ENERGY EFFICIENCY AND ENERGY POLICY

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Summary

Policy makers in both developed and developing countries are concerned about the efficiency with which energy is utilized. Higher efficiency means lower costs and lower environmental emissions. Both are major issue in the transportation sector as well as in electric and natural gas sectors; the latter two being the focus of the present article. After trying centralized command-and-control techniques to increase energy efficiency, many policymakers now favor standards, economic incentives, and market transformation to achieve the same objectives.

1. Introduction

Energy is an essential input to all economic endeavors, whether it is manufacturing, transportation, agriculture, or the domestic sector. What form of energy is used in a given process, and how much, is determined by many factors; for example, its availability and relative cost, the available infrastructure and technology, as well as other factors such as local customs, preferences, and regulations—when applicable. If a given form of energy (e.g. natural gas) is not available in a given area, then something else (e.g. fuel oil) is substituted. If labor is cheap relative to energy, then a more labor-intensive process may be utilized. The reverse happens in areas where labor is scarce and energy is relatively cheap. The choice of equipment or capital stock utilized is strongly influenced by the costs of inputs and the output of the process.

As a rule, rational firms and individuals choose the combination of inputs—capital equipment, labor, and energy—in proportions that minimize the costs and produce the best results. In practice, the choice is complicated by many factors, and strongly influenced by the present stock of capital equipment at a firm's or individual's disposal. This tends to be a major determining factor in how, and how much, energy is used, since capital stocks have a long life and are seldom replaced before they are physically worn out. Local customs, culture, and regulations also play a significant role.

Policymakers in both developed and developing countries are rightfully concerned about efficiency with which energy is utilized. Higher utilization efficiency means lower costs, improved productivity, and has the added advantage of lowering environmental emissions. This article is focused on efforts and techniques to encourage efficient use of energy in the electric (and natural gas) sectors. The transportation sector, which primarily uses liquid petroleum products, is not addressed here.

2. Why Energy Efficiency Matters

Energy utilization efficiency, broadly defined as a unit of energy input needed to produce a dollar of output in a given process, is an important measure of overall productivity or efficiency. If a firm can produce twice the output using the same input of energy in a given process—all else being equal—it would have a significant comparative advantage relative to its rivals. Aside from pure economic benefits, energy efficiency has other benefits, including lower environmental emissions per unit of output.

The environmental benefits, however, are not monetized because there are currently few or no direct costs associated with emitting most greenhouse gases (for example, CO_2) into the atmosphere. If these costs were internalized (for example, due to CO_2 taxes), then there would be strong incentives to further increase the efficiency with which energy is utilized. Some emissions associated with manufacturing (for example, water and waste) are regulated, and these impose tangible costs on the production processes where they apply. Finally, there are concerns about national security and over-dependence, particularly in countries where energy has to be largely imported.

But even setting environmental externalities and national security concerns aside, there are ample reasons to be concerned with the efficiency of energy use. For many industries, particularly those where energy represents a significant percentage of their operating costs, using energy efficiently is a matter of business survival. For smaller users, whether in the commercial or residential sector, efficient use of energy results in higher discretionary income, which can be used for other essential goods and services.

Relatively speaking, low-income consumers stand to benefit disproportionately from energy efficiency because a significant percentage of their income goes to pay for energy. These consumers, however, are least able to afford to invest in efficient appliances that use less energy. For all these reasons, policymakers in both developed and developing countries are concerned about the efficiency with which energy is utilized in all sectors of the economy.

3. The Electricity Supply Industry (ESI)

This article is focused on the efficient use of energy in the electricity, and to a lesser degree, the natural gas sector. In most industrialized countries, over one third of primary energy (for example, coal, hydro, nuclear, natural gas, and fuel oil) is used in the electric power sector. The percentage is higher the more advanced the economy, and continues to grow as an increasing percentage of the gross domestic product (GDP) comes from services. With the widespread developments in information technology and electronic commerce, electricity will play an even more significant role in advanced economies in the future.

The electricity supply industry (ESI) is basically an energy conversion and distribution business. It takes in various forms of primary energy and converts them into electricity—which is the cleanest and most versatile form of energy known to mankind. Once converted to electricity, the energy flows through a massive transmission and distribution network to end-users. At the point of ultimate use, electricity is clean (i.e., has no emissions or by-products); efficient (i.e., a large percentage of the energy can be converted into useful services such as heat, lighting, or motor power, depending on the application); and highly versatile (it can run an entire factory or a single electric tooth brush).

Electricity, however, has some peculiar characteristics. For example, once it is generated, it must be instantly used. It cannot be easily or inexpensively stored. This instantaneous matching of supply and demand poses some interesting challenges for the system operators. Another noteworthy feature of converting primary to electrical energy is that a significant percentage of the energy is lost during the conversion (or generation) process—as high as one third. Depending on many factors, most importantly the distance and the voltage level, a smaller percentage of the energy is lost in transmission and distribution, of the order of 10 percent. In some developing countries, a significant amount of energy is illegally diverted from the distribution network, further reducing the amount that reaches the legitimate end customers.

Hence, by the time electricity reaches the wall outlet in a typical home or office, a significant percentage of the original amount of energy, contained in the barrel of oil or the pile of coal that was used at the power plant, has already been lost. This article's primary focus is on the efficiency with which electricity is used once it reaches the end users. What happens up-stream (i.e., before electricity reaches the customer's premises), while highly important, is not addressed in this article.

3.1 Energy Conservation and Energy Efficiency in the ESI

Policymakers have long been interested in the efficient use of energy in the ESI, in generation, in transmission, in distribution, and at the point of consumption, the latter aspect being the main focus of what follows. The reasons for this focus are obvious. First, as already mentioned, the ESI accounts for a significant and growing percentage of energy used in most industrialized countries. Consequently, along with the transportation sector, power generation is the most visible source of pollution and environmental emissions. Reducing energy use at the point of consumption reduces the amount of pollution at the power plants. While there is no disagreement on the end, there is considerable debate on the means. That is to say, there is no consensus on how best to reduce consumption at the point of use, by how much, or through what means.

The fundamentals are straightforward. One can reduce electricity usage at the point of consumption by:

- cutting down on activities that use a lot of energy, for example, by substituting more labor or capital in order to use less electricity;
- getting by with less, for example, by setting the thermostat at a lower level in the winter (and putting on a sweater); or
- using energy more wisely and efficiently, for example, by replacing old and inefficient appliances with more modern and efficient ones.

The first option may include reducing reliance on certain heavy electricity-using processes, such as aluminum smelting. Prices tend to rationalize the use of electricity to the most value-added activities in given countries and regions. This explains why heavy electricity-using industries tend to locate in areas where electricity is plentiful and inexpensive (such as in Norway or Tasmania, both blessed with ample, inexpensive, hydroelectric energy). This also explains why heavy manufacturing, which tends to be energy (and labor) intensive, has gradually been migrating to developing countries, where labor and energy costs tend to be lower.

The second option includes practices such as:

- reducing non-essential uses (e.g. outdoor advertising);
- reducing discretionary uses (e.g. street lighting); or
- slightly reducing the level of service or comfort (e.g. office lighting, particularly in hallways or garages, or adjusting the thermostat in the summer or winter).

There is much room for such adjustments in rich industrialized countries where huge quantities of energy are superfluously used and/or wasted with little tangible effect on comfort or standard of living. Having said this, one must point out that defining what is essential or discretionary is highly subjective—and controversial. For example, while many environmentally conscious citizens may consider outdoor advertising as superfluous and undesirable, others may not. In any event, these efforts are referred to as energy conservation. This term has the connotation of getting by with less.

The third option, using energy more wisely and efficiently has, by far, the greatest potential and deserves most attention. Many schemes, of course, address more than one objective.

3.2 Definitions: Energy Conservation, Energy Efficiency, Conservation and Load Management (CLM), and Demand-Side Management (DSM)

Four terms are predominately used in energy efficiency literature:

- energy conservation;
- energy efficiency;
- conservation and load management (CLM); and
- demand-side management (DSM).

There are subtle, but important, differences among them.

The term energy conservation usually suggests using less, settling for a lower standard of comfort, or getting by without. For these reasons, it has a negative connotation. Energy efficiency, on the other hand, suggests no lowering of standards of comfort, no cutting back, or going without. It refers to using energy wisely, smartly, and efficiently. There are no negative connotations. These two terms are equally applicable to all forms of energy, not just electricity.

The term conservation and load management, or CLM, is specific to ESI and combines conservation (using less at all times) with load management (using less during peak demand periods). Demand-side management or DSM, refers to a wide range of initiatives, undertaken by a utility and/or customer, on the demand side to change the pattern and/or the amount of consumption in desired ways. The term was coined in the early 1980s by Clark Gellings of the Electric Power Research Institute (EPRI). A practical definition, attributed to Gellings, is:

Demand-side management (DSM) is the planning and implementation of those utility activities designed to influence customer use of electricity in ways that will produce desired changes in the utility's load shape—i.e., in the time pattern and magnitude of a utility's load. Utility programs falling under the umbrella of demand-side management include load management, new uses, strategic conservation, electrification, customer generation, and adjustments in market share.

Another popular term, coined by Amory Lovins of the Rocky Mountain Institute (RMI), is negawatts, which refers to megawatts not used, or conserved. A negawatt is an unused megawatt. In a widely publicized article in the *Scientific American*, A. Fickett, C. Gellings, and A. Lovins show two vastly different estimates of the potential for electricity savings (Figure 1).

The different estimates presented in Figure 1 are the result of different assumptions about what is physically possible versus what is economically cost-justified and practical. Lovins, a physicist by training, adheres to the former, while Fickett and Gellings focused on the more pragmatic latter approach.

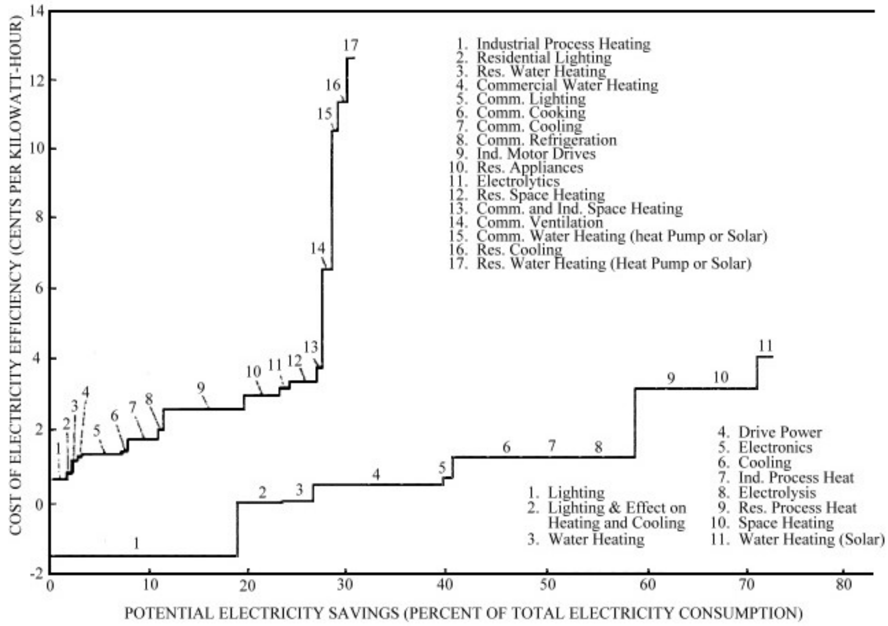

Figure 1. Potential for Electricity Savings: Two Approaches, Two Very Different Outcomes (Source: A. Fickett, C. Gellings, and A. Lovins, *Scientific American* (1990))

4. A Brief History of Energy Conservation in North America

The interest in energy conservation in North America, as in many other countries, has had its ups and downs. The first surge in interest followed the Arab oil embargo of 1973 and the ensuing energy crisis. Prior to 1973, energy prices in general, and electricity prices in particular, were low by international standards and were falling in real terms. Utilities had no incentives to promote energy conservation and consumers had little or no interest in participating in such activities.

The 1973 energy crisis, which resulted in a quadrupling of oil prices, was a major shock to this period of price stability and plentiful supplies. Electricity prices were adversely affected, particularly in areas that relied heavily on oil and natural gas for electricity generation. Suddenly, energy conservation was a high priority. Utilities and the policymakers were unanimous in their desire to reduce energy consumption through energy conservation schemes.

It was during this period that the US President Jimmy Carter held his much publicized television addresses to the American people, wearing a sweater and sitting by the fireplace. His message was to lower the thermostats, turn off the lights in unoccupied rooms and observe a newly-set 55 miles-per-hour speed limit to reduce energy consumption.

He called energy conservation the “moral equivalent of war.” Energy conservation, in this context, meant reducing superfluous consumption (say, by turning off outdoor advertising lights) as well as doing without (say, by driving less) or getting by with less (say, by turning down the thermostat and putting on a sweater to stay warm, driving at a lower speed, and so on).

The effect of these early conservation measures was initially quite noticeable and relatively painless. Overnight, millions of signs were posted by every light switch in every office building, asking the occupants to "Please Turn the Lights Off When Leaving."

Similarly, lower thermostat settings in the winter and higher settings in the summer had an immediate effect at virtually zero cost. In many offices, every other light in the hallways and stairways was removed at little cost and negligible impact on quality of service. Thousands of ornamental fountains and outdoor floodlights on public buildings (including some in the White House) were turned off as symbolic gestures.

There were two reasons for the early success of these energy conservation measures. First, the American people truly believed that conserving energy was necessary and the right thing to do. Second, so much energy was being wasted on so many superfluous things that it took virtually little or no effort and very little personal sacrifice to conserve energy.

For many US utilities, load management (for example, shaving peak load consumption) made even more sense. If the utility could convince its customers to use less energy during heavy demand periods (which normally rely on inefficient oil- or natural gas-fired peaking units) then everyone would save money.

Not surprisingly, conservation and load management, or CLM, became popular in the mid-1970s in the US electric power industry. Many of the practices of the US utilities were equally applicable to other regions of the world and were quickly adopted and applied elsewhere.

This period of relatively painless CLM activity and high level of customer participation and interest, however, gradually faded. Oil prices, which were a visible yardstick for all energy prices, reached their all-time high in 1980 and collapsed in 1981. Not surprisingly, customers lost interest in energy conservation.

They got tired of turning off the lights, turning down their thermostats, and putting on their sweaters. More importantly, they no longer perceived a compelling reason to do so. The government and the utilities also lost their energy conservation fervor. US utilities, in particular, learned that successful energy conservation can in fact significantly cut into their kWh sales and hence put upward pressure on their rates.

Beginning in the early 1980s, utilities began to gradually—and quietly—phase out some of their CLM programs. The regulators either didn't notice at first or chose to ignore the trend.

In the mid 1980s, the regulators in influential California and the Northeast became alarmed at the rapidly declining CLM budgets and equally dramatic drops in energy conservation results. The regulators decided that they had to act forcefully. But how were they to reverse the downward trend in CLM and the customer apathy? The customers were no longer interested in energy conservation; the utilities were not particularly keen on selling fewer kWhs. The regulators' answer was to devise regulatory-mandated energy conservation, or demand-side management (DSM). They could set DSM goals or spending targets.

To reduce utilities' resistance, however, the regulators had to allow full recovery of prudent DSM expenditures as well as full recovery of lost revenues. Lost revenues refer to kWhs conserved or not sold as a result of successful DSM programs.

Under such schemes—which were widely endorsed in many states, US utilities would feel little or no pain when they engaged in DSM activities. This was a necessary, but not sufficient, condition for active embracement of DSM by privately-held, profit-driven, utilities.

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Biographical Sketch

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