Chapter 2
Energy Efficiency Becomes First Fuel

Abstract Energy efficiency can be defined as an energy resource because energy efficiency is capable of yielding energy and demand savings that can displace electricity generation from primary energy resources. Investments in energy efficiency and the resulting resource benefits are factored directly into utility energy resource decision making about investing in new resources and operating existing systems. Defining energy efficiency as a resource and integrating it into utility decision making is especially critical because of the clear resource cost advantage of energy efficiency. Energy savings from customer energy efficiency programs are typically achieved at one-third of the cost of new generation resources. Efficiency programs can also reduce the need to install, upgrade, or replace transmission and distribution equipment. In addition, energy efficiency when integrated with smart grid technologies can improve system reliability and allow utilities to reduce and manage peak demand in their power systems. Finally, energy efficiency will reduce fossil fuel consumption and increase energy security; it is indeed considered the first fuel now by many countries.

2.1 History of Energy Efficiency—A Hidden Fuel

Prior to the first energy crisis in 1973, there was little discussion on energy efficiency. Oil had been cheap, and discoveries of new oil fields offered a promise of many years of sustainable oil supply. However, Meadows et al. (1972) pointed out that finite resource supplies could not sustainably support the exponential economic and population growth. In their book, Meadows and his co-authors (1972) used a computer model (the world model) to simulate the consequence of interactions among world population, industrialization, pollution, food production, and resource depletion, presented a new intellectual trend for human beings to use limited resources efficiently. In 1973, the Arab oil embargo to the Western industrialized countries awaked concerns about threats to national energy security for oil-importing countries. This new vision saw that increasing energy demand along with

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shortages of fossil fuel supplies would threaten economies built on the promise of cheap energy, and oil-importing countries would have to seek efficient use of energy.

Lovins (1976) articulated the implication of the new vision for energy efficiency policy in *Energy Strategy: The Road Not Taken.* The paper described alternative sources of energy that were plentiful, renewable, and more environmentally benign than fossil fuels. The key point of Lovins's argument was the development of the concept of energy efficiency: using less energy to produce more economic output. "*My own view is that we are adaptable enough to use technical fixes alone to double, in the next few decades, the amount of social benefit we wring from each unit of end-use energy. Then over the period 2010–2040 we should be able to shrink per capita primary energy use to perhaps a third or a quarter of today's*" (Lovins 1976). Soon after the publication of this paper, ideas about energy efficiency as a fuel began having a significant effect on government policies.

Energy efficiency as a fuel contributed the largest share of "energy use" in the first 11 IEA member countries. The IEA estimated that energy efficiency policies in its first 11 member countries (Australia, Denmark, Finland, France, Germany, Italy, Japan, Norway, Sweden, UK, and USA) saved approximately 65 % actual energy use in 2010 (Fig. 2.1). Since 1974, energy efficiency in the 11 countries avoided burning of 1.5 billion tonnes of oil equivalent. Between 2005 and 2010, these 11 countries made energy bills equal to US$420 billion, and the saved energy is more than what any other single fuel source provided. In 2010, energy efficiency as a fuel met 65 % of total final consumption of energy in the 11 IEA member countries.

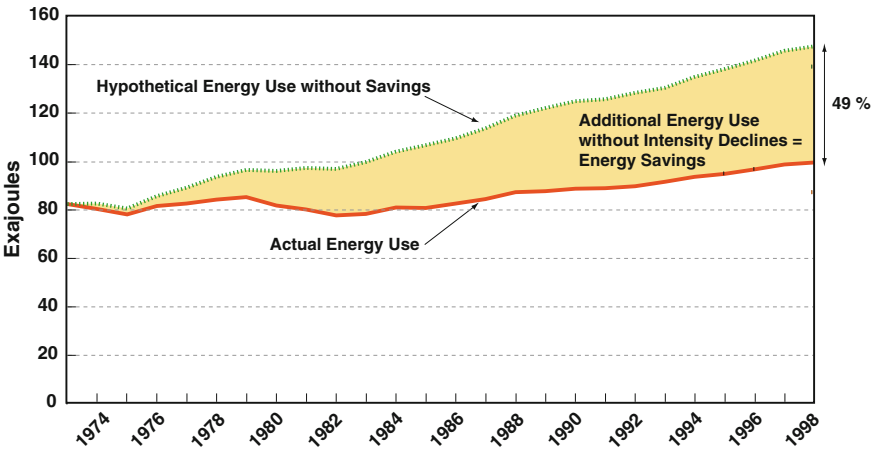

Fig. 2.1 Impact of energy policy on energy efficiency improvement in IEA countries. *Source* Yang (2013)

Without these energy efficiency measures implemented from 2010 to 2013, consumers in these 11 countries would have been paying two-thirds more than they paid for their energy bills (IEA 2013b).

However, despite being the most cost-effective and clean energy resource, energy efficiency was not always treated as the first fuel. In energy and power expansion planning, people kept forgetting it as a resource of energy supply against coal, oil, and natural gas. Energy efficiency was not included in any country on the list of the "all of the above" energy policies and strategies discussed in public discourse and government energy plans. Indeed, in the global phenomenon, energy efficiency was referred as a "hidden fuel" before 2010.

2.2 Energy Efficiency as the First Fuel

The IEA estimated the efficiency potentials at a range of approximately 20 to 50 % of total final energy consumption. According to IEA (2007), energy efficiency policy in 11 OECD countries between 1973 and 1998 had saved approximately 49 % of energy use (Fig. 2.1). Jollands et al. (2010) showed that energy efficiency policy will be able to help save an average of 20 % of final energy consumption from 2010 to 2030 in five major sectors, namely buildings, equipment, lighting, transport, and industry in OECD countries. IEA (2013a) stressed that energy efficiency should be treated as "the first fuel" rather than "the hidden fuel." It also indicated that global energy efficiency investments and their effects on energy supply are now equal to the net contribution of other energy resources. "Energy efficiency has been called a 'hidden fuel', yet it is hiding in plain sight," IEA Executive Director Maria van der Hoeven said as she presented an IEA report at the Second World Energy Congress in Korea in 2013. "Indeed, the degree of global investment in energy efficiency and the resulting energy savings are so massive that they beg the following question: Is energy efficiency not just a hidden fuel but rather the world's first fuel?" (IEA 2013b).

2.3 The First Fuel Never Runs Out

There is always a potential to enlarge the first fuel in any country or any sector due to at least three driving factors. First, energy prices are generally growing all the time since the energy resources are limited and energy demand is increasing. Second, government policies on energy and climate change always require industries, businesses, and the households to adapt stricter and high energy standards and codes. Third, energy-efficient technologies, products, and equipment are always invented and made to harness the first fuel, either in developed or developing

countries. These factors drive countries to move toward being more and more energy efficient, regardless how efficient the country is already.

For example, Japan always has new sources of the first fuel supply from energy efficiency. With a long history of energy efficiency policies and improvement efforts, by 1990, Japan was already a relatively efficient economy, with comparatively fewer opportunities to improve energy efficiency. However, energy efficiency has been the main contributor to the reduction in actual energy use since 2000 (IEA 2013b). From 2001 to 2012, Japan's energy intensity has been decreasing from 0.14 to approximately 0.11 tonnes of oil equivalent (toe) per US$1,000 (2005 constant price), which was well below the world average of 0.187. In addition, per capita energy use has also declined since 2004, reaching 3.5 toe per person, also below the IEA average of 4.5. However, in 2012, Japan could still save its consumers US$3 billion in energy bill reductions, with more efficient lighting, vehicles, and appliances (IEA 2013b) (Fig. 2.2).

Other countries have also gained the first fuel supply from energy efficiency improvement and energy intensity reductions. According to the IEA (2013a), in 2012, the USA made the biggest relative improvement in energy intensity as a result of efficiency gains in industry and services, together with fuel switching in power generation to natural gas. The second biggest improvement was in Russia due primarily to lower energy use per unit of output in industry and services. Russia was closely followed by China, where efficiency improvements in industry and higher output from hydropower and other renewables led to a 4 % improvement in energy intensity in 2012. From being four times higher than the global average in 1990, China's energy intensity is now less than twice the global average. In the Middle East, in contrast to other regions, energy intensity increased in 2012, mainly due to increased activity in energy-intensive industry (e.g., petrochemicals) and rapid energy demand growth in buildings and transport. Energy intensity across almost all regions improved over the last two decades. Between 1990 and 2000,

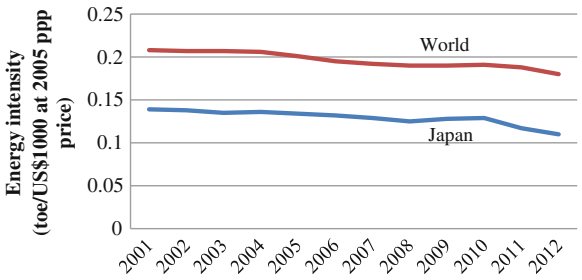

Fig. 2.2 Energy intensities of Japan and the world. *Source* Authors developed chart from data of Yang (2013) and IEA (2013b)

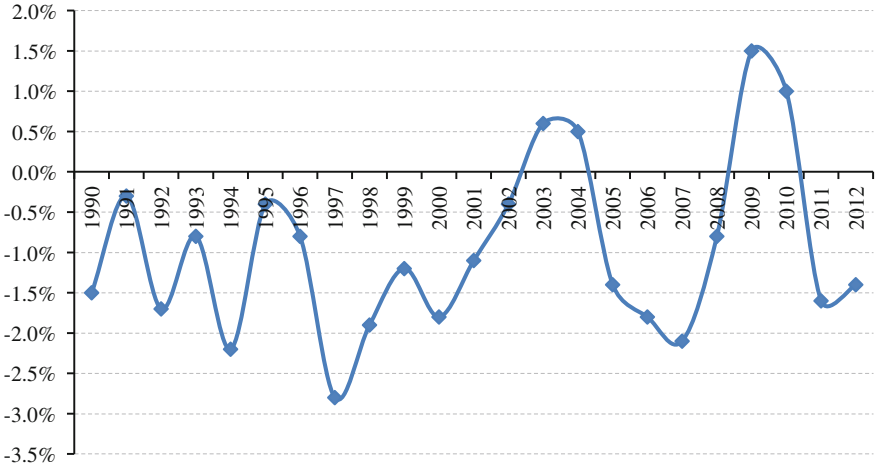

Fig. 2.3 Annual average change in global primary energy intensity, 1990–2012. *Source* Authors developed chart from self-collected data and calculations

global energy intensity (disregarding changes in the regional makeup of regional GDP) improved by 1.4 % per year and 1.8 % per year over the period from 2000 to 2012 (Fig. 2.3).

2.4 The Future Potential of the First Fuel

The IEA (2012) showed that if new energy efficiency policies and technologies had been put into practice and operation, the 11 IEA first member countries would have been able to achieve much more savings. Figure 2.3 shows the percentages of energy savings achieved in industry, transport, power generation, and buildings against the full potential of energy savings with the implementation of the new government policies and new energy-efficient technologies.

In OECD countries, energy efficiency policies and technologies would help generate the first fuel about 2.2 billion toe to meet an average of 20 % of total final energy consumption in 2030 in five major sectors, namely buildings, equipment, lighting, transport, and industry (Fig. 2.4). If other sectors are considered, the saving potential would be more than 20 %. The potential for generating the first fuel from energy efficiency in developing countries could be higher than IEA/OECD countries because of the widespread use of inefficient energy technologies. There is a huge economic opportunity to develop the first fuel globally, and the world is not even close to tapping it yet.

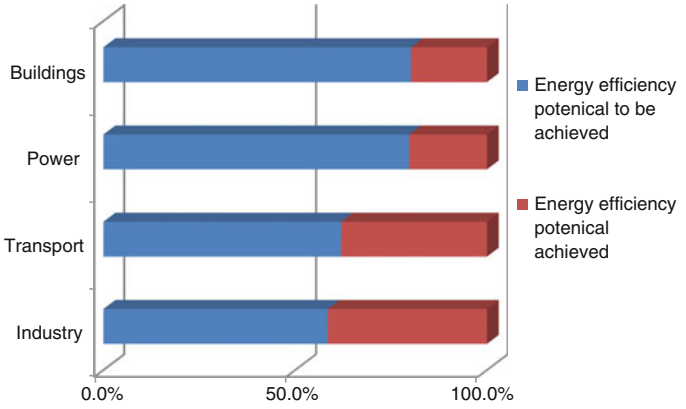

Fig. 2.4 Proportion of economic energy efficiency potential 2012–2035. *Source* Authors developed chart from data of the IEA and others

2.5 Challenge to the First Fuel

The "first fuel" has not been widely accepted in the world due to a large number of challenges and barriers. The major challenge is fossil fuel production and consumption subsidies, which distort energy efficiency markets in many countries, pushing up energy use and emissions, and engendering large economic costs. Fossil fuel consumption subsidies worldwide were estimated to have totaled US$544 billion in 2012 (IEA 2013a). Investment in energy efficiency was approximately US $300 billion, although it is cheaper and more effective than any other energy resources (renewables and fossil fuels) in terms of meeting the increasing world energy demand and mitigating global environment pollution. As such, the total investment in energy efficiency was still less than two-thirds of the level of fossil fuel subsidies in the world in 2012. Where there are more energy subsidies, there are less energy efficiency investments. Besides this major challenge, there are other barriers to energy efficiency as the first fuel. Chap. 6, after the methodology chapter, presents details of these barriers and approaches to removing them.

2.6 Applications of Energy Efficiency as Fuels

Energy efficiency resource standards (EERS) in the USA established specific, long-term targets for energy savings that utilities or non-utility program administrators must meet through customer energy efficiency programs. An EERS can apply to either electricity or natural gas utilities, or both, depending on the state, and can be adopted through either legislation or regulation. An EERS is similar in concept to a renewable energy standard (RES) or renewable portfolio standard (RPS). While an

RES requires that electric utilities generate a certain percentage of electricity from renewable sources, an EERS requires that they achieve a percentage reduction in energy sales from energy efficiency measures. In terms of result impact to the country, both RES and EERS perform as fuel supplies to the country.

As of July 2013, 25 states in the USA have fully funded policies in place to establish specific energy-saving targets that utilities or non-utility program administrators must meet through customer energy efficiency programs. The strongest EERS requirements exist in Massachusetts and Vermont, which require almost 2.5 % savings annually.

A federal EERS would complement existing state-level energy efficiency standards by setting a national goal for energy savings that would be implemented over a specific period of time. The American Clean Energy Security Act of 2009 proposed a 5 % efficiency target, with an option for governors to petition that an additional 3 % of the reductions come from efficiency in their states. Because business-as-usual projections for efficiency savings in 2020 are already close to 5 % of nationwide electricity sales, a 10 % requirement as a more appropriate target would have a significant and positive impact on the US economy.

At both the federal and state levels, an EERS is a critical policy that lays the foundation for sustained investment in energy efficiency to harness the first fuel. The long-term goals associated with an EERS send a clear signal to market actors about the importance of energy efficiency in utility program planning, creating a level of certainty that encourages large-scale investment in a cost-effective manner to use the first fuel to power economy.

2.7 Summary

Energy efficiency as the largest share of fuel has significantly contributed to meeting energy demand in the first 11 IEA member countries over the past 40 years. Since 1974, energy efficiency in these 11 countries helped to avoid burning 1.5 billion tonnes of oil equivalent. Between 2005 and 2010, these 11 countries achieved saving US$420 billion in importing energy from the international market. Without these energy efficiency measures implemented, consumers in these 11 countries would have paid two-thirds more than they paid for their energy bills during 2010–2013. However, for many years, energy efficiency was not treated as the first fuel in energy and power expansion planning and was referred as a "hidden fuel." Today, this situation is changing, and energy efficiency has been treated by more and more countries as "the first fuel."

The first fuel will never run out due to limited fossil energy resources; government new policies on energy and climate change; and incoming new energy-efficient technologies, products, and equipment in the market. The actual potential of energy efficiency as a fuel is much greater than what the world has harnessed over the past 40 years. In OECD countries alone, energy efficiency policies and technologies would help generate the first fuel about 2.2 billion toe to meet an

average of 20 % of final energy consumption in 2030 in five major sectors, namely buildings, equipment, lighting, transport, and industry.

There are many barriers to harnessing the first fuel. The major barrier is the subsidy for fossil fuel production and consumption. Fossil fuel consumption subsidies worldwide were estimated approximately 30 % more than total investments in the first fuel worldwide, which significantly distorted energy efficiency market.

Governments can use policy tools to facilitate harnessing the first fuel. In the USA, for example, the government established EERS for utilities or non-utility program administrators to follow and comply. An EERS is a critical policy that lays the foundation for sustained investment in energy efficiency, send a clear signal to energy market players about the importance of energy efficiency in utility program planning, and encourage large-scale investments in a cost-effective manner in energy efficiency.

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