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CAP AND TRADE IS NOT ENOUGH

SUMMARY: A market-based mechanism (e.g. cap and trade or a carbon tax) is likely to be a key part of America's strategy to reduce carbon dioxide (CO_2) emissions. We need to do this soon so that a framework for emissions reductions is established. However, for at least the next decade, a market-based approach alone will not induce the investments in long-lived technology needed to put the nation on a track to achieve a 50 to 80% reduction in emissions of carbon dioxide by mid-century. The range of prices for CO_2 being discussed will be too low to make this happen.

In *addition* to instituting a cap and trade regime, Congress should simultaneously design, integrate and implement these targeted strategies:

1. For **electric power**:
   - A tradable carbon emission portfolio standard (CPS) that gradually reduces the average amount of CO_2 emitted per kW-hour for the electricity that companies sell to end users;
   - Promotion of strategies that separate utility profit from the amount of electricity it sells so that utilities can earn profit from increasing energy efficiency;
2. For **buildings and appliances**
   - Higher and more inclusive efficiency standards for building design and construction, appliances, equipment, and lighting;
   - Federal incentives to induce localities to adopt building codes that lower the annual energy use in new buildings by at least 50% compared to conventional buildings;
3. For **automobiles**
   - Efficiency standards that at least double miles per gallon of automobiles and light trucks over current vehicles (CAFE);
   - Reduce the number of miles driven with road pricing, pay-as-you-drive insurance, and by encouraging transportation alternatives.

On the pages that follow we explain why we recommend each of these targeted strategies, and suggest how they might be implemented.

In the rush to reduce CO_2 emissions, and improve energy efficiency, there is a risk that inefficient, but well-intentioned policies may mandate technologies that cost dramatically more than more efficient routes to the same goals. Both Congress and the Executive Branch need to support careful, but rapid, engineering-economic analysis that can be performed in 90 days before undertaking any specific mandates. Such analysis can be performed more rapidly than most legislative and executive processes, and should not be an excuse for delaying action.

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The Department of Engineering and Public Policy (www.epp.cmu.edu) is a department in the Engineering College at Carnegie Mellon University. The views expressed in this policy brief are those of the authors and do not necessarily reflect those of the University, or any of the organizations that have supported the research on which these policy prescriptions have been based.

1 Why Cap and Trade Alone is Not Enough

Climate policy in the U.S. is beginning to gain momentum. Congress is debating a framework for greenhouse gas emissions trading in the near future. The most likely policy mechanism is a cap-and-trade program for greenhouse gases.

Fossil fuels burned for transportation, electricity production, and heat for homes, businesses and industries are the primary contributors to U.S. greenhouse gases. Any effective climate policy will need to achieve large reductions in both the amount of energy used and the carbon intensity of energy[1] in each of these sectors. CO_2 emissions from energy use are given by:

CO2 Emissions = (The energy we use) X (The carbon intensity of that energy)

The cap and trade system is meant to perform two functions: 1) induce future investment decisions to reduce CO_2 emissions efficiently (e.g. build low-carbon power plants, buy fuel-efficient vehicles), and 2) influence current behavior (e.g. turn the thermostat up in the summer and down in the winter).

However, the effective CO_2 price under the various cap-and-trade bills that have been introduced or are being discussed is likely to be so low initially, and to rise so slowly over time, that it will not induce the types of investment that will be needed to achieve a 50-80% reduction in CO_2 emissions by mid-century.

Low carbon prices under cap-and-trade bills will not induce the needed 50 to 80% reduction in CO_2 emissions by mid-century.

Indeed, most U.S. cap and trade proposals[2] provide a price ceiling or other measures to prevent allowance prices from rising quickly above a few tens of dollars per ton of CO_2. Analysis of the Lieberman-Warner and Bingaman-Specter climate bills in the last Congress by the Energy Information Administration (EIA) concludes that due to low allowance prices, fewer than 20% of their 2030 projected emissions reductions will come from sectors other than the electricity sector[3]. Even in the electricity sector, a firm making a decision today about a plant that is expected to operate for 40 years will calculate the net present value of the sum of all

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1 We refer to the carbon intensity of energy as the amount of CO_2 emissions from a unit of energy. Carbon intensity of energy from fuel is [the percent of carbon in the fuel combusted (g C/MJ)] * [fraction oxidized (usually >0.99)] * [conversion from C to CO_2 (44/12)], which yields a g CO_2/ MJ intensity. Since fossil fuel is used for electricity generation, we can express the carbon intensity of electricity as g CO_2/ kWh delivered, which would take into account the efficiency of the power plant and the transmission and distribution losses.

2 For example: The Boxer-Lieberman-Warner climate bill (S.3036) had a cost containment measure that is triggered between $22-$30/ton, effectively reducing the price of allowances. The Bingaman-Specter climate bill (S.1766) had an allowance price cap of $12/ton that would rise to a ceiling of about $30/ton by 2030.

3 EIA (2008). Energy Market and Economic Impacts of S. 2191, the Lieberman-Warner Climate Security Act of 2007. SR/OIAF/2008-01.

expected future allowance prices in order to decide whether to invest in low-carbon technologies, or whether to simply purchase allowances. If the firm uses a discount rate of 10%, even for the upper curve in Figure 1.1, the average net present value is only $9/ton of CO_2, far too low to stimulate investment.

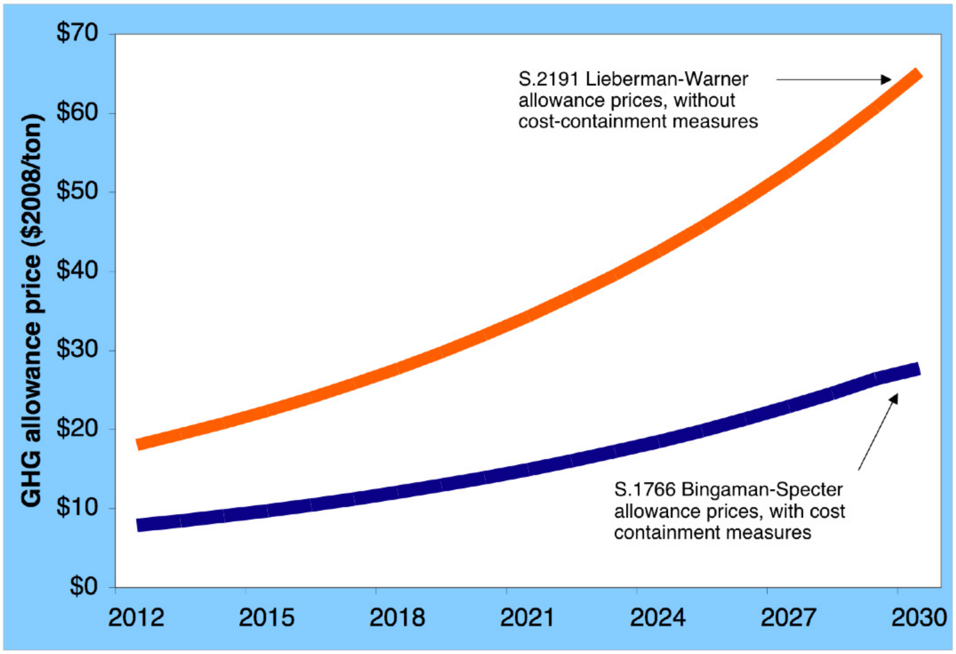

Figure 1.1: While new climate policy bills introduced will be different than S.2191 and S.1766, this plot illustrates the EIA[3] projected allowances prices (in $2008) with and without cost containment measures.

How Cap and Trade Works

Under a cap and trade proposal, the number of annual permits to emit carbon dioxide (carbon allowances) are limited or "capped". The allowances are allocated to people wanting to burn fossil fuels or otherwise release carbon to the atmosphere through grants or an auction.*

In theory, the number of allowances can be stringently capped (or an appropriate carbon tax could be enacted) so as to produce an allowance price that is high enough to achieve the necessary emissions reductions. The number of allowances can be reduced over time (carbon price increased) so as to yield higher emissions controls in the future. If this is done in a predictable way, it should help to induce appropriate capital investment in anticipation of higher future carbon prices.

* Generally, cap and trade systems require producers of petroleum and natural gas products and consumers of coal to purchase allowances, often after a transition period when they are granted allowances that recognize their investment in existing capital stock.

1.1 Low Allowance Prices: A Problem for Stimulating Reductions from Electric Power

The future price of CO_2 permits must rise to at least $50/ton before electric power generating companies will find it cost-effective to build coal-fired power plants that will capture and sequester the CO_2 they emit (CCS).[4] Similar or higher allowance prices are required for other types of low-carbon power plant investment.[5]

The price of CO_2 permits must reach at least $50/ton before power companies will build CCS plants.

The cap and trade proposals now being discussed will not yield prices that high for several decades. In the meantime, in the absence of any other regulatory constraints, new coal or gas-fired generation will be built without CO_2 emissions controls. Even with a CO_2 price as high as $40/ton, it is cheaper to build a pulverized coal facility and buy relatively inexpensive CO_2 emission permits. The same is true of natural gas-fired plants. Without subsidies or other mechanisms that achieve high effective CO_2 prices, other technologies such as wind, nuclear and solar will also not be cost-effective strategies for limiting emissions. With suitable CO_2 prices, utilities can weigh the cost of, for example, energy efficiency or coal with CCS against the cost of other low-carbon technologies.

In Part 2 of this briefing note, we discuss some simple steps that can be taken to make sure that low-carbon power plants get built much sooner than they will under just a simple cap and trade policy.

A modest price for allowances will encourage some demand reduction and energy efficiency investments. Efficiency is traditionally the cheapest source of CO_2 reductions and should be aggressively pursued. Finding ways to align the incentives for a utility to help customers save energy and/or using public benefit funds through a third party to promote energy efficiency programs is critical to improving efficiency. Reducing electricity use at existing power plants also should be pursued, although major improvements may be inhibited by current laws for air pollution control that impose new source performance standards if an existing plant is

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4 The prices of steel, concrete and engineering services have been changing rapidly. Thus, price estimates keep changing. While $50/ton is a reasonable minimum, the cost for CCS could be significantly higher. Higher electricity prices will induce some small changes in consumption, but will not move the U.S. very far toward the objective of dramatically reducing CO2 emissions. See for example: [1] Patiño-Echeverri, D.; Morel, B.; Apt, J.; Chen, C., Should a Coal-Fired Power Plant be Replaced or Retrofitted? *Environ. Sci. Technol.* 2007, 41 (23), 7980. [2] Bergerson, J. A.; Lave, L. B., Baseload Coal Investment Decisions under Uncertain Carbon Legislation. *Environ. Sci. Technol.* 2007, 41 (10), 3431. [3] Reinelt, P. S.; Keith, D. W., Carbon Capture Retrofits and the Cost of Regulatory Uncertainty. *Energy Journal* 2007, 28 (4), 101.

5 For example, the present 2.1 cents per kilowatt-hour (kWh) production tax credit for renewables is the equivalent of about $30/ton of avoided CO2. This subsidy would likely be ineffective in stimulating new renewables without another mechanism such as a renewables portfolio standard.

retrofitted.[6] As the low-cost consumer and producer efficiency opportunities are exhausted, the price of achieving CO_2 reductions with efficiency begins to climb.[7] To achieve a 50-80% reduction in CO_2 emissions, we will need both significant increases in energy efficiency and low-carbon electricity supplies. In Part 2.2 and Part 3 of this briefing, we discuss strategies for increasing power plant and consumer efficiency.

1.2 Low Allowance Prices: An Even Bigger Problem for Stimulating Reductions from Transportation

While a price on CO_2 emission permits of $50/ton will likely lead to demand reduction[8] and new capital investment in the electricity sector, the effect of such a "carbon price" on the transportation sector will probably be much smaller.[9] For each increase of a dollar per metric ton of CO_2, the price of a gallon of gasoline can be expected to increase by only about one cent.[10] Thus, if an allowance price of $50 per ton of CO_2 were passed on to consumers at the pump, they would see an increase of about 50 cents per gallon.

Each increase by one dollar in the price of a CO_2 emission permit will add only about one cent to the price of a gallon of gasoline.

Within six months of July 2008, gasoline prices fell from $4.50 to $1.70 per gallon. The high price appears to have led to a reduction in vehicle miles traveled and an emerging trend among consumers to purchase more efficient vehicles.[11] As the price fell, consumers again began to purchase less efficient vehicles and anecdotal and preliminary evidence suggests demand for gasoline has begun to rebound.[12,13] These data suggest that a $10-$30 CO_2 emission permit price (10 to 30 cents per gallon) will

6 Under the New Source Review (NSR) provisions of the Clean Air Act, any existing source that undergoes a "major modification" is required to meet the more stringent standards required for new power plants. Electric companies claim that this inhibits major investments in energy efficiency, although plants making improvements can avoid NSR by upgrading emissions control equipment and/or accepting new permit terms. Modest, low-cost electricity reduction investments (like more efficient motors to run process equipment) can be made without triggering NSR provisions and should be specifically identified and more widely implemented.

7 Azevedo, I.L., Energy Efficiency in the U.S. Residential Sector: An engineering and economic assessment of opportunities for large energy savings and greenhouse gas emissions reductions, Ph.D. Thesis, Carnegie Mellon University, 2009.

8 Newcomer, A.; Blumsack, S. A.; Apt, J.; Lave, L. B.; Morgan, M. G., Short Run Effects of a Price on Carbon Dioxide Emissions from U.S. Electric Generators. *Environ. Sci. Technol.* 2008, 42 (9), 3139-3144.

9 Davis, L.W.; Kilian, L, Estimating the Effect of a Gasoline Tax on Carbon Emissions. NBER Working Paper 14685, 2009.

10 One gallon of gasoline has 19.4 lbs CO2 from direct combustion (ignoring CO2 in extraction and refining). 19.4 pounds = 0.00879 tons, so 1 gallon of gas has about 0.009 embodied tons of CO2. So a $1 CO2 price per ton results in a $0.009 (or 0.9 cents) increase in gasoline prices, a $10 dollar price would be 9 cents, a $100 price per ton would add about 90 cents to a gallon of gas. If extraction and refining emissions allowance costs are added in, prices would increase approximately 10-25%, but overall prices would still not be large enough to induce widespread action.

11 Congressional Budget Office, Effects of Gasoline Prices on Travel Behavior and Vehicle Markets, 2008.

12 Puentes, P.; Tomer, A., The Road…Less Traveled: An Analysis of Vehicle Miles Traveled Trends in the U.S. The Brookings Institution, December 2008.

13 Krauss, C. "As Gas Prices Go Down, Driving Goes Up," New York Times, October 29, 2008. Also, in February 2009 Lundberg Survey reported part of the increase in gasoline prices was due to demand beginning to recover.

have at best a tiny effect on vehicle technology, consumer choices among vehicles, or miles driven, unless the underlying price of gasoline is already high. The mandated increase in CAFE to 35 miles per gallon, if it is attained, will further reduce the incentive to drive fewer miles by reducing the cost of travel. To achieve the large emissions reductions required to ensure that atmospheric concentrations of CO_2 do not reach levels considered by many scientists to be disastrous, additional measures beyond cap and trade will be necessary. In Part 4 of this briefing note, we discuss some simple steps that could be taken to make sure that low emission automobiles become common much sooner than they would under just a traditional cap and trade policy.

2 Electric Power

2.1 A Carbon Emission Portfolio Standard

A number of state legislatures have begun to adopt "renewable portfolio standards" (RPSs) and there is now proposed legislation for a national renewable portfolio standard.

Renewable energy, especially wind, holds great promise, but if renewables are to generate more than a modest fraction of our electric needs, formidable problems must be solved. Careful analysis is important before setting targets. New Jersey and Pennsylvania offer sobering lessons:

- Without considering other environmental impacts, New Jersey has mandated 22.5% renewable generation by 2021. Wind will be the most cost-effective way to meet that goal. But, wind turbines generate only a third of their rated capacity averaged over a year. So New Jersey will probably fill in the gaps with natural gas turbines. But today's gas turbines emit considerable nitrogen oxides (NOx) when they are ramping up and down,[14] and New Jersey has a serious NOx air pollution problem.

- Without considering the cost implications, Pennsylvania has mandated 800 MW of solar photovoltaics (PV), despite the fact that cloud cover and latitude reduce the potential solar energy for the state. What the legislature did not know when they passed that mandate is that between now and 2020 meeting this requirement will cost Pennsylvania's ratepayers $1.8-billion more than the same amount of wind power (and $400-million per year thereafter).

Rather than telling power companies how to run their business by instructing them to buy specific generation technologies or setting the price of CO_2 permits at too low a level to induce them to invest now in new generation that does not emit CO_2, we suggest a more direct strategy.

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[14] Katzenstein, W., Apt, J., Air Emissions Due to Wind and Solar Power. *Environ. Sci. Technol.* 2009. 43 (2), pp 253–258.

A carbon emissions portfolio standard (CPS) can serve as a market signal and driver of innovation toward a low-carbon economy, regardless of the strength and timing of cap and trade legislation. A CPS should be applied to all distribution companies that sell electricity to end-users.[15] A CPS for power companies would be roughly like a Corporate Average Fuel Economy (CAFE) standard for automotive companies. Unlike the state standards in California and Washington, that limit individual new power plants to a fixed amount of 1,100 pounds per MWh (about 500 grams/kWh) of CO_2 emissions, a CPS should start out at a higher level and be applied to the average generation mix of *all* the plants that serve a distribution company.[16] Trading among companies would be allowed so that companies that have only coal plants could buy permits from companies whose power comes largely from hydroelectric, renewables, and nuclear plants. Perhaps most importantly, a CPS would give power companies a certain and long-term signal to invest in renewables, low-carbon generation, and efficiency improvements in existing fossil-fired power plants.

A carbon emission portfolio standard (CPS) should be applied to all electric power companies that sell electricity to end-users.

Special provisions might be added for states like Ohio or Pennsylvania whose high emissions result from reliance on coal for electricity generation. As was done for the sulfur-dioxide cap and trade program, the level of CO_2 emissions in a base period could be used to set the initial CPS. The CPS would then be ramped down over a period of time, with all utilities eventually converging to a uniform national level. Designing the detailed workings of such a program will require additional analysis, but could be accomplished quickly once the general policy framework was established. The average limit for the CPS should ramp down in a clearly specified way over time so that power companies can see the higher standards coming and plan accordingly. Figures 2.1 and 2.2 illustrate how this might work.

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15 Apt, J.; Keith, D. W.; Morgan, M. G., Promoting Low-Carbon Electricity Production. *Issues in Science and Technology* 2007, (Spring Issue).

16 California and Washington performance standards apply to baseload generators only. Oregon has performance standards of about 300 g/kWh for baseload natural gas plants and for peaking plants. Oregon is developing standards for baseload plants using other fuels. In a national CPS, existing plants that only operate for a small percentage (<10%) of the year or have minimal total GHGs per year, could potentially have different requirements or be exempt from a CPS.

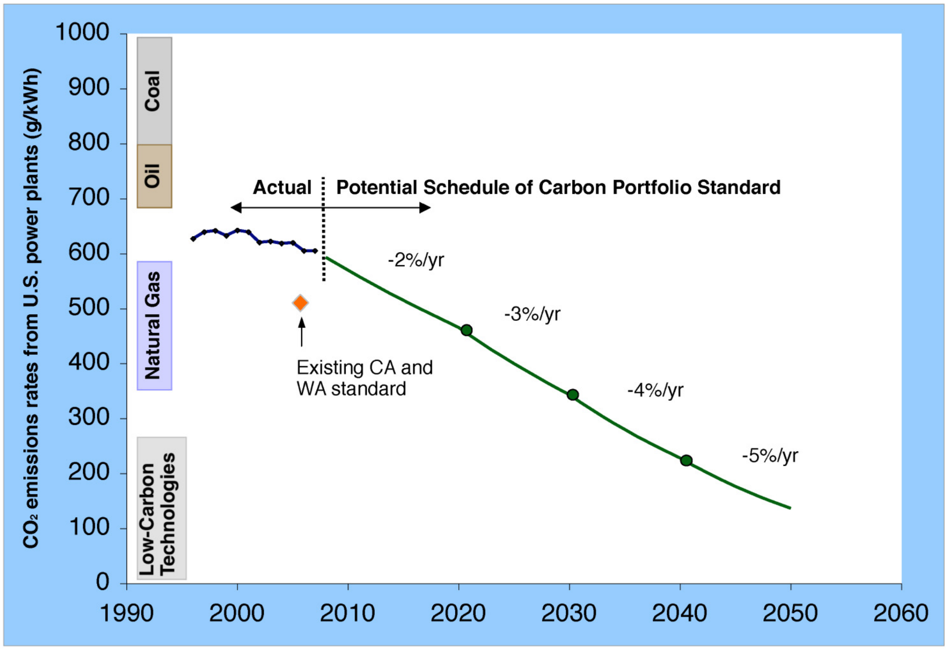

Figure 2.1: Actual U.S. power plant average CO_2 intensity (g CO_2/kWh) and potential carbon emissions portfolio standard declining schedule. Ranges of direct combustion CO_2/kWh for existing fossil technologies shown. Low-carbon technologies could include carbon capture and sequestration, demand reduction, hydropower, geothermal, nuclear, solar and wind.

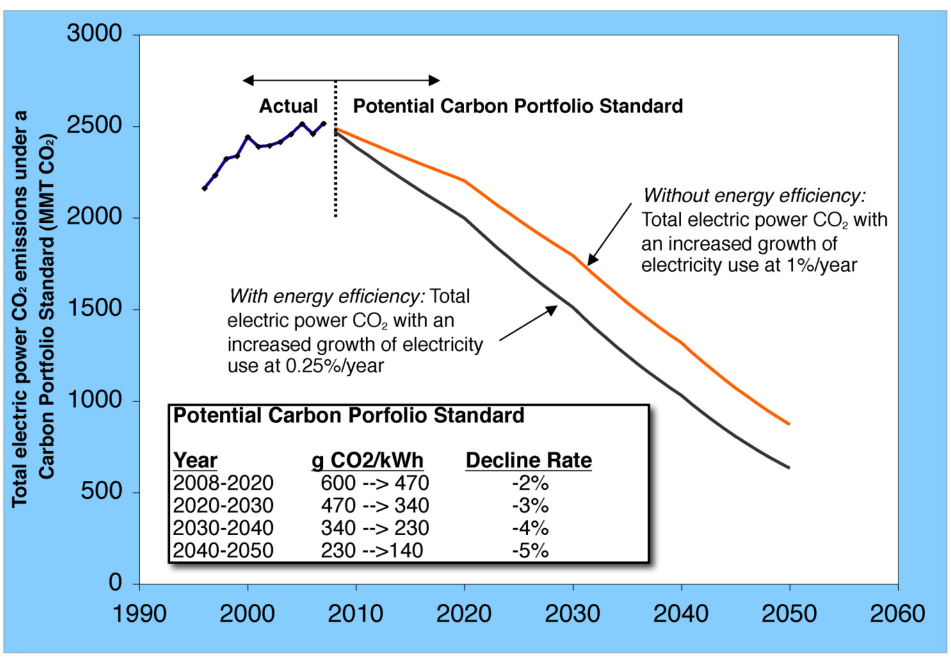

Figure 2.2 : Illustrative representation of total electric power CO_2 emissions under potential carbon emissions portfolio standards. When coupled with energy efficiency achievements, emissions reductions through carbon standards are enhanced.

To give utilities maximum flexibility to meet the CPS, a national cap and trade system could allow utilities with lower costs of meeting the standard to sell allowances to utilities that have higher costs of meeting the standard, as happened for the sulfur-dioxide cap and trade system. Indeed, two past cap and trade bills have also included scaled-down versions of a carbon portfolio standard.[17] Provisions might also be made for temporary relief when a utility can clearly demonstrate that it is making major investments in building low carbon generation technology.

2.2 Promoting Energy Efficiency Strategies in Utilities

A CPS can reduce the carbon intensity of electricity, but we also need to take advantage of the large opportunities in energy efficiency. The relationship between carbon dioxide emissions and electricity generation can be described by:

$$\text{CO}_2\text{ emission from the power sector} = \left(\text{Carbon in combusted fuel converted to CO}_2\right) \times \left(\text{Electricity generation efficiency}\right) \times \left(\text{Total electricity demand}\right)$$

This section highlights some market design and utility strategies for energy efficiency, while Section 3 of this document details technology standards for efficiency. **Additional measures to increase efficiency significantly and reduce emissions from the power sector include:**

- **Find ways for utilities to profit from helping customers save energy. This requires *decoupling* electricity sales from utility profits, and implementing a proper system of incentives for utilities and consumers to invest in energy efficiency and conservation measures in the residential, commercial and industrial sectors**

- **Find ways to encourage the reduction of electricity used at power plants (e.g. with more efficient blowers, pumps and lighting) that will not result in a New Source Review[18]**

- **Encourage investments in more efficient transmission and distribution infrastructure in order to reduce losses and congestion**

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[17] S.1227 (Kerry) included a provision requiring all new coal plants to emit about 125 g/kWh, effectively requiring carbon capture and sequestration (CCS). S.309 (Sanders-Boxer) phased in a low-carbon portfolio standard of about 115 g/kWh for generators using coal, petroleum coke, or lignite. This standard could be met by either using CCS or purchasing low-carbon electricity credits.

[18] Given the site-specific nature of New Source Review determinations, this analysis is intended only to serve as a guide to utilities, regulators and others.

2.2.1 Getting the incentives right for utilities to invest in efficiency

One market design strategy to promote energy efficiency in the power sector is to decouple a utility's energy sales from their profit, giving them an incentive to invest in efficiency rather than promote increased energy sales. This strategy has been particularly successful in California, where recent assessments of the energy efficiency programs indicate that utility-based energy efficiency programs saved about 20TWh in 2003 (a 7% reduction in total state electricity consumption), at a cost of about 1% of the electricity bill (see Figure 2.3).

Electricity decoupling with the right energy efficiency incentives provides flexibility for utilities to choose energy efficiency investments. While total electricity consumption in California still is increasing due to population growth, the state achieved stabilization in per capita electricity consumption. Structural and climate differences in California (e.g. fewer energy-intensive industries and lower heating loads) contributed to this stabilization, but policy actions had an important role in encouraging efficiency improvements.[19] New York State has also achieved zero growth in electricity sales per capita, with both states having per capita sales 40% below the national average.

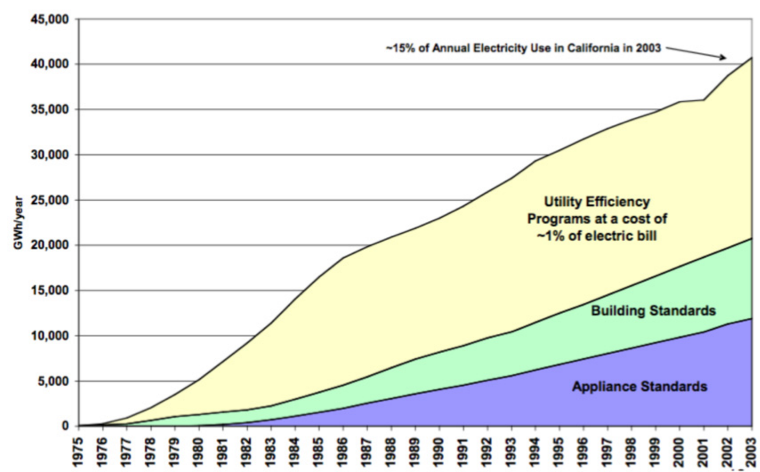

Figure 2.3 : Annual electricity savings from efficiency programs and standards in California. Source: California Energy Commission, presentation CEC-999-2008-032.

Electricity decoupling in California uses a shared net benefits incentive. Another strategy is to use a third party to implement energy efficiency measures. Ratepayers are charged a small "energy efficiency charge" in their monthly energy bills, and the third party uses that amount to implement energy efficiency measures. This has been the strategy in Vermont, where energy efficiency charges corresponding to 1.5% of the electricity bill were applied. Vermont used a non-profit statewide energy efficiency service company (Efficiency Vermont[20]) to administer the efficiency investments, and the state has achieved a modest decrease in per capita consumptions and managed to keep total electricity consumption roughly constant over

[19] Sudarshan, A.; Sweeney, J.L. Deconstructing the Rosenfeld Curve: Understanding California's Low Per Capita Electricity Consumption. USAEE/IAEE North American Conference. New Orleans, LA, December 3-5, 2008.

[20] For details see: www.efficiencyvermont.com.

the last few years. A number of states have shown that decoupling electricity sales from utility profits together with incentives to pursue efficiency can lower consumption significantly.

2.2.2 Waste less energy between power plants and customers

Often, the discussion of energy efficiency is limited solely to the end users. However, policy can also play a role in increasing efficiency in the utilities, or "before the meter". Through the process of electricity generation, transmission and delivery to a home electrical outlet, more than 68% of the energy is lost, mostly in thermal losses at the generator.[21] A CPS would encourage efficiency investments at the power plant, and reduce the carbon intensity of electricity. Power plants are large users of electricity themselves, and power plant consumption accounts for close to 5% of gross electricity generation.[22] Therefore, reducing the electricity used at the power plant itself offers a key opportunity for energy savings. Analysis and stakeholder collaboration should be undertaken to promote and clarify specific electricity reduction investments that will *not* result in New Source Review under the Clean Air Act.[23]

Furthermore, transmission and distribution (T&D) losses account for about 9% of gross electricity generation, making the policies surrounding T&D infrastructure investments, distributed generation, microgrids and the siting of new facilities key issues to improving efficiency before the meter.

3 Making Buildings and Appliances More Efficient

Energy consumption from residential appliances and services accounts for about 20% of U.S. primary energy consumption and 17% of national GHG emissions. Residential sector energy consumption and carbon emissions primarily result from the energy required to power our largely inefficient appliances (including lighting), heating, and cooling services. When our buildings themselves are inefficiently insulated and sealed, even more energy is needed for heating and cooling.

Hence, additional measures beyond cap and trade policies to significantly reduce energy use from buildings should include better and broader appliance standards as well as stronger policies to make new and existing buildings more energy efficient.

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21 EIA, 2009. Annual Energy Outlook 2009. Using AEO2009 figures for year 2008.

22 Estimate based on EIA (2008). Annual Energy Review.

23 These could include use of LED plant lighting, installation of variable speed drive fans and other methods used by industrial facilities to reduce auxiliary power.

3.1 Make New Appliances that Use Less Energy

Energy efficiency and conservation strategies are now beginning to be included in the portfolio of carbon mitigation planning, and are likely to be among the most cost-effective options. However, consumers have historically made appliance purchases based on initial costs, not the potential for energy cost savings over time. In addition to producer tax credits and consumer rebates for efficient appliances, federal appliance standards are an effective way to guarantee large energy and cost savings.[24] Higher and more inclusive appliance standards can encourage the widespread adoption of more efficient technologies that provide the same or better level of service to American households.

Efficiency standards led to refrigerators that are larger, less expensive, and now consume one-third as much energy.

The large potential for energy saving has induced several states to implement financial incentives (e.g. taxes, rebate grants, loans or other) or regulations (as appliance efficiency standards, public benefit funds or other). Several successful cases of energy efficiency standards have been implemented in the past, such as for refrigerators. Since California refrigerator efficiency standards were implemented beginning in 1978, followed by Federal standards and Energy Star labels (see Figure 3.1), refrigerators became larger, less expensive and now consume one-third of the energy they did before the efficiency standards.

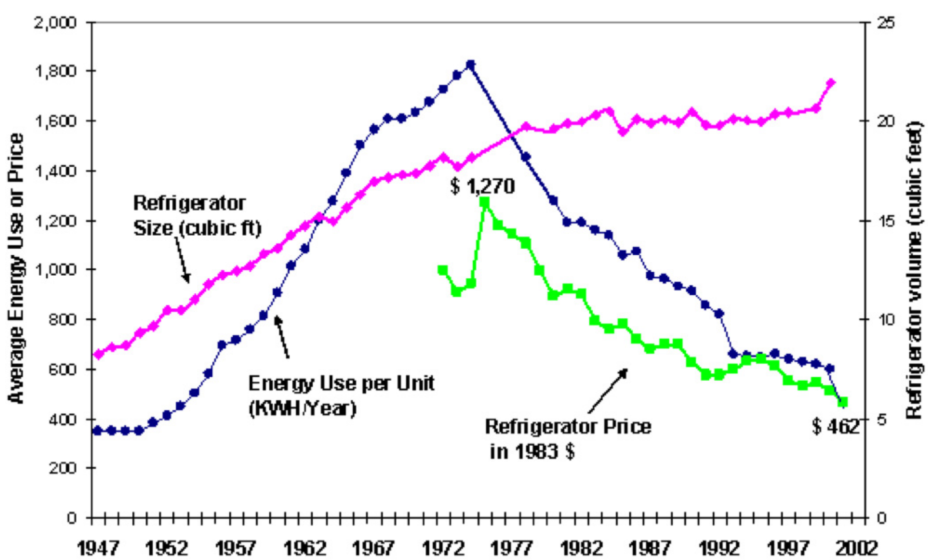

Figure 3.1: Average energy use (kWh/year), price (in 1983 $) and size (cubic ft) of refrigerators in the United States. Sources: CLASP and APEC ESIS.

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[24] Meyers, S.; McMahon, J. E.; McNeil, M.; Liu, X., 2003. Impacts of US Federal Energy Efficiency Standards for Residential Appliances. *Energy* 28 (8), 755-767.

Under the 2007 Energy Independence and Security Act (EISA 2007), and the Energy Policy Act of 2005, several appliance standards will be implemented or updated, and DOE will be allowed to expedite rulemaking in response to broad consensus agreements on recommended new standards. The DOE has lagged in releasing mandated standards, and President Obama recently issued a Presidential Memorandum[25] instructing DOE to swiftly release mandated energy efficiency standards for several product categories.

It is imperative that these standards be feasible, yet aggressive. Specifically, energy intensive end-uses (heating and cooling, hot water, lighting, refrigerators, TVs) deserve more attention (see Figure 3.2). These end-uses alone account for more than 80% of residential energy consumption and 70% of residential greenhouse gas emissions. Shifting to today's best available technologies could achieve a reduction in residential energy consumption of at least 20% with net benefits to consumers.[26]

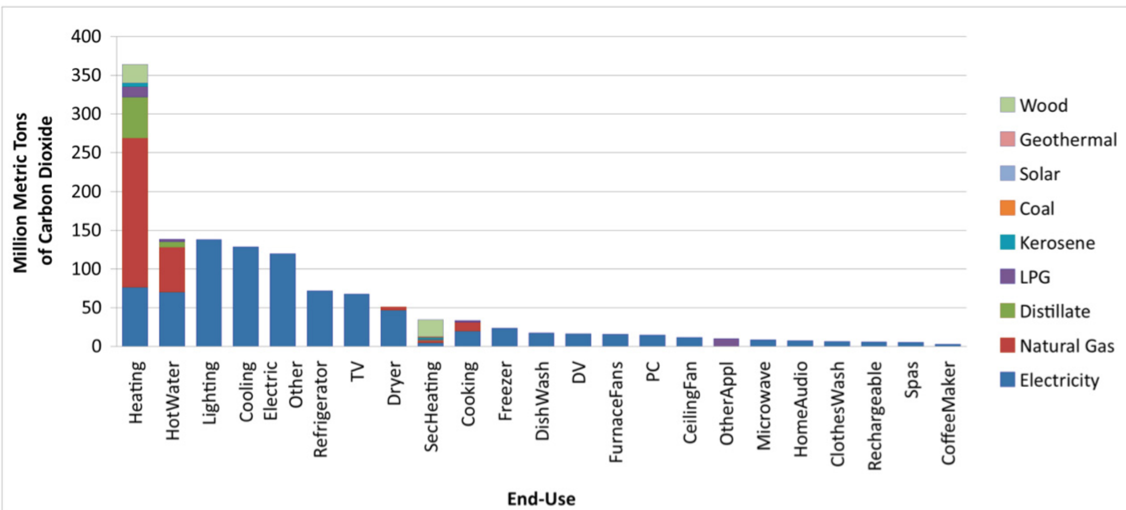

Figure 3.2: Contribution of different residential end-uses to carbon dioxide emissions in 2008. Source: data from EIA, 2008.

To avoid technology lock-in, the implementation of more stringent appliance standards should be based on efficiency of the end-use service provided. The appliance and equipment standards should evolve over time toward more stringent standards, and be reviewed and tightened when market developments suggest further energy consumption reductions can be achieved. The implementation of such standards should be one of the key priorities of future energy and climate legislation.

[25] http://www.whitehouse.gov/the_press_office/ApplianceEfficiencyStandards/

[26] Assuming a 7% discount and including the reductions of energy bills due to energy savings from implementing energy efficiency measures. Underlying data for this estimate from detailed tables provided by DOE.

3.2 Getting New and Existing Buildings to Use Less Energy

In 2008, residential and commercial buildings used 73% of total electricity sold in the United States.[27]

Achieve at least a 50% reduction in the amount of energy used by new buildings.

Few US buildings have been designed to be energy-efficient.[28,29] Large amounts of energy for heating and cooling are lost due to leaks around windows and doors, insufficient insulation in ceilings and walls, single pane windows, and inefficient furnaces, air conditioners, and appliances. New residential buildings have demonstrated that 50% or more energy can be saved by improved design, construction, and energy using devices. Similarly, new commercial buildings have demonstrated energy savings of 50% or more.[30,31] Studies report that the cost of these energy efficient buildings is not much greater than the costs of current design and construction. Retrofitting existing buildings is more expensive and less cost-effective than designing new buildings to be energy efficient. Changing the design has little or no cost; ordering better quality windows and more insulation for the roof and walls does add to cost, but the payback period is short. For example, using natural light can cut lighting bills while improved windows and shading keep out much of the summer heat and reduce winter heating loads.[32] Building codes should mandate at least a 50% reduction in the amount of energy used by new buildings. While Congress may not be able to implement such a change directly, there are a variety indirect tools that could be used to move states and cities to adopt such a change.

The American Recovery and Reinvestment Act begins to require states and localities to adopt a set of minimum best practices in building codes in order to be eligible for some federal energy efficiency funding, however this is just a start. A variety of other federal banking, insurance, tax, subsidy and other programs might be used to induce the implementation of better codes, and make energy efficiency a factor in mortgages. Other barriers could be overcome through alignment of incentives and education: many architects and builders are not familiar with the

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[27] Electric Power Monthly, U.S. Energy Information Administration, 2009.

[28] Energy Innovations. 1997. Energy Innovations: A Prosperous Path to a Clean Environment. Washington, DC: Alliance To Save Energy, American Council for an Energy-Efficient Economy, Natural Resources Defense Council, Tellus Institute, and Union of Concerned Scientists.

[29] IWG. 1997. Interlaboratory Working Group on Energy-Efficient and Low-Carbon Technologies. Scenarios of U.S. Carbon Reductions: Potential Impacts of Technologies by 2010 and Beyond. Oak Ridge, TN and Berkeley, CA: Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory. ORNL/CON-444 and LBNL-40533. Sept. http://enduse.lbl.gov/projects/5lab.html.

[30] IWG. 2000. Interlaboratory Working Group on Energy-Efficient and Clean-Energy Technologies. Scenarios for a Clean Energy Future. Oak Ridge, TN and Berkeley, CA: Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory. ORNL/CON-476 and LBNL-44029. November. http://www.ornl.gov/sci/eere/cef/.

[31] Nadel, S.; H. Geller. 2001. Smart Energy Policies: Saving Money and Reducing Pollutant Emissions Through Greater Energy Efficiency. Washington, DC: American Council for an Energy-Efficient Economy. Sept. http://aceee.org/pubs/e012full.pdf.

[32] EETF [Energy Efficiency Task Force]. 2006. Energy Efficiency Task Force Report. Prepared for the Clean and Diversified Energy Initiative, Western Governors' Association, Denver, CO. Jan. http://www.westgov.org/wga/initiatives/cdeac/Energy%20Efficiency-full.pdf.

more efficient designs, or do not know how to secure better components, and speculative builders attempt to minimize the sales prices. Many consumers are not aware of the savings from the more efficient buildings and appliances, and often the decision concerning which appliance to buy or how much insulation to use is made by someone concerned with the initial price who will not have to pay for the ongoing energy costs.[31]

4 Automobiles

Reducing global greenhouse gas emissions substantially from transportation is challenging. The CO_2 emissions from passenger transportation is given by:

$$\text{CO}_2 \text{ emissions from vehicles} = \left(\text{Carbon in combusted fuel converted to CO}_2\right) \times \left(\text{Vehicle fuel consumption per mile}\right) \times \left(\text{Total miles driven}\right)$$

Reducing the emissions of CO_2 and other greenhouse gases (GHGs) from transportation to acceptable levels will require tougher mileage standards and reduced vehicle miles traveled. With petroleum currently providing more than 95 percent of United States' transportation energy supply, options to achieve large GHG reductions in transportation include increasing vehicle fuel economy, reducing the annual distances traveled, or diversifying to an energy source with lower (life cycle) emissions of CO_2. Light duty passenger vehicles accounted for about 62 percent of transportation-related GHG emissions in 2006, so it is clear that large reductions in passenger transport emissions are required (See Figure 4.1). Large-scale sustainable biofuels supplies appear to be limited in the near-term and have significant land use and other environmental impacts. Hybrid and plug-in hybrid vehicles are showing promise, while it appears that hydrogen will not be widely viable for many years.

4.1 Higher CAFE Standards

The Corporate Average Fuel Economy (CAFE) standards passed in 2007 have a goal of a combined fleet fuel economy of 35 mpg by 2020. While this is an improvement from the existing standards, these new targets still lag behind the fuel economy standards in China, Japan, and Europe.[33] Additionally, CO_2 reductions from more efficient vehicles can be eroded by the increase in the total number of vehicles, and increases in annual miles traveled.

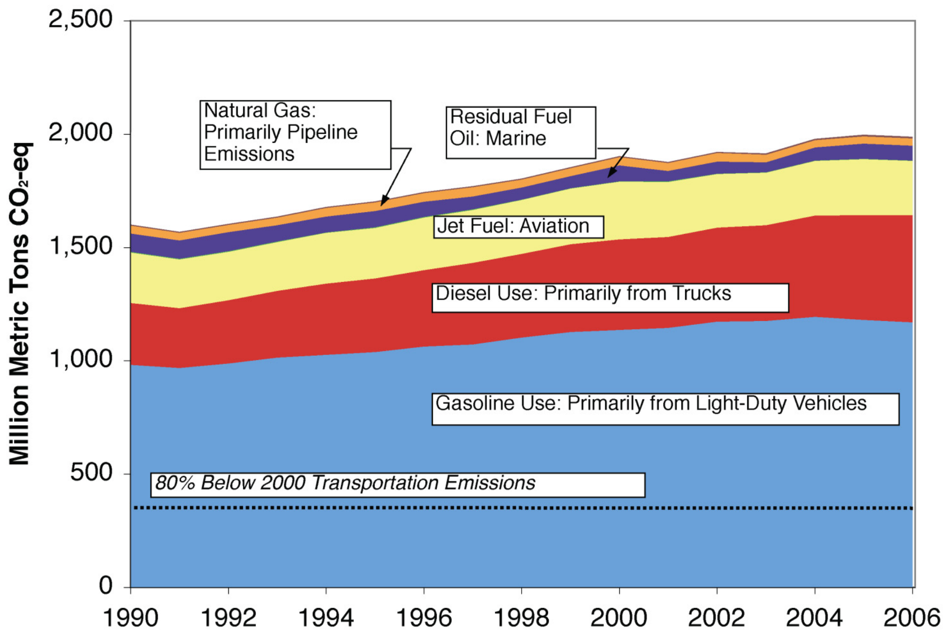

Figure 4.1: U.S. GHG emissions from the transportation sector. Source: EPA.

Because a modest CO_2 price alone will likely not lead to major shifts in vehicle purchasing habits, we need to act beyond cap and trade proposals if large GHG reductions are desired from the transportation sector. CAFE standards should be enhanced beyond existing standards, and should decline annually as a moving performance standard beyond 2020. Additional options include encouraging low-carbon fuels and electrified transportation with low-carbon electricity, increased focus on mass transit and demand reduction activities, and potentially enacting a price floor for gasoline. If the California vehicle standards, shown in Figure 4.2, were implemented nationwide, GHG reductions from light duty vehicles could be almost double that achieved under existing U.S. CAFE standards.[34]

Both to reduce the emissions of carbon dioxide and to reduce the nation's dependence on imported oil, the U.S. should implement efficiency standards that at least double the miles per gallon of automobiles and light trucks.

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33 The International Council on Clean Transportation, 2008, http://theicct.org/documents/ICCT_PV_global_update_dec08.pdf.

34 California Air Resources Board, 2008. Comparison of Greenhouse Gas Reductions for the United States and Canada Under U.S. CAFE Standards and California Air Resources Board Greenhouse Gas Regulations.

CAFE standards are however, benchmarked to miles per gallon (mpg) and only serve as a proxy for CO_2 emissions with petroleum-fueled vehicles. As electric, plug-in hybrid vehicles, and alternative-fueled vehicles enter the fleet, the link between "mpg" and CO_2 emissions begins to unravel. To encourage innovation and diffusion of alternative vehicles, automakers should gain enhanced vehicle credits toward CAFE requirements through plug-in hybrid, electric and other alternative vehicles. Alternative vehicles and fuels (and associated CAFE credits or low-carbon fuel standards) should be evaluated over the full "life cycle" to properly account for any significant emissions upstream or downstream of the vehicle (such as CO_2 from power plants providing energy for electric vehicles[35]). With the certainty of a fleet standard that becomes more stringent over time, and the flexibility to meet standards with alternative-fueled vehicles, automakers could capitalize on investments in efficient vehicles and trade credits to increase fuel economy and lower greenhouse gas emissions.

The U.S. should implement efficiency standards that at least double the miles per gallon of automobiles and light trucks, with flexibility to meet standards with plug-in hybrid, electric and other alternative vehicles.

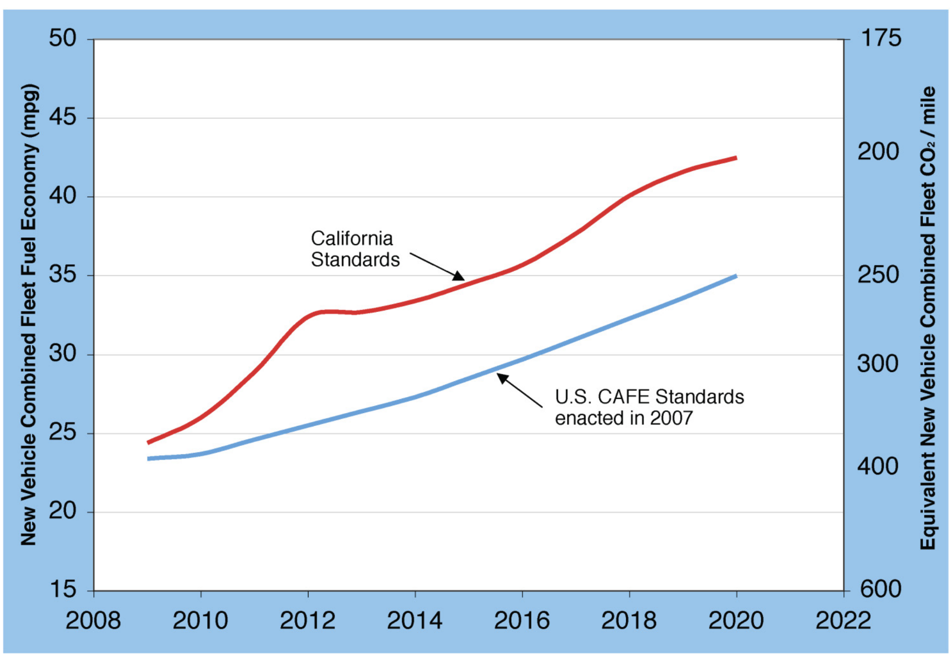

Figure 4.2: U.S. and California fuel economy standards and estimated CO_2/mile. Source: California Air Resources Board, 2008.

[35] Samaras, C., Meisterling, K., 2008. Life Cycle Assessment of Greenhouse Gas Emissions from Plug-in Hybrid Vehicles: Implications for Policy. *Environ. Sci. Technol.* 42, 3170-3176.

4.2 Reducing How Far We Drive

To ensure gains in fuel economy are not eroded by increased vehicular travel, policies to reduce Vehicle Miles Traveled (VMT) are also essential to reduce emissions from transportation. After decades of growth, U.S. VMT began to stabilize in 2004 at around 3 trillion annual miles, and then began to fall in 2007 and 2008.[36,37] As gasoline prices climbed above about $3.50/gallon in 2008, U.S. VMT began to fall more steeply; it appears to take gasoline prices in this range to have appreciable influence on vehicle travel (See Figure 4.3), although this period also coincided with worsening economic conditions which would affect demand. Other factors such as household income, vehicle ownership and the availability of transportation alternatives will also influence transportation trends, however long run changes in consumer behavior in the transportation sector will require sustained high gasoline prices. Previous price rises of 10, 20 or 30 cents per gallon did not stem the increase in vehicle miles traveled, as long as the total price was under about $3.00/gallon. Hence, a cap and trade policy for transportation is likely to be effective only when the underlying price of gasoline is sufficiently high to reduce demand. Until oil prices return to their 2008 highs, this leaves policymakers faced with politically difficult, but likely necessary options such as significantly increasing gasoline taxes and/or expanding use of road pricing and tolling, to achieve GHG reductions from passenger transportation through prices.

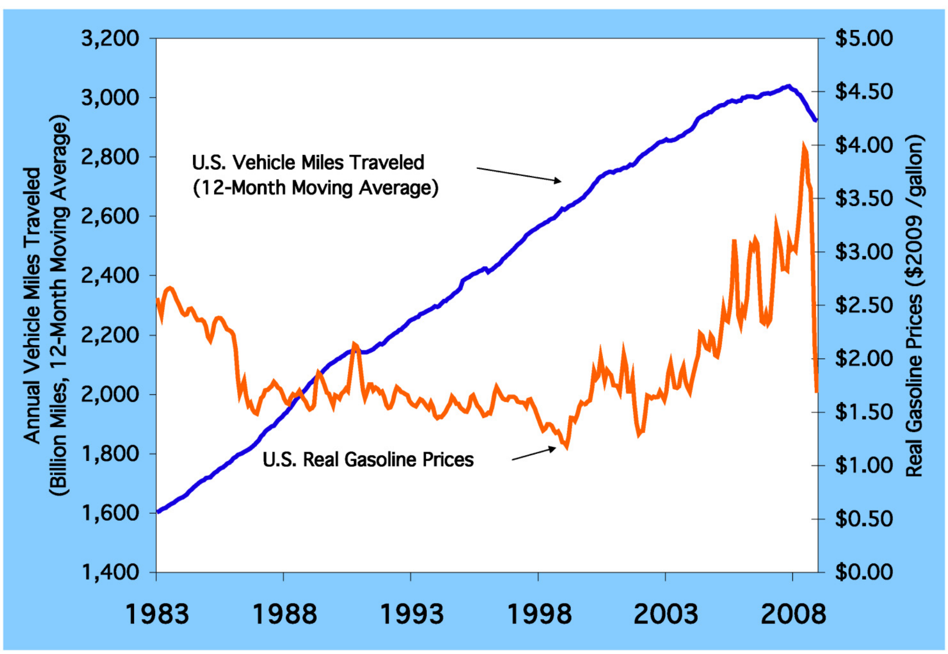

Figure 4.3: U.S. Vehicle Miles Traveled[38] and Real Gasoline Prices. Sources: EIA and FHWA.

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36 FHWA Office of Highway Policy Information, 2008.

37 Puentes, P.; Tomer, A., The Road...Less Traveled: An Analysis of Vehicle Miles Traveled Trends in the U.S. The Brookings Institution, December 2008.

38 VMT data used is total VMT, of which light duty vehicles are responsible for about 92%, see: http://www.fhwa.dot.gov/policyinformation/statistics/.

Increased VMT can also erode gains in fuel economy of the vehicle fleet, as shown in Figure 4.4. If VMT increases as projected by the EIA, then GHG benefits achieved through the updated U.S. CAFE standards would be offset by increased travel. Hence, reducing, or at least stabilizing, VMT should be a critical element to curbing transportation GHG emissions. Demand reduction policies could also include Pay-As-You-Drive (PAYD) automobile insurance, which prices insurance based on actual annual miles driven, instead of the prevailing practice of flat prices that are independent of the actual amount of driving. A preliminary estimate[39] found that PAYD insurance would be an efficient way to reduce automobile externalities, and the Brookings Institution estimates PAYD could reduce VMT by 8% and save two-thirds of U.S. households a few hundred dollars per year.[40]

Additionally, a large share of federal highway funding is allocated to states according to local annual VMT.[36,37] This creates a strong incentive for states to maintain or increase VMT so that desperately needed federal funding is not reduced. To align incentives with greenhouse gas emissions reduction goals, policies could encourage states to reduce VMT by designing formulas to maintain federal transportation or infrastructure funding as local VMT decreases.

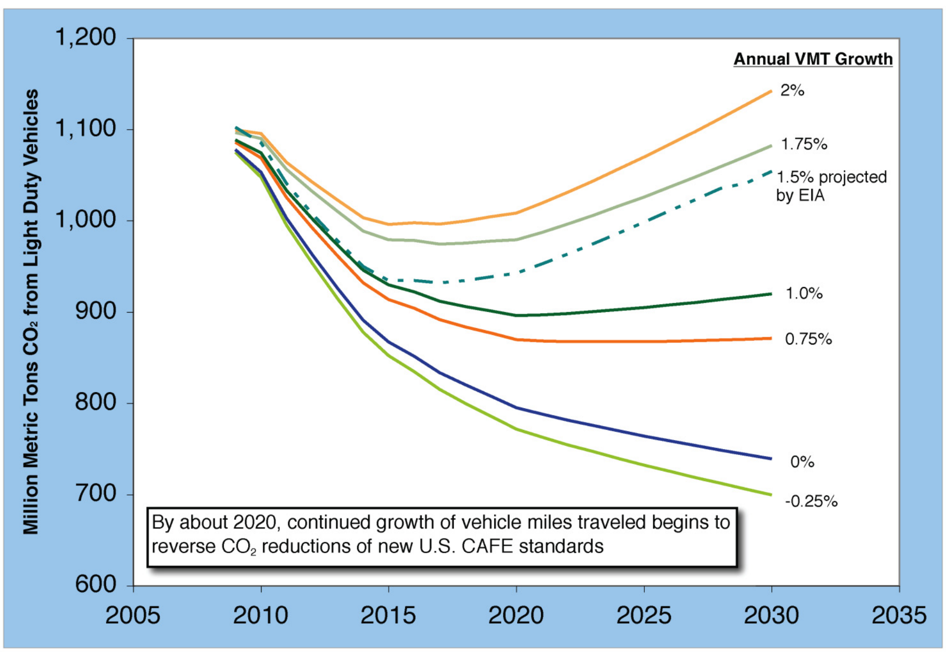

Figure 4.4: U.S. CO_2 emissions from on-road light duty vehicles under existing updated CAFE standards and varying VMT growth scenarios. Sources: EIA Annual Energy Outlook and EPA.

39 Parry, I.W.H., Is Pay -As-You-Drive Insurance a Better Way to Reduce Gasoline than Gasoline Taxes? Resources for the Future Discussion Paper 05-15, 2005.

40 Bordoff, J.E.; Noel, P.J., Pay -As-You-Drive Insurance: A Simple Way to Reduce Driving-Related Harms and Increase Equity, The Brookings Institution, July 2008.

5 The Need for Rapid Analysis Before Action

In the rush to reduce CO_2 emissions, and improve energy efficiency, there is a risk that technologies or policies may be mandated that cost dramatically more than more efficient routes to the same goals. Both Congress and the Executive Branch need to support careful engineering-economic analysis before undertaking any specific mandates. Such analysis can be performed in 90 days so that they do not delay legislative and executive processes, and thus should not be used as an excuse for delaying action.

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