Background Papers on Panel Topics

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Preface

This series of background papers was prepared by a team of graduate students in the School of Public and Environmental Affairs (SPEA) at Indiana University in support of the conference "*the Search for Wise Energy Policy.*" This conference was organized by SPEA and is scheduled for June 11, 2009 in the Mayflower Hotel in Washington, D.C.

The primary purpose of these papers is to provide background information related to most of the primary topics of the conference. The students were asked to review the appropriate literature and web sites in each of seven areas of energy policy and to prepare fairly concise review articles for use of the panelists. These papers have not yet been subjected to expert peer review. The opinions expressed are those of the individual authors, not the School of Public and Environmental Affairs or Indiana University.

This team of students was supervised by Professors Evan Ringquist and J.C. Randolph. Any omissions or errors are the responsibility of this team.

Panel 3: Changing Patterns in Energy Demand and Use

C. Energy Efficiency and Conservation – *Rachel Krause*

1.0 The Context for Energy Efficiency and Conservation

A dual-pronged approach, which simultaneously increases supply and reduces demand, is necessary to confront the energy challenges faced by the United States. This decreases reliance on either individual approach to "solve" the problem alone, and makes it easier to pursue each only up to its point of maximum economic efficiency.

Experts suggest that a considerable reduction in energy demand can be achieved through efficiency improvements without a noticeable change to most people's quality of life. Effective demand reduction efforts bring about increased environmental protection and energy security with little trade-off. However, these efforts have more potential to conflict with the goals of energy affordability and a non-intrusive government. This section reviews the two main types of demand reducing behaviors, then details the technical potential of energy efficiency, the major obstacles to its achievement, and possible policy approaches for overcoming those obstacles.

1.1 General categories of energy-reducing behavior

Actions taken to reduce energy consumption fall into one of two broad categories: curtailment and efficiency improvements. Curtailment involves reducing the demand for energy services (e.g., turning down thermostats, biking to work). Increasing efficiency involves using new technologies to satisfy demand for energy services using less energy (e.g., using programmable thermostats and driving a hybrid vehicle to work). Although both are often identified as necessary to achieve dramatic reductions in energy demand, these categories warrant distinct consideration. The behaviors that fall into each are dissimilar enough so that different barriers inhibit them and different policy strategies are needed to effectively encourage them.

Curtailment and efficiency behaviors differ on two dimensions (Gardner and Stern, 1996). The first dimension involves the behaviors' frequency and complexity characteristics. Curtailment requires small but continuously repeated decisions to be made and/or habits to be formed. Efficiency improvements, on the other hand, involve actions that are infrequent and generally more complex and less familiar. They often require more planning and resources – such as the capital, research, and negotiations that go into the purchase of a vehicle or retrofit of a building – but do not require continuous effort or attention.

The second dimension on which curtailment and efficiency improvements differ is on their perceived lifestyle impact (Gardner & Stern, 1996). Curtailment behaviors are often perceived as being inconvenient, uncomfortable, or otherwise reducing quality of life. They connote "sacrifice." Increases in energy efficiency do not face this psychological barrier, as existing lifestyles can be maintained. Efforts to reduce energy demand through curtailment or efficiency each face barriers that the other does not. Policy able to have a lasting impact on energy use through curtailment must reshape society's dominant norms and values, whereas policy creating substantial demand reduction through energy efficiency must maneuver around the obstacles posed by capital expenses and transaction costs (Wilhite, Shove, Lutzenhiser, & Kempton, 2000).

Curtailment and efficiency improvements are often complementary, but the policies promoting efficiency are generally preferred. First, efficiency is estimated to have a larger energy savings potential (Stern & Gardner, 1981). Second, there are fewer obvious trade-offs, which make pursing efficiency more politically palatable. Third, efficiency improvements entail less uncertainty. Although actual savings from efficiency improvements rarely meet engineering estimates of potential savings acheivable, they involve considerably less uncertainty than do predictions regarding the impact of voluntary changes in mass public behavior.

In addition to direct reductions in energy use, changes in the timing of customer demand can improve efficiency and reduce resource use in the electricity sector. A range of "demand response" programs are used by utilities to adjust customer demand to power sector conditions. These programs commonly encourage industrial and commercial customers to curtail power use during times of peak electricity use. By using demand response programs, utilities can avoid the need to build or buy additional fossil fuel-based electricity in order to meet peak electricity demand. (Cowart, 2001.)

1.2 Technical overview of energy efficiency

A demand does not exist for energy directly, but rather for the services which energy provides, i.e. people want lighting and transportation, not electricity and gasoline. Inefficiency in the energy-to-services conversion process can be examined from quantity and quality perspectives. The quantity perspective draws from the first law of thermodynamics and is a ratio of energy input to useful energy output. The quality perspective draws from the second law of thermodynamics and involves the match between an energy source and the service it is being used to provide. Certain services, such as low temperature heat, do not need to be produced with a high quality, low entropy, energy source like electricity. Using energy of superfluous quantity or quality is wasteful (Lovins, 2004).

Technically, energy efficiency can be described as the product of five efficiency components:

> Technical energy efficiency = extraction efficiency * conversion efficiency * distribution efficiency* end use efficiency * hedonic efficiency.

Extraction efficiency involves gathering the initial raw sources of fuel (oil, coal, sun, wind, etc.) and making it available as primary energy. Conversion efficiency refers to the transformation from primary energy into a more useable secondary energy, for example burning coal to get electricity. Distribution efficiency characterizes the movement of secondary energy from its point of conversion to its point of end use (e.g. the transport of electricity along a grid from the power plant to users' homes). Energy is then converted into a desired service with a certain degree of end use efficiency. For example, the amount of energy required for refrigerators to cool to forty degrees differs by make and brand, with EnergyStar labels being assigned to those with the highest end use efficiency. Finally, hedonic efficiency involves the conversion of energy services into increases in human welfare. A family's main refrigerator provides a service with high hedonic efficiency, whereas an almost empty second refrigerator has low hedonic efficiency. A full accounting of efficiency should involve the estimation of all five components (Lovins, 2004). Any point along this energy conversion chain is an opening for policy intervention.

1.3 Prioritizing energy efficiency as a resource

The U.S. EPA has recommended that policy makers treat cost-effective energy efficiency "as a resource," that is, comparable to supply-side resources as a means of meeting energy needs. EPA and the Department of Energy's National Action Plan on Energy Efficiency calls for full integration of energy efficiency into state energy markets by including efficiency in long-term demand forecasting and investment decisions and by providing stable funding streams for investments in energy efficiency. Several states have made energy efficiency a priority resource by requiring that electric and natural gas utilities exhaust cost-effective efficiency measures before procuring supply-side resources. (United States Environmental Protection Agency and Department of Energy, 2006).

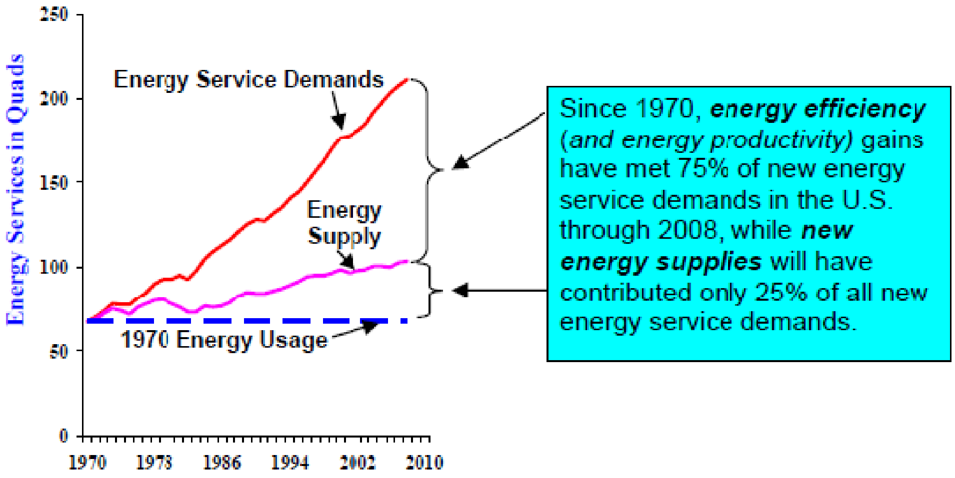
2.0 Changing Patterns

Energy efficiency has a large untapped energy savings potential. Both estimates of past savings and projections of future potential are frequently used to underscore this point. Such estimates are necessarily based upon an approximated no-improvement counterfactual, i.e. the amount of energy that would have been used had no efficiency improvements taken place.

2.1 Evaluation of efficiency's impact in recent history

How much energy have efficiency improvements already saved the United States? Answers to this question generally are quantified in terms of energy intensity (i.e. the quantity of energy consumed per dollar spent or earned). Historically, economic growth and increased energy consumption have been strongly correlated, but have become less so in the past few decades. Some of this decoupling is credited to increased energy efficiency. Estimates of the total impact that efficiency improvements have had on the country's energy use hover around a 40 percent decrease in energy intensity. In other words, running today's economy without the efficiency improvements that have occurred since 1973 would require the use of approximately 40 percent more energy (Lovins, 2004; Ungar, 2006). An estimated three-fourths of the growth in energy demand since 1970 have been met through efficiency improvements (see Figure 3.1). Approximately 80 percent of recent energy savings are a result of efficiency improvements made to buildings and industrial operations (see Table 3.1).

Figure 3.1: Efficiency Gains and New Supply, 1970-2000



Since 1970, ***energy efficiency*** *(and energy productivity)* gains have met 75% of new energy service demands in the U.S. through 2008, while ***new energy supplies*** will have contributed only 25% of all new energy service demands.

Source: Ehrhardt-Martinez and Laitner, 2008

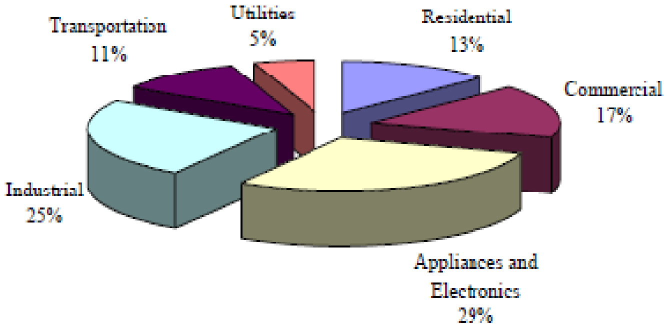
2.2 Investments in Efficiency

While inconsistent definitions of "energy efficiency investments" make comparisons across studies and over time difficult, a recent ACEEE study estimates that public and private sources cumulatively invested

$300 billion into the United State's energy efficiency infrastructure in 2004. Approximately $43 billion of this amount, 14 percent, was an "efficiency premium" (Ehrhardt-Martinez & Laitner, 2008). This is the cost differential between an efficient and non-efficient version of the same good. Efficiency investments are spread unevenly across sectors; residential and commercial buildings and appliances and electronics together receive nearly 2/3 of the total (see Figure 3.2 and Table 1).

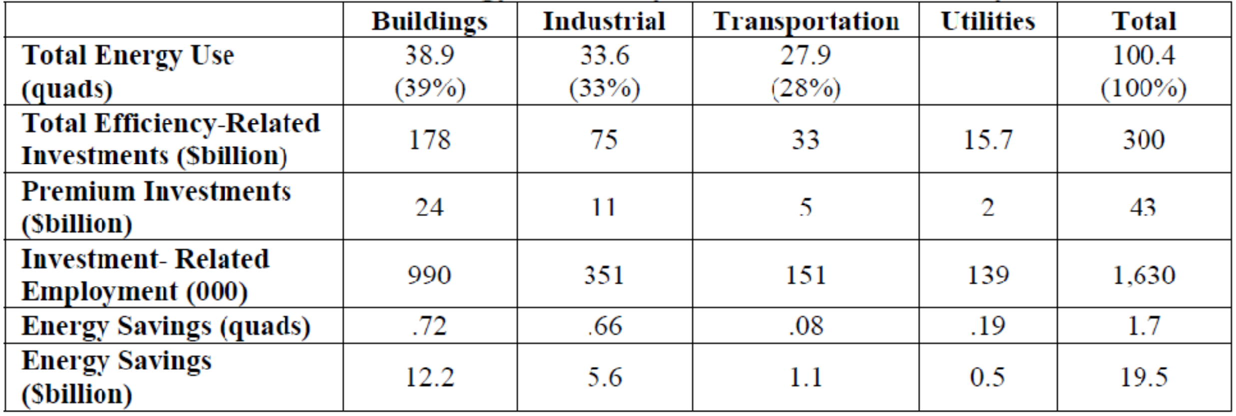
Figure 3.2: Efficiency Investments by Sector, 2004

Total = $300 billion



Source: Ehrhardt-Martinez and Laitner, 2008

Table 3.1: Energy Use, Savings, and Investment by Sector, 2004



	Buildings	Industrial	Transportation	Utilities	Total
Total Energy Use (quads)	38.9 (39%)	33.6 (33%)	27.9 (28%)		100.4 (100%)
Total Efficiency-Related Investments ($billion)	178	75	33	15.7	300
Premium Investments ($billion)	24	11	5	2	43
Investment- Related Employment (000)	990	351	151	139	1,630
Energy Savings (quads)	.72	.66	.08	.19	1.7
Energy Savings ($billion)	12.2	5.6	1.1	0.5	19.5

* Note: Totals may not match due to rounding.

Source: Ehrhardt-Martinez and Laitner, 2008

2.3 Projections of efficiency's future potential

Projections of efficiency's energy saving potential are based upon the predicted difference in the amount of energy consumed in a "no improvements" scenario and an "efficient" scenario some number of years in the future. Energy use estimates in both scenarios are based on assumptions about population and economic growth. Estimates that specifically look at efficiency's *cost effective* potential[1], as most do, must also make assumptions about future energy and technology prices.

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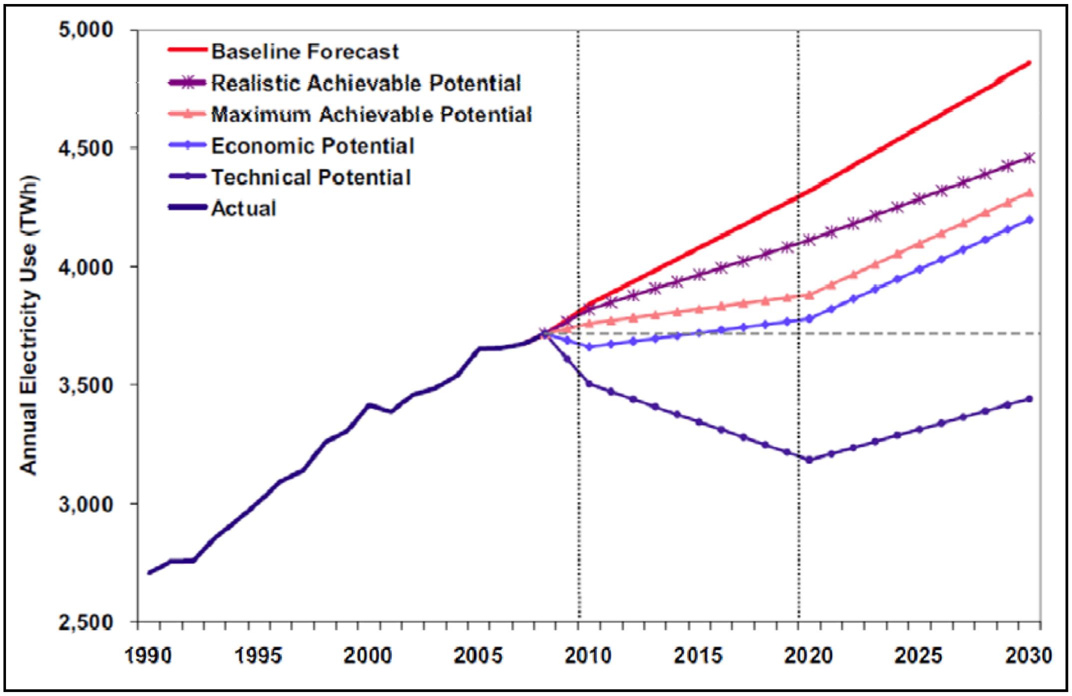
[1] Cost-effectiveness may be determined based on short- or long-term energy savings, and may be measured from a social welfare, ratepayer, or utility perspective. A wider range of efficiency measures will be considered "cost-effective" when the long-term social benefits of the measure are considered. (Regulatory Assistance Project, 2005).

Globally, an international effort to increase energy efficiency between 2009 and 2020 could reduce world-wide energy demand by 16 to 20 percent below a no improvement baseline. This equates to an almost 2/3 reduction in that period's potential energy demand growth (McKinsey Global Institute, 2009). Within the United States, cost effective efficiency improvements have the potential to offset 19 percent of total energy use by 2020, effectively holding consumption constant over the next decade (Ungar, 2006).

The electricity sector offers the greatest savings potential. The Electric Power Research Institute estimates that end-use efficiency measures have the potential to eliminate load growth and reduce electricity consumption below 2005 levels for the period 2010-2030. However, realistically achievable potential is expected to have a more modest impact, reducing load growth rates from 1.2% to 0.8% annually. See Figure 3.3.

Figure 3.3: Potential U.S. Savings from Energy Efficiency, 2010-2030



Source: EPRI, 2009

Population and economic growth patterns, along with existing infrastructure and policy, largely determine the amount of future electricity demand that can be met by cost effective efficiency improvements. This potential varies widely among U.S. states, as a series of ACEEE studies illustrate. For example, with the implementation of recommended efficiency policies, Texas is able to offset 11 percent of projected growth in electricity demand between 2008 and 2023 (Elliot, et al., 2007). In Maryland, on the other hand, efficiency improvements may be able to reduce total demand 28 percent below 2007 levels by 2025 (Eldridge, et al., 2008).

2.3.1 Buildings

Excluding their electronics and appliances, residential and commercial buildings together account for approximately a third of the energy used in the U.S. (Ehrhardt-Martinez & Laitner, 2008). Most energy used in buildings powers heating, cooling, and lighting systems, each of which offers significant energy savings potential. The EPA estimates that upgrading heating systems typically reduces heating energy use by 5% to 30% in commercial buildings; upgrading cooling systems can reduce cooling energy use by 15% to 35%. Similarly, lighting upgrades in commercial buildings can reduce lighting energy use up to 83% (U.S. Environmental Protection Agency, 2008).. If these improvements were made to all existing buildings in the U.S., an estimated 6.5 to 16 QBtu of energy could be saved a year. (Clinton Climate Initiative, 2007) The nation-wide application of model energy codes to new buildings could reduce their average energy consumption by 30 percent and save .85 QBtus of energy each year compared to a no improvement baseline (U.S. Environmental Protection Agency, 2006) .

2.3.2 Appliances

When electronics and appliances are added to building energy use, commercial and residential buildings account for 39% of total energy use. (Ehrhardt-Martinez & Laitner, 2008). State and federal appliance standards mandate minimum efficiency levels for certain appliances, such as refrigerators, freezers, clothes washers, and dryers. Current appliance standards are estimated to save approximately 1.2 QBtu of energy a year, or approximately 1.7 percent of the total non-transport energy used in the U.S. in 2000 (Gillingham, Newell, & Palmer, 2004). Projections suggest that by 2020 savings from federal appliance standards will increase to 4.9 QBtu a year, with much of the acceleration occurring prior to 2015 as existing appliance stock is replaced with products meeting or exceeding federal standards (Nadel, deLaski, Eldridge, & Kleisch, 2006). The ACEEE estimates that new or updated standards for 15 key products could increase these projected savings by an additional 0.64 Qbtu of energy a year (ibid).

Although federal standards can save a significant amount of energy, standards alone will not capture all of the potential energy efficiency savings from appliances. First, not all appliances are covered by federal standards. Second, appliance standards must be periodically updated to reflect technological improvements in appliance efficiency levels. Over time, standards that are not updated to reflect current technologies will become less effective at mandating that the most energy-efficient products reach consumers.

2.3.3 Transportation

The 2007 legislation raising the Corporate Average Fuel Economy (CAFE) standards for cars, SUVs and light trucks to 35 miles per gallon is estimated to increase the annual efficiency of the U.S. vehicle stock by 1.5 percent a year until 2020 (McKinsey Global Institute, 2009). By 2020 this standard is estimated to save 1.03 million barrels of oil a day or 1.80 Qbtu a year (American Council for an Energy Efficient Economy, 2007). On May 19, the Obama administration proposed accelerating these standards to require a fleet average of 35.5 mpg by 2016. This acceleration will result in an estimated savings of 1.8 billion barrels of oil (The White House, 2009)

Assuming an average gas price of $2.61 a gallon, tougher fuel economy standards requiring 40 miles per gallon by 2020 are estimated as cost effective (Kliesch, 2008). In addition to improved technology, policies promoting more efficient driving habits can result in modest fuel demand reduction, without necessarily changing travel patterns. For example, properly inflating tires can increase fuel economy by up to 3 percent (U.S. Department of Energy) and a national 55 mile per hour speed limit could result in a .8 to 1.3 percent drop in national fuel consumption (U.S. Government Accountability Office, 2008).

Air transportation in the U.S. utilized 3.2 QBtu, or an equivalent of 27.8 billion gallons of gasoline, in 2006 (McKinsey Global Institute, 2009). The potential for efficiency-induced energy savings is limited for this sector because of slow stock turnover and operating practices which already capture most non-equipment based savings potential (ibid).

2.3.4 Industry

The U.S. industrial sector – which includes manufacturing, agriculture, construction and mining – used approximately 33 QBtu of energy in 2004 (Ehrhardt-Martinez & Laitner, 2008). After the US economy recovers, energy consumption is expected to increase by 0.6 percent a year (McKinsey Global Institute, 2009).

Volatile energy prices are increasing efficiency investments, particularly within manufacturing. Manufacturing firms account for approximately 80 percent of the industrial sector's efficiency investments. Forty percent of firms surveyed in the EIA's 2002 *Manufacturing Energy Consumption Survey* reported participating in at least one energy efficiency activity, up from 33 percent in 1998.[2] In 2004 they invested an estimated $60 billion in efficiency improvements which saved 5.20 QBtus the following year (Ehrhardt-Martinez & Laitner, 2008). If the approximately 60 percent of manufacturing firms that are not taking efficiency actions make improvements that yield similar energy savings, an additional 6.8 QBtu per year can be saved.

Table 3.2: Estimated Energy Savings Potential from Cost Effective Efficiency Improvements beyond the Policy Status Quo[1]

	Estimated Energy consumed (2004)	Annual energy savings achievable by 2020
Sector	**QBtu**	**QBtu**
Buildings	31.7	7-17
Appliances	7.9	0.6
Transportation[2]	28	2.0
Industry	33.6	6.8

[1] Estimates of energy savings consider cost effective and technically viable improvements that have not been adopted by federal policy. They do not include projected future savings from policy that has already been adopted. For example, potential savings for transportation include only the *difference* between the energy that could be saved with a 40 mpg CAFÉ standard (cost effective potential) and the current 35 mpg standard. The savings that will result during the transition to 35 mpg are not included.

[2] See appendix 3A for calculation details

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[2] The EIA's *Manufacturing Energy Consumption Survey* is administered every 4 years. Preliminary findings from the 2006 survey were released May 2009, with final results to follow over the next several weeks.

3.0 Energy Efficiency Policy

3.1 What are the goals of energy efficiency policy?

Pursuing economically rational efficiency improvements is a relatively trade-off free way to address the energy challenges facing the United States. By reducing demand, efficiency automatically achieves environmental protection and energy security. Efficiency improvements are also expected to save money after an initial capital investment. Efficiency and demand response measures can also promote electric power system reliability and reduce system-wide costs when they eliminate or delay the need for capital-intensive investments in generation, transmission, and distribution infrastructure. (Cowart, 2001.)

Given this, four goals for wise energy policy are presented: Energy policy in the United States should a) increase the technical potential for energy efficiency; b) reduce the gap between potential and achieved efficiency; c) do this affordably and in a way that does not overly burden any specific segment of society; and d) promote the development of “green jobs”. These goals do not necessarily involve trade-offs, and will often be complementary. However, affordability is the binding constraint, both politically and ethically. Finally, it is important to emphasize that policy should only encourage efficiency improvements where benefits exceed costs.

3.2 What are the challenges to achieving these goals?

If energy efficiency is a win-win solution to national energy problems, why has its potential been left unfulfilled, particularly in areas where efficiency gains are both already economically rational and technologically feasible? A large part of the answer is rooted in a series of financial and structural barriers which have the effect of increasing the cost of efficiency improvements, reducing their value, and/or separating the realization of costs and benefits across parties.

3.2.1 Barriers that increase the cost of efficiency investments

Efficiency enhancing products are often not mass produced, causing them to have higher upfront costs than their traditional counterparts. Some of this higher cost is due to the use of higher quality materials, but much of it is a result of the customized nature of efficient products and buildings.

Uncertainty inhibits the commercialization of technological innovations. Private companies are unsure of the true demand for efficient products and are hesitant to invest in them for fear they will not sell (Lovins & Lovins, 1997). Unlike traditional innovation, efficient products neither offer an enhanced service nor a lower price. Rather, they compete on the basis of eventual cost savings resulting from reduced energy consumption. Consumer discount rates are variable and the extent to which efficiency premiums will cut into stated demand can be difficult to predict. The most efficient versions of products thus often remain technological prototypes and are not made available for mass consumption. This is particularly problematic for outputs of government funded technological development which are often not picked up by American firms (United States National Academies of Science, 2008)

3.2.2 Barriers that reduce the benefits of efficiency investments

Several barriers exist which prevent consumers from reaping the full financial benefits of energy savings.

Subsidies for Traditional Energy Sources

Energy subsidies, both for traditional and renewable sources, make energy prices artificially low. An estimated $15.6 billion was spent by the federal government in fiscal year 2007 to support energy production and consumption (see table 3.3). Conservation and efficiency, in comparison, received $926 million (Energy Information Administration, 2008). Energy subsidies reduce the amount of money that consumers can save through increased efficiency and extends the length of time an efficient product will take to "pay for itself." Energy subsidies prevent efficiency investments from competing on an even playing field with supply-side alternatives.

Table 3.3: Federal Energy Subsidies by Type and Fuel, 2007 (in millions of dollars)

	Direct Expenditures[1]	**Tax Expenditures**[2]	**Research & Development**	**Electricity Support**[3]	**Total**
Coal	-	2,660	574	69	3,303
Natural gas & petroleum liquids	-	2,090	39	20	2,149
Nuclear	-	199	922	146	1,267
Renewables	5	3,970	727	173	4,875
Electricity	-	735	140	360	1,235
End Use	2,295	120	418	-	2,833
Total	2,300	9,774	2,820	768	15,662

[1] Funds provided by the Federal government that result in direct payment to energy consumers or producers.
[2] Reduced tax liability to consumers or producers in return for specified energy-related actions.
[3] Electricity programs, like the Tennessee Valley Authority, which serve targeted/regional categories of consumers.
Source: Adapted from Energy Information Administration, 2008

Energy rate structures that favor consumption

Energy prices are often structured in a way that fails to reward decreased use. Utilities and regulators try to satisfy several objectives via rate structure, including revenue stability, load management, a fair apportionment of costs among consumers, and simplicity of implementation (United States Environmental Protection Agency and Department of Energy, 2006). These often competing priorities tilt the focus of rate design away from promoting reduced use. For example, to promote cost effective load management, a growing number of states are employing real time pricing (RTP) for large commercial and industrial customers. RTP determines rates based on the variable costs of energy production and delivery at different times throughout the day. RTP favors basing rates on short run marginal costs over long-run costs, which also include the cost of capital expansion. While the use of long-run marginal costs better promotes efficiency investments, it is often not used in RTP because it dilutes the strength that price signals have to direct the timing of daily energy use (United States Environmental Protection Agency and Department of Energy, 2006).

Utilities are often tasked by regulating agencies to administer energy efficiency programs. Several things limit their incentive to do this well, most notably, rate structures which tie utilities' profits to their volume of energy sales. This presents them with the conflicting task of working to get consumers to buy less of the very products they make money from selling (United States Environmental Protection Agency and Department of Energy, 2006). Utilities profit directly from reduced consumer demand only in limited circumstances – for example, in states that have removed the utility disincentive to reduce energy use, or where they are near current capacity and efficiency improvements are able to postpone or prevent the need for large capital investments to increase energy production. In most cases, however, energy efficiency programs are not in line with utilities' priorities.

3.2.3 Barriers that separate the realization of costs and benefits

There is often a disconnect between the individuals who make decisions about efficiency investments and those who pay the subsequent energy bills. If the decision-makers will not benefit financially from future energy savings, they have no incentive to invest in efficiency. This "split incentive" can be seen clearly in the relationship between the builders and eventual buyers of buildings (United States Environmental Protection Agency and Department of Energy, 2006). For example, a builder, after winning a lowest bid, has little incentive to use higher quality, and more expensive, materials in its electric wiring of a building, even if that investment would pay for itself in a matter of weeks. In most construction, then, building codes become de-facto efficiency standards (Lovins, 2004).

Split incentives are also common in the landlord-renter relationship and pose an obstacle to the retrofit of existing infrastructure. Building retrofits often require large upfront investments. For example, the weatherization of a low income residence costs an average of $6,500, with larger households and commercial buildings costing considerably more (United States Department of Energy). This cost barrier becomes more formidable in the face of split incentives, which can be seen in any situation where renters pay their own utility bills. Neither the owner of a building nor its renters have incentive to make a capital investment in efficiency because neither party is able to reap the full benefits.

Utility administered energy efficiency programs are also often hindered by split incentives. Utilities incur program administration costs and often the cost of subsidizing consumers' efficiency investments. While consumers experience lower energy costs, utilities benefit only if the energy saved allows them to avoid capital investments in new power generation facilities.

3.2.4 Barriers to rational consumer decision making

Even when the benefits of efficiency improvements clearly exceed their costs, consumers often do not take full advantage of them. Several factors help explain this failure to act rationally.

The generally higher upfront cost of efficient products may pose an obstacle to their purchase, even when their payback time is short. High personal discount rates and/or a failure to quantify future energy and monetary savings can result in selecting the less efficient alternative. A lack of standardized, comparable information about products' energy requirements contributes directly to this.

Subsidies to lower or eliminate the cost of efficiency improvements are common. However, there is a noted reluctance on the part of consumers to accept financial assistance for efficiency investments, suggesting that economics are only part of consumers' bundle of considerations (Gardner & Stern, 1996; Miller & Ford, 1985). In addition to financial incentives, trust and convenience stand out as important factors in consumers' decisions to participate in energy efficiency programs. Even when programs offer the same financial incentives, considerable variation in participation rates has been observed. Key obstacles to participation include the number of steps and approval processes required before participants can cash in on incentives, and the identity of the entity offering the incentive (Gardner & Stern, 1996; Miller & Ford, 1985).

3.3 Policy instruments

3.3.1 Criteria for prioritizing policy options

Rather than suggesting that large amounts of money be allocated for research and development, this paper focuses on pursuing policy alternatives that remove barriers to energy savings that are already technologically feasible and cost effective. The recommended instruments focus directly on the goal of reducing the gap between potential and actual energy efficiency while maintaining affordability. This is a valuable starting point and has the potential to bring about the other goals of increasing technical potential and the demand for green jobs.

3.3.2 Policy instruments to deflate efficiency's cost

Uncertainty about consumers' willingness to invest in efficiency improvements inhibits the mass production of efficient products, which keeps their prices high and limits consumers' willingness to invest in them. Policy can intervene in this cycle directly. Subsidies can include rebates and loan guarantees for purchase of energy efficient products, as well as provision of information about energy usage and cost savings that will decrease consumers' transaction costs. In addition, governments can commit to purchase only the most efficient products for their own operations. Both of these policies will increase producers' confidence that there will be sufficient demand for efficient products and facilitate their mass production.

3.3.3 Policy instruments to reveal efficiency's benefits

Minimizing subsidies for supply-side resources

Current energy pricing schemes often limit the financial benefit that can be achieved through efficiency investments. The removal of energy subsidies is key to maximizing the financial benefit of energy savings and is in line with the idea of "high rates, but low bills." Under this scenario, the per-unit cost of energy is increased, but the size of overall bills is not because improvements in efficiency will have reduced the amount of energy needed to be consumed for the same services. Maintaining energy affordability is a political and ethical necessity, so the timing of efficiency improvements and rate increases must be well managed. If, for political reasons, energy subsidies cannot be fully removed, they should be made transparent and reviewed often to ensure they are not encouraging unnecessary consumption or are otherwise working against over-arching energy goals.

Developing rate structures that encourage conservation by consumers

In order to encourage efficiency, regulators should work with utilities to develop rate structures that incentivize energy savings on the part of energy consumers. A common recommendation is the use of increasing block rates, which employ a low per unit charge for base levels of energy consumption and increase it as successive blocks are consumed.

Defining utilities' role in program implementation and addressing utility incentives to increase consumption

If, as is the case in many states, utilities are tasked with the implementation of energy efficiency programs, their motivations as administrators must also be considered. Decoupling utilities' profits from their volume of energy sales is the primary strategy recommended to minimize their disincentive to implement successful efficiency programs. This can be done by rewriting regulations in order to tie profits to the number of customers served rather than the amount of energy sold or allowing utilities to recover more revenue via fixed customer charges (United States Environmental Protection Agency and Department of Energy, 2006). However, the latter may also reduce consumer incentive to save. It is not an easy task to structure rates that simultaneously provide efficiency incentives to energy consumers and utilities, while meeting other important goals such as revenue stability and a fair distribution of the cost burden across consumer classes. This challenge raises questions about the appropriateness of utility administered efficiency programs (addressed more depth in section 3.4).

While utilities often face a natural disincentive to reducing energy use, they can also serve as important agents in reducing barriers to procurement of cost-effective energy efficiency. Utilities have access to significant amounts of knowledge about individual and aggregate customer energy use. This knowledge can help utilities to identify the greatest untapped opportunities to reduce energy, as well as cost-effective ways of achieving reductions in energy usage. Utilities also have an established relationship with customers, and can work with customers to overcome the information and transaction cost barriers to using energy efficient products. This role is particularly important for capturing energy efficiency savings in the commercial and industrial sectors, where the aggregate savings are large and the needs of customers within specific industries are similar. Utilities can work with these customers to design a suite of products and rates that allow the utility and customer to work together to minimize energy use.

An alternative to utility administration of efficiency programs is the creation of a third-party entity to administer programs. Several states, including Vermont, New York, Wisconsin, and Oregon have taken this approach. The third-party entity may be a state agency or a private company that contracts with the state to deliver energy savings. (Harrington, 2003).

Exhausting cost-effective efficiency measures before turning to supply-side options

Several states have adopted policies that require all cost-effective energy efficiency measures to be exhausted before utilities can use ratepayer dollars to invest in new supply sources. This policy approach, advocated by the EPA in its National Action Plan on Energy Efficiency, requires integrating statewide energy efficiency administration with utility long-term demand forecasts and supply plans. In order to make this approach effective, state regulators must assess the cost-effective efficiency potential and establish energy efficiency savings goals based on cost-effective potential. A utility or other entity then aggressively pursues cost-effective energy savings opportunities and is rewarded for achieving savings goals. (United States Environmental Protection Agency and Department of Energy, 2006).

Providing a stable funding stream for energy efficiency measures

Even the most cost-effective efficiency measures will never be implemented without adequate funding. A number of states have adopted a “public goods” tariff assessed on each kWh of electricity sold to provide a funding stream for efficiency measures. Public goods charges are commonly used to provide incentives or loans for consumers to purchase new equipment, assist utilities in targeting various customer segments with efficiency programs, and to provide funding for new approaches to reductions in energy use. Funding from public goods charges may be held and administered by utilities or government agencies. (United States Environmental Protection Agency and Department of Energy, 2006).

Developing nationwide measurement and verification protocols for efficiency

If states are to adopt EPA’s recommendations and treat energy efficiency as a resource, regulators and utilities alike need to be certain that any programs they invest in will deliver the expected savings. The federal government has a natural role to play in developing measurement and verification protocols so that savings estimates are consistent across state boundaries, and so that regulators and utilities can incorporate savings estimates into their resource planning processes to avoid unnecessary investments in generation.

3.3.4 Policy instruments to circumvent split incentives

The problems caused by split incentives are manifest in efforts to achieve efficient buildings. How they are best approached varies, depending on whether they affect new construction or retrofits, and whether they target owners or renters.

New construction

Split incentives could be minimized from new construction if policymakers include minimum efficiency standards in building codes, much like minimum safety codes. All developers will assume efficiency improvements as part of their standard costs of construction and pass them on to the purchasers who benefit from them. As an additional benefit, minimum efficiency standards will reduce uncertainty about demand for energy efficient products, allowing the private sector to commercialize energy efficient innovations with more confidence. Building code adoption is under the authority of state governments, which makes the federal role one of providing incentives and information to encourage state action.

A related federal policy instrument involves restructuring loan eligibility standards to consider buildings' total cost. Efficient buildings will cost more to purchase, but less to operate, than their standard counterparts. Thus, their total cost should remain the same or decrease. However, eligibility for loans is not based on *total* price but rather on *purchase* price as a percentage of income (P&I), which may prevent some classes of consumers from getting loans for more expensive, more efficient buildings. Restructured loans, which consider both P&I and projected utility costs as eligibility standards, would minimize this barrier. Fannie Mae, Freddie Mac and the Comptroller of Currency (OCC) could develop and implement these changes.

Rental properties

Addressing split incentives in existing structures is challenging because developing a policy that restructures landlord-renter relationships may not be feasible. Therefore, the provision of subsidies and/or direct services may be necessary. To be effective, both will require the *targeted* use of a considerable amount of money. For example, the 2009 American Recovery and Reinvestment Act allocated $5 billion to the Department of Energy to weatherize low income homes. This directly addresses the barrier that upfront cost poses to efficiency improvements, but addresses split incentives only indirectly. Targeting subsidies toward the most inefficient rental properties, both residential and commercial, may be the most viable way to overcome this barrier. Subsidies should target property owners, as they likely have a longer-term stake in a given property as well as the authority to make permanent improvements. Since the owners of rented properties will not receive payback for their investment through smaller utility bills, subsidies need to be large enough so that improvements are not perceived to be a loss of money. Once energy savings materialize, landlords may be able to renegotiate rental rates with tenants.

Several states have addressed the split incentive problem by either requiring or rewarding utilities for procuring maximum cost-effective efficiency savings. This places the utility (or the third party administrator, in some states) in a position to work with landlords and tenants to install efficiency measures. In some states, this can take the form of a “pay as you save” model, in which utilities install efficiency measures and allow customers to pay the upfront costs incrementally as part of their monthly utility bill. If the customer moves to a new location, the next tenant or owner inherits the efficiency measure and continues paying the incremental charges until the measure is paid back. (Midwest Energy, 2009). Utility administration of efficiency programs is most effective with commercial and industrial customers, whose greater energy use creates greater opportunities for customer savings.

3.3.5 Policy instruments to minimize consumer choice failure

Consumers sometimes forgo economically rationale efficiency improvements because of high personal discount rates, limited information, and non-financial considerations like trust and convenience.

Although personal discount rates cannot be altered by policy, relatively simple changes in program design can address the other causes of consumer choice failure. Limited information makes it difficult for consumers to determine how much energy and money they will actually save over a given period with the purchase of efficient, but initially more expensive, products. Efficiency labels like EnergyStar are already credited with saving approximately 0.93 QBtu of energy a year (Gillingham, Newell, & Palmer, 2004). The addition of standardize quantitative information about energy use, similar to the fuel efficiency ratings given to vehicles, could do more to encourage efficient product purchases.

"Cost" includes investments of time as well as money. Efficiency improvements often are unfamiliar and time intensive. If there is doubt about the accuracy of product information, or there are questions about the legitimacy of an efficiency promoting program, or if a large amount of paperwork is required to receive a subsidy, consumers may conclude the efficient purchase is not worth the extra trouble. The importance of maximizing consumers' trust and convenience presents another argument in favor of standardized information. It also suggests that efficiency programs be implemented by entities consumers perceive as trustworthy. Consumers are aware of the conflict of interest utilities face when encouraging efficiency and have expressed their skepticism through lower participation rates in utility-administered programs (Miller & Ford, 1985). This suggests that unless the decoupling of utilities profits and sales volume can be effectively and *transparently* achieved, responsibility for the administration of energy efficiency programs should be relocated.

3.4 Trade-offs and unintended consequences of efficiency policy

Several caveats are frequently raised in the face of efficiency-focused policies. These include that (a) efficiency gains lead to an increase in the consumption of energy services, (b) efficiency incentives result in the premature turn-over of equipment, and (c) price increases resulting from new efficiency requirements cause people to use inefficient products longer. These side-effects of successful policy can diminish the potential energy savings from efficiency improvements.

3. 4.1 Rebound Effect

The familiar paradox that improvements in efficiency can lead to increased overall consumption in energy services is often casually pointed to as a means of lowering expectations about efficiency's ultimate energy savings potential (Schiermeier, Tollefson, Schully, Witze, & Morton, 2008; Pearce, 1998). This "rebound effect" deserves systematic examination.[3] Can the size of a rebound be predicted? How quickly will it come about? To what extent will it impact the return on energy efficiency investments and how might this rearrange policy priorities? Is it inevitable? These questions are often dismissed, giving general rebound effect criticisms undue influence in many areas, while diluting its message in areas where it poses a significant concern.

Studies consistently find that, under normal market conditions, rebound reduces the energy savings of efficiency improvements (Saunders, 2000). The effect's estimated size depends in part on the economic context in which the efficiency improvements occur. Larger rebound effects are seen in developing countries and among low income consumers in wealthy countries (Schipper, 2000). In the United States, rebound has been estimated to decrease potential energy savings by between 10 and 40 percent (ibid). A summary of the empirical estimates of the rebound effect for efficiency improvements for specific end-uses can be found in Appendix 3B.

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[3] See *Energy Policy's* (2000) special issue on the rebound effect for a thorough, technical treatment of the subject.

Policy interventions have the potential to prevent or reduce the expected rebound. For example, implementation of the idea of "high rates and low bills" could considerably reduce rebound. Under this scenario, energy efficiency improvements would make for a lower overall energy bill, while a higher per unit cost of energy would continue to encourage reduced use.

3.4.2 Premature equipment turnover

Energy efficiency frequently requires the retirement of old inefficient equipment. However, a rush towards more efficient appliances, vehicles, and even buildings may lead to premature turnover and replacement. Energy is an input to the manufacturing of these products, and efficiency requires that the energy embodied in the production of replacements be more than compensated for by the savings provided by their more efficient operation (Bin & Dowlatabadi, 2005).

For example, the average 3,330 pound automobile requires approximately 100.4 mmBtu to manufacture (Burnham, Wang, & Wu, 2006). Assuming a lifespan of 12 years, this is equivalent to 8.4 mmBtu a year. Therefore, the early retirement of a vehicle will only yield net energy savings if the amount of energy saved by the operation of its more efficient replacement exceeds 8.4 mmBtu a year. Given these parameters, the replacement of a vehicle that gets 20 miles per gallon with one that is 25 percent more efficient saves 13.7 mmBtu a year, and thus is easy to justify. However, replacing a 35 miles per gallon vehicle with one that is 25 percent more efficient actually results in more net energy expended when its manufacturing is considered (see Appendix 3C for calculations). In sum, policy makers should be cognizant of the energy embodied in the production of efficient replacement products and structure policy to avoid the premature retirement of in-service equipment.

3.4.3. Delayed equipment turnover

The opposite problem can also occur. If minimum efficiency requirements are strengthened, the upfront costs of goods will likely increase. Even if they are cost effective and can start saving consumers money in a matter of weeks, the higher initial costs may cause consumers to postpone new purchases. Thus, inefficient products would be kept in use longer than they otherwise would. This response is particularly likely to occur among low income consumers. Subsidies and tax incentives could counteract this effect, but must be carefully structured to avoid accelerating turnover.

3.5 Who should be responsible for administering energy efficiency policy?

State and federal governments share responsibility for developing and implementing energy efficiency policy. Cumulatively, states are estimated to have invested two to three times more resources than has the federal government into pursuing energy efficiency (Eldridge, Neubauer, York, Vaidyanathan, Chittum, & Nadel, 2008).

The federal government has a clear role in shaping energy and efficiency subsidies and designing product standards and information/label requirements. It also determines its own actions as the nation's single largest energy consumer (U.S. Government Accountability Office, 2008). The federal government can utilize these policy instruments directly to encourage energy efficiency. Its role in some other areas of energy efficiency policy is limited by statutes that block its direct involvement.

State governments have primary regulatory oversight of the utilities operating within their borders.[4] State regulators work with utilities to determine future energy needs and supply options, rate structures, and frequently task them with administering efficiency programs and/or achieving efficiency goals. State and local governments also determine local building codes. Federal policy has only indirect influence in these areas: it can employ financial incentives for state action and act as a clearinghouse of information about best practices and new innovations. If the federal government requires a more direct role to promote national energy efficiency, it will need to redistribute power from the states to the federal government, as is being considered with development of the smart grid.

4.0 Conclusions

Energy efficiency remains one of the "low hanging fruits" for addressing the United State's energy challenges. Many technically feasible and cost efficient improvements have not been made because of a number of financial and structural barriers. These barriers increase the cost of efficiency improvements, reduce and divide their resulting benefits, and contribute to consumer choices which are "irrational" from a strict economic point of view. Many of these barriers can be mitigated through relatively modest regulatory and programmatic changes and/or subsidy shifts. The pursuit of cost effective efficiency improvements has the potential to offset growth in U.S. energy demand over the next decade. In doing so, it will contribute to energy security and environmental protection, while potentially developing a new sector of green jobs.

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[4] The Federal government operates several wholesale utilities: the Tennessee Valley Authority and Bonneville Power Administration, Southwestern Power Administration, and the Western Area Power Administration. It has direct regulatory power over these utilities and can set their rates and rate structures.

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Appendices

Appendix 3A: Calculation of potential energy savings from cost effective efficiency investments (in Qbtu)

Transportation

1.12	Projected savings from "cost effective" 40 mpg standards*
0.367	Effect of reducing speed limit to 55 mpg (1.3% drop in fuel consumption coverted into Qbtu)
0.537	Increase in fuel economy from properly inflating tires (increase 40 mpg fuel economy by 3%)
2.024	Total additional cost effective energy savings

*This draws from the ACEEE estimate that the 2007 increase in CAFÉ standards from 27 to 35 mpg will result in a savings of 1.03 million barrels of oil a day by 2020. Assuming proportionate savings as standards tighten, an increase from 35 to 40 mpgs should yeild an additional .644 million barrels in savings each day (1.03/8 = .128 *5 = .644). This converts to 1.12 Qbtu a year.

Appendix 3B: A Summary of Empirical Evidence for Rebound Effects

Economic actor	**End use**	**Potential size of rebound**	**Number of studies**
Consumers	Space heating	10-30%	26
	Space cooling	0-50%	9
	Water heating	<10-40%	5
	Residential lighting	5-12%	4
	Appliances	0%	2
	Automotive transport	10-30%	22
Firms	Process uses (short-run)	0-20%	1
	Lighting (short-run)	0-2%	4
Economy-wide effects	Change in total output growth (increase of standard of living)	.48%	1

Adapted from: Greening, Greene, & Difiglio (2000)

Appendix 3C : Calculations of total annual energy savings obtained through vehicle replacement

Hypothetical in-use vehicle

Vehicle Production		
Energy for vehicle production[1]	100,400,000	Btu
Vehicle lifespan	12	yrs
Annualized energy input, vehicle production	*8,366,667*	*Btu/yr*
Vehicle Operation		
Annual vehicle miles travelled	12,000	mi
Fuel economy	**20**	mi/gal
Annual gallons of gasoline used	600	gal
Btu per gallon of gasoline[2]	114,000	Btu/gal
Annual energy requirements, vehicle operation	*68,400,000*	*Btu*

Vehicle with 25% better fuel economy

Vehicle Production		
Energy for vehicle production	100,400,000	Btu
Vehicle lifespan	12	yrs
Annualized energy input, vehicle production	*8,366,667*	*Btu/yr*
Vehicle Operation		
Annual vehicle miles travelled	12,000	mi
Fuel economy	**25**	mi/gal
Annual gallons of gasoline used	480	gal
Btu per gallon of gasoline	114,000	Btu/gal
Annual energy requirements, vehicle operation	*54,720,000*	*Btu*

Annual energy savings from efficient vehicle operation:

13,680,000 Btu

Total annual energy savings from vehicle replacement (production and operation):

5,313,333 Btu

Hypothetical in-use vehicle

Vehicle Production		
Energy for vehicle production[1]	100,400,000	Btu
Vehicle lifespan	12	yrs
Annualized energy input, vehicle production	8,366,667	*Btu/yr*
Vehicle Operation		
Annual vehicle miles travelled	12,000	mi
Fuel economy	**35**	mi/gal
Annual gallons of gasoline used	343	gal
Btu per gallon of gasoline[2]	114,000	Btu/gal
Annual energy requirements, vehicle operation	39,085,714	*Btu*

Vehicle with 25% better fuel economy

Vehicle Production		
Energy for vehicle production	100,400,000	Btu
Vehicle lifespan	12	yrs
Annualized energy input, vehicle production	8,366,667	*Btu/yr*
Vehicle Operation		
Annual vehicle miles travelled	12,000	mi
Fuel economy	**44**	mi/gal
Annual gallons of gasoline used	274	gal
Btu per gallon of gasoline	114,000	Btu/gal
Annual energy requirements, vehicle operation	31,268,571	*Btu*

Annual energy savings from efficient vehicle operation:

7,817,143 Btu

Total annual energy savings from vehicle replacement (production and operation):

(549,524) Btu

[1] Data on the amount of energy to produce a typical 3,300 lb internal combustion engine vehicle from Argonne National Laboratory, Energy Systems Division

[2] Data on the amount of energy (in Btu) per gallon of gasoline from NAFA Fleet Management Association

All other values are hypothetical