy supply and demand by fuel and process;
- energy prices to consumers (residential, industrial, and commercial) by fuel;
- dependence on foreign oil imports and impacts on energy security;
- impacts on energy infrastructure (transmission, pipelines, refineries, etc.); and
- emissions of greenhouse gases and air pollutants.

As the Daschle/Bingaman bill (S. 1766) contains several "placeholders" reserved for future legislative proposals, I ask that for the purposes of your analysis, you include for Section 801 of S. 1766, S. 804, introduced by Senators Feinstein, Snowe and Reed making changes to the Corporate Average Fuel Economy (CAFE) program. For Section 1821 of S. 1766, use the provisions contained in S. 1746, introduced by Senator Reid on nuclear facility security. Also, to ensure a consistent comparison, please exclude from your analysis of H.R. 4 the amendments to the tax code contained in Division C of that bill. I expect to request from EIA a follow-up analysis of the tax-related proposals contained in H.R. 4 and an expected Senate Finance Committee mark at a subsequent date.

When assessing the costs and benefits of these legislative proposals, please be sure to point out which specific policy actions have the most significant positive or negative impacts on the factors outlined above. In order to inform our deliberations on national energy policy which are due to begin in the next several weeks, I ask that the requested information be made available by January 23, 2002. In addition, I request that a briefing of your results prior to release of any written report.

If you have any questions regarding this request, or desire further clarification with respect to translating legislative proposals into assumptions you will use in your analysis, please contact Bryan Hannegan with my Senate Energy and Natural Resources Committee staff at 224-7932. Thank you for your timely attention to this request, and for your efforts to ensure that our Nation's energy policy decisions are informed with the best available analysis.

Sincerely,

Frank H. Murkowski

Frank H. Murkowski
Ranking Member