Module 12

Energy efficiency technologies and benefits

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

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1. MODULE OBJECTIVES

1.1. Module overview

This module introduces the concept of energy efficiency and some approaches—together with the associated technologies—to achieving higher energy efficiency for both energy supply and demand. It seeks to inform the reader about the real benefits which energy efficiency measures can unlock and aid the reader to understand why energy efficiency is a high priority in supporting greater sustainable energy supplies for development.

The module is particularly relevant to Africa, where levels of access to basic energy supplies are among the lowest in the world and where modest energy consumption can often have very high developmental benefits. By using energy more efficiently, African nations can maximize the effective use of available resources for the economic benefit of their populations.

1.2. Module aims

The aims of the present module are as follows:

- To introduce the concept of energy efficiency and how it may be applied for carrying out all types of energy-dependent activities, such as manufacturing products, heating/cooling buildings and transporting freight/passengers by rail;
- To indicate the benefits attainable by improving energy efficiency in both supply and demand;
- To outline a range of approaches to achieve increased levels of energy efficiency;
- To outline the typical barriers to enhanced energy efficiency.

1.3. Module learning outcomes

The present module attempts to achieve the following learning outcomes:

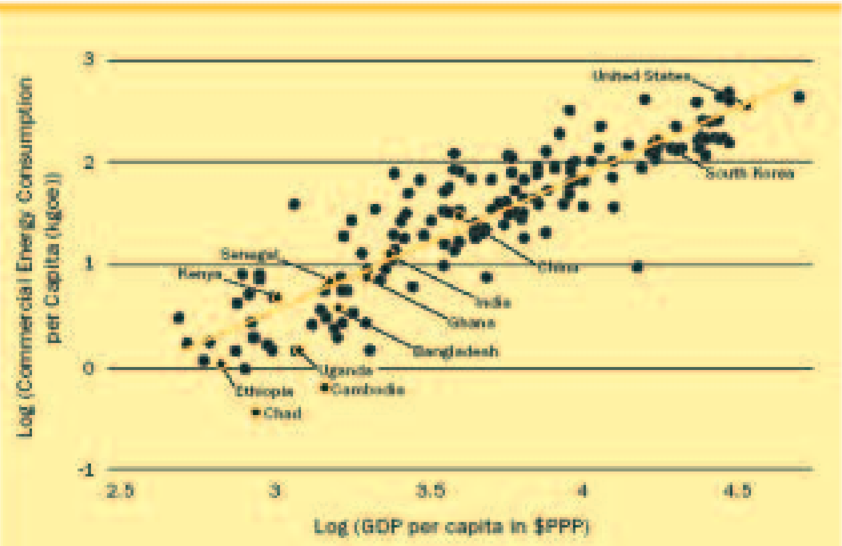
- To be able to define energy efficiency in all sectors of the economy;
- To understand the energy supply-demand chain;
- To appreciate the means of increasing energy efficiency throughout the supply chain and at the level of the energy consumer who is undertaking a specified activity;
- To appreciate the range of approaches and technologies available;
- To understand the typical barriers to achieving higher energy efficiency.

2. INTRODUCTION

2.1. Why is energy efficiency an issue?

Energy consumption is an essential element in development. This is illustrated in figure I below which is a plot of commercial energy consumption against GDP per capita and shows clearly higher energy consumption correlating with higher GDP per capita.

Figure I. **Commercial energy consumption and GDP, 2000**



Note: This is a log-log plot of per capita commercial energy consumption (kgoe) vs. GDP (in$PPP). In a log-log plot, the x- and y-axis numbers 0, 1, 2, 3, 4 ... correspond to 1, 10, 100, 1,000, 10,000...

Source: United Nations Common Database,2000.

While increased energy use clearly has many benefits, we are also becoming increasingly aware of the negative impacts of energy use. We experience these negative impacts globally and locally in the form of climate change (and the associated effects) and degradation of local environments in terms of—for example—poor air quality, degradation of soils (leading to desertification in extreme cases), resource depletion (e.g. water) and noise pollution.

However, more efficient use of energy at all stages of the supply/demand chain could reduce the negative impacts of energy consumption, while still allowing the same economic development. In addition, the inefficient use of energy generally implies higher than necessary operating costs to the customer (the energy end-user). At the company or enterprise level, higher energy efficiency will thus reduce operating costs and enhance profitability. At a national level, improved energy efficiency implies reduced energy imports, thus reducing foreign exchange pressures as well as increasing the availability of scarce energy resources for others to utilize, allowing increases in energy-dependent activities to contribute to the economic well-being of the population as a whole. Society as a whole also benefits from increased energy efficiency, principally through reduced adverse environmental impacts of energy usage.

Lastly, global primary energy resources (mainly fossil fuels) are finite and they will eventually be exhausted. They form part of the natural capital on which our lives—and economies—depend. However, their accelerated use in recent years has only brought the date that they will run out closer and reduced availability and higher costs have increased the pressure on countries that rely on fossil fuel imports. Sustainable future development depends on using these resources wisely and maximizing the benefit received for each unit of energy consumed.

2.2. What do we mean by energy efficiency?

Energy efficiency is understood to mean the utilization of energy in the most cost effective manner to carry out a manufacturing process or provide a service, whereby energy waste is minimized and the overall consumption of primary energy resources is reduced. In other words, energy efficient practices or systems will seek to use less energy while conducting any energy-dependent activity: at the same time, the corresponding (negative) environmental impacts of energy consumption are minimized.

Various ways of defining energy efficiency are discussed below in box 1. It can be appreciated that energy efficiency is a broad term and there are various ways of using it in the real world. The specific definition depends on the context and—in whatever way it is used—it represents a ratio of output to energy input (or of course the inverse, energy input per defined output).

Box 1. **Defining energy efficiency**

Energy efficiency is a term that is used in different ways, depending on the context and possibly on the person using the term. The strict technological usage relates an energy output to an energy input, and is used typically by engineers for machines and equipment. Thus, the energy efficiency of an electric motor is the ratio of mechanical output (that is, the work done using the motor) to the electrical input. Quantities must be expressed in the same units, e.g. kilowatt-hours per day, and the result—a dimensionless number—is conventionally expressed as a percentage. This approach is used extensively in industrial plants and buildings for a wide range of equipment including motors, pumps, compressors, furnaces and boilers. For boilers, for example, the efficiency might be say "85 per cent", meaning that 85 per cent of the energy value of the fuel has been converted into useful steam (and the sum of various losses is thus 15 per cent).

For many manufacturing processes and other energy-dependent activities such as the operation of passenger and freight vehicles, comparing input and output in the same units to derive a dimensionless number is not a practical approach. The "technical" definition is therefore little used for many types of energy efficiency analysis. In many real situations, energy efficiency is most often expressed as a surrogate, the ratio of energy input to the "output" from a specific activity. Thus in industry, the energy efficiency of a cement kiln can be expressed as X thousand litres of oil fuel fired per ton of clinker produced, and that of a rolling mill as Y tons of standard coal per ton of steel rebar manufactured. For the transport sector, the energy efficiency of a truck can be expressed as Z litres of diesel oil per ton-km of freight transported, and of a city bus as W litres of gasoline per thousand passenger-km achieved. Such indicators are often called "specific energy consumptions" and are widely used to compare energy efficiency across plants, buildings, transport vehicles and modes.

In practical situations therefore, to monitor energy efficiency over time, we need to relate energy consumption to a specific level of activity or output. The indicators used to express energy efficiency are not percentages but will have defined units, and changes observed from one time period to another will indicate if the activity is being carried out more or less efficiently—other factors remaining unchanged (e.g. no change in a manufacturing process, no fuel switching, similar weather conditions, etc.)

At national level, the term "energy efficiency" is not often used. Rather, "energy intensity" is typically adopted. Energy intensity is the ratio of energy consumption to some measure of the demand for energy-related activities, and it can be applied to an entire sector of the economy. An example is the energy intensity of say the industrial sector of a country, expressed as X joules per unit of GDP generated by that sector. Sometimes the energy intensity is expressed entirely in monetary terms, e.g. energy expenditure of Z dollars per dollar of GDP. Thus energy intensity—similar in many respects to the energy efficiency concept illustrated for processes or transport—will typically include structural and behavioural components. Changes in the sector—such as shifts in the types of product manufactured—will impact on the energy intensity, irrespective of changes in energy efficiency of the plants, processes and machines involved.

Other terms seen in reports worldwide include energy conservation and energy saving. These too are defined in a variety of ways and need to be used with care. Energy conservation tends to be associated—often wrongly—with "deprivation" of some sort, such as lower levels of comfort in buildings, lower industrial production levels. Energy saving generally means a lower consumption of energy and this may or may not be accompanied by changes in the quality or quantity of an output or activity.

Reference: A useful introductory discussion of energy efficiency definitions and terms is given in www.eia.doe.gov/emeu/efficiency/definition.htm

2.3. Who should be concerned with energy efficiency?

The impacts of energy use affect all of us and consequently, we should all be concerned about how to use energy more efficiently. However, the main bodies responsible for defining national approaches to energy efficiency are typically government agencies, whose responsibilities will usually include:

- Enacting legislation relating to energy efficiency if required, including defining an oversight role for energy regulators, when relevant.
- Deciding the state budget for promoting and conducting energy efficiency activities and programmes for the general public, including tax or other incentives when appropriate.
- Promoting energy awareness and disseminating useful information on energy efficiency measures and on recommended procedures for all sectors of the economy.
- Allocating the budget and carrying out energy efficiency programmes in relation to government-owned assets, e.g. government buildings, vehicle fleets. These actions will serve as examples of good practices for others to follow.

The government usually takes a lead role in promoting energy efficiency because of the diverse and essential role that energy plays in the national economy, and because government often has a major responsibility for long-term energy planning to meet the needs of society as a whole. The government is also in a special position to address many of the barriers to higher energy efficiency, including the key barrier formed by lack of reliable and timely information for all sectors.

In most countries, the main agency involved will be the Ministry of Energy, with other agencies and ministries also involved in specific areas of energy supply and consumption (e.g. agencies such as a Ministry of Energy and Mines, Ministry of Industry, Ministry of Public Works and Construction, Ministry of Public Utilities and Ministry of Finance, depending on the government structure in each country). In some countries, there are regulators to oversee the operations of oil, gas, electricity and water supply companies, in the private or public sector. These regulators may have responsibilities for observing the efficiency of supply activities and for taking efficiency into account in the setting of energy (and water) prices and tariffs.

Other organizations with a strong interest in improved energy efficiency are known as “stakeholders”. While this could cover the entire population, the main stakeholders are usually deemed to include industrial enterprises, industry associations, transport companies, owners of major commercial and other buildings (e.g. schools, hospitals), financial organizations, equipment manufacturers, gas and electric utility companies, and fuel supply companies. Many will themselves be energy consumers who have a direct incentive to improve energy efficiency and increase profits by cutting energy costs.

Thus while government has a role to play in establishing the right “environment” to promote energy efficiency, it is generally true that initiatives for carrying out energy efficiency actions will be taken by private firms and individuals. There may also be some government agencies responsible for energy-consuming activities, e.g. operating government buildings, running schools and universities, building and operating hospitals. These agencies should be required to carry out energy efficiency activities and investments themselves (possibly with the assistance of private-sector subcontractors). In the main, however, improved energy efficiency in most parts of the economy will often be achieved by the efforts of companies that have an interest in increasing their profits.

To some extent this applies to the domestic sector, where higher efficiency appliances will normally be promoted by manufacturers and their agents and importers. Nevertheless, individuals also have a responsibility for ensuring that they operate and maintain household equipment properly, and that they are aware of energy waste in the home caused by behavioural “deficiencies”, e.g. forgetting to switch off lights when not needed, and setting thermostats too low in air conditioned premises (or too high in heated buildings).

This module describes a range of energy efficiency approaches (including management actions and technologies) and the associated benefits to enable these major stakeholders to understand and implement more effective energy efficiency programmes within their own areas of responsibility.

3. THE BENEFITS OF INCREASED ENERGY EFFICIENCY

There are many benefits of increased energy efficiency. These can broadly be categorized into financial/economic, environmental and social benefits. The relative importance of each of these benefits depends on the actual situation in a given country or area, including for example the prices of different types of energy, the cost of energy efficiency measures and equipment, the tax regime and the current levels of energy efficiency already being achieved.

For private companies, the most important benefits of higher energy efficiency will be linked to the financial benefits of lower costs for running the business (see box 2). This applies to typical manufacturing companies as well as to energy suppliers such as electricity generating plants and oil refineries. Examples are:

- Energy efficient companies can gain a competitive advantage over less efficient companies, allowing them to increase their profits at current product prices, or lower their prices to gain market share, or a combination of these items.
- Utility regulators may require utility suppliers to reduce their prices to consumers, with the benefits of higher operating efficiency shared between energy producers and consumers for mutual benefit (and for the overall benefit of society).
- Reduced environmental impact can also serve as a significant marketing tool for efficient companies, as public perception of “green” companies takes an increasing role in purchasing decisions. Environmental benefits include many elements, such as reduced local pollution through burning less fuel, lower greenhouse gas emissions, less use of firewood and hence less destruction of forests.
- Even where company output is increased (e.g. through expanding manufacturing capacity) energy efficiency improvements can contribute significantly in most cases to reducing the negative impact of energy consumption per unit of output. Any increase in pollutant emissions will thus be minimized.

At a national level, these kinds of benefits could reduce the dependence of a country on imported energy, or could extend the life of energy reserves where present. These are worthwhile contributions to the national economy, often achievable at modest cost to the companies involved, and little or no cost to the government itself.

Box 2. **The business benefits of energy efficiency**

In most businesses, the initial stages of raising energy efficiency can be achieved through little or no capital investment. Correct and timely maintenance can have a substantial effect on improving energy efficiency (e.g. replacing broken or inadequate insulation on hot or cold piping). Boilers and furnaces can usually be operated more efficiently by ensuring the proper combustion conditions are maintained at all times. In some factories or buildings, the boiler/furnace operators might lack the necessary skills (and proper testing instruments) to know how this may be achieved. However, training programmes and the installation of a few simple low-cost devices could typically pay for themselves in a matter of a few weeks.

High efficiency light bulbs are another example of a modest investment that typically pays off in a very short time.

Of course, some major investments in energy efficiency improvements—e.g. new process equipment, totally new boilers—are well justified in financial terms and can often be undertaken by a business to produce big increases in profits. Large investments in new equipment will often be accompanied by increases in manufacturing capacity, and hence the benefits are not strictly limited to energy reduction. At the same time, new equipment may provide a safer and cleaner environment for the workers in addition to achieving higher energy efficiency.

Overall, higher energy efficiency brings lower operating costs to almost all businesses, allowing an “efficient” company to gain a competitive edge over more wasteful competitors.

In addition, as noted in the main text, a resource-efficient business demonstrates a responsibility towards the environment. This can be used to promote the business as an environmentally friendly business and this can be a strong marketing message.

Finally, we should note that businesses can be encouraged to undertake energy efficiency investments through various forms of tax incentives. Many of these are oriented to increasing the rate of depreciation for certain categories of efficient equipment or processes. In some countries, a lower consumption of energy can lead to a reduction in the company’s tax burden.

4. WHERE DOES ENERGY EFFICIENCY FIT IN TO THE OVERALL ENERGY MIX?

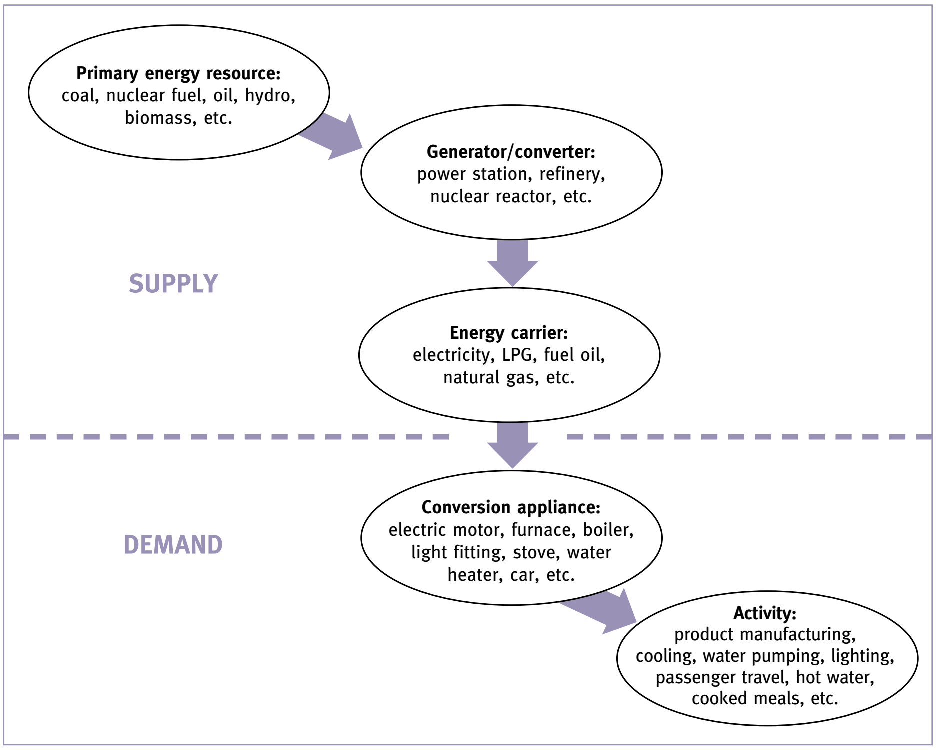
To appreciate the importance of energy efficiency, we must understand where energy efficiency fits into the overall energy picture and where the main energy losses occur.

4.1. Energy-dependent activities and the energy supply chain

All so-called end-users use energy to carry out an "activity", such as manufacturing a product, transporting goods or passengers, cooking a meal or providing light. Customers are generally not particularly interested in the details of how the energy is provided to them, rather they are interested in the utilization of energy within their own activities and how they may operate safely and efficiently to produce the required output, and for a low, or at least acceptable, cost. Of course, the energy supply companies themselves have relatively broad interests covering both supply and demand aspects of energy use.

It is useful to understand the overall supply/demand chain for providing the energy to an energy consumer and carrying out a specific activity (see below).

Figure II. **The energy supply-demand chain**



4.2. Energy losses

Inefficiencies can occur at any stage of the supply-demand chain. For example, the overall efficiency of a conventional electricity generating plant—even if well operated—can often be little more than 30 per cent, while a poorly operated coal fired boiler might struggle to reach 50 per cent efficiency. The energy losses can thus be significant throughout the chain. Losses can be divided into two main types:

- Intrinsic losses, i.e. unavoidable losses such as those that are a function of the activity and depend on thermodynamic and physical laws. For example, electricity distribution lines (and steam pipelines) will always have some associated losses, even if properly sized (or well insulated).
- Avoidable losses, i.e. losses resulting from sub-optimal/poor design, maintenance and operation of systems (steam leaks, non-insulated lines, inadequately sized electricity wiring, incorrectly adjusted combustion equipment, etc.).

The avoidable losses in the supply-demand chain will result in missed opportunities, requiring additional primary energy resources to be consumed in achieving the required output from a given activity. In addition to added costs, there will be a corresponding increase in environmental degradation.

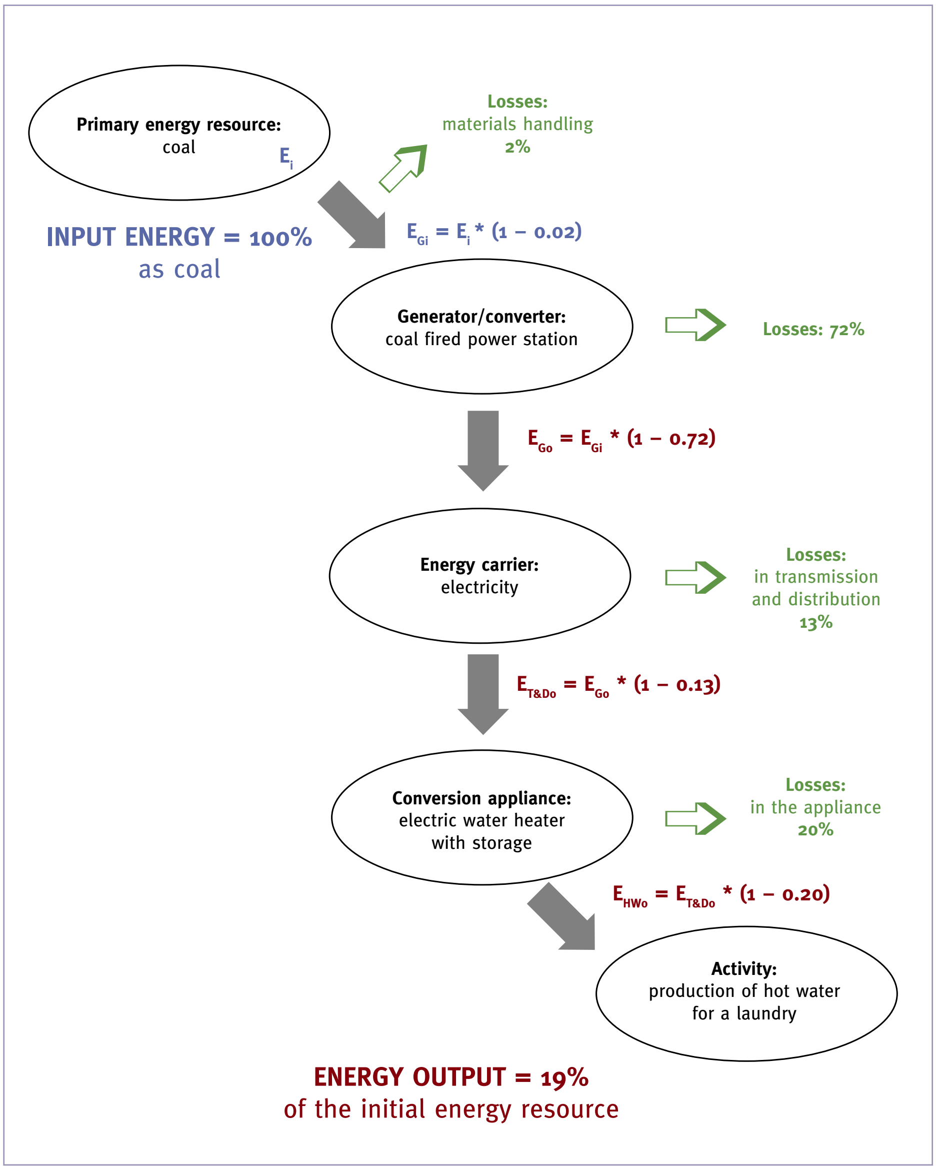
Raising the energy efficiency of all steps in the supply-demand chain is of course the means by which we can reduce energy losses. In the short term, improving energy efficiency addresses directly the so-called avoidable losses but, in the long term, we may be able to address the "unavoidable" losses to a degree. For example, we may be able to redesign a process or item of equipment to ensure the losses that are built-in for technical reasons are kept to the minimum.

Practical experience suggests that the avoidable losses are typically much more significant that the "technical" losses. Major losses occur in all sectors of the economy from the use of old and inefficient technologies or outdated processes. With very few exceptions, however, of even greater importance are the avoidable losses that result from poor management of plants, processes and equipment, and—in many cases—from inappropriate behaviour of energy consumers.

As an example of typical system losses, figure III below illustrates the provision of hot water for a laundry using coal-based electrical energy.

Figure III shows four key steps of hot water production and the various losses associated with each step. The numbers are illustrative and represent typical numbers found in practice, although there could be wide variations from plant to plant. Losses accumulate over the four steps because:

Figure III. **Example of energy losses in hot water production**



- Handling of the coal results in a loss of 2 per cent (lost to the area around the plant, lost in loading and unloading trucks, etc.);

- The power station is actually operated at about 28 per cent overall efficiency (losses of hot combustion gases from the stack, warm cooling water discharges, mechanical inefficiencies in turbines and generators, etc.);

- The transmission of electricity to the location of the hot water production and distribution within the generator plant itself is only 87 per cent efficient overall (mainly losses in lines and transformers);

- The efficiency of the water heater at the laundry is 80 per cent (heat losses are experienced from the boiler, storage tanks and pipe work).

The cumulative losses over the four stages thus amount to over 80 per cent of the original coal energy content. In terms of efficiency, the overall efficiency is:

$$0.98 \times 0.28 \times 0.87 \times 0.80 = 0.191 \text{ (or 19.1\%)}$$

The table below breaks down the results for each step:

Key steps	Energy input (energy units)	Step losses (per cent)	Energy output (energy units)	Corresponding efficiency (of the step per cent)
Step 1: primary energy resource	100	2	98	98
Step 2: power station	98	72	27.4	28
Step 3: electricity transmission and distribution	27.4	13	23.3	87
Step 4: water heater	23.9	20	19.1	80
Overall result	**100**	**80.9**	**19.1**	**19**

Efforts to improve energy efficiency can be undertaken in every step. For example:

- Material handling could perhaps be improved by better management of equipment to reduce losses to 1.8 per cent (efficiency 99.2 per cent);
- Power station efficiency could be raised through improved maintenance to 32 per cent (losses down to 68 per cent);
- Transformer upgrading could reduce transmission/distribution losses to 10 per cent (efficiency 90 per cent);
- An improved design and better insulation of the water heater, tanks and piping could reduce losses to 15 per cent (efficiency 85 per cent).

The figures are again illustrative and represent typical improvements achievable in many practical situations. The overall system efficiency would become:

$$0.992 \times 0.32 \times 0.90 \times 0.85 = 0.243 \text{ (or 24.3 per cent)}$$

Through the improved efficiency of the various step processes and equipment, the overall efficiency can reach 24 per cent. From a product output perspective, the same input energy can produce more than 24 units of output compared to previous 19—an increase of 26 per cent.

The cost-effectiveness of energy efficiency measures needed to achieve such gains will depend on many factors, including the cost of new and improved equipment, the cost of energy and the value of the energy saved. Changes in the use patterns of energy-dependent activities will also offer another opportunity to increase the overall efficiency (e.g. lower usage of hot water by lowering the amounts needed for washing laundry items, or lowering the wash temperature by blending hot water with some cold water).

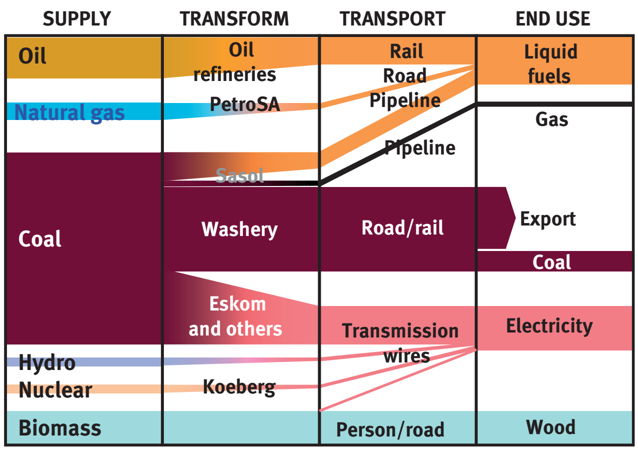
Thus energy efficiency has an important role to play in reducing the need for energy throughout the economy. The next sections outline both supply-side and demand-side energy efficiency approaches. More detailed information can be found in modules 13 and 14 respectively.

4.3. Energy flows in national economies

The energy transformations within the energy supply chain for different energy-dependent activities in national (and regional) economies can be summarized in a simplified diagram in terms of energy flows, such as the example for South Africa which is shown in figure IV below.

A diagram such as figure IV will show the relative amounts of energy supplied and consumed, and the amounts of primary energy allocated to each sector of the economy. The quantities suggested in the diagram are, of course, specific for South Africa. Diagrams for other countries will be different.

Figure IV. **National energy flows in South Africa (DME, 1997)**



Source: Andre Otto, Dept. of Minerals and Energy, South Africa

The energy flows, together with energy consumption data and an understanding of the relevant supply-demand chains for different sectors, can be used to suggest where energy efficiency improvements could have a major impact and indicate the types of energy that could be saved. With this information, some initial priorities could be developed for an energy efficiency programme at the national level.

An overall goal for such a national energy efficiency programme would be to reduce the energy intensity of the various sectors of the economy (see box 3), thereby decreasing the amount of primary energy per unit of economic activity (measured in GDP).

Box 3. **Energy intensity**

As already mentioned in box 1, energy intensity can be used as a rough measure of the energy efficiency of a nation's economy. For that purpose it is usually expressed as the ratio of national energy consumption to GDP and quoted in units of energy per unit of GDP (e.g. kilojoules per dollar of GDP). While it is true that a high energy intensity could possibly reflect an inefficient use of energy in an economy, a high figure may also simply reflect that the underlying structure of the economy is oriented strongly to basic industries—with relatively low value added and using large quantities of energy. These basic industries might well be quite efficient although this might not be appreciated at first sight from the quoted energy intensity.

While energy intensity is often used as a surrogate for energy efficiency, we can see that this may lead to misleading conclusions being drawn. Many factors influence the overall energy intensity for a national economy. The figure will—for example—reflect the overall standards of living for a nation, as well as its climate. It is not untypical for particularly cold or hot climates to require greater energy consumption in homes and workplaces for heating or cooling. As suggested above, energy intensity is most often strongly affected by the relative size of the industrial sector, and by the specific nature of industrial activities within that sector.

Indicators of energy intensity are thus useful provided underlying components are well understood and the data interpreted accordingly. Without a structural context, energy intensity figures can be misleading. A well-defined and quantified structural context allows government policymakers to decide where policy changes might be made and what the potential impacts might be. These will include the impact of energy efficiency improvement measures throughout the economy (e.g. changes in the efficiency of industrial furnaces and boilers, electric motor efficiencies, standards of construction for domestic and commercial buildings, the fuel economy of vehicles).

"Energy intensity" is discussed at www.eia.doe.gov

5. TARGET SECTORS

Energy efficiency interventions at a national level are generally developed and implemented in response to priorities identified within an integrated energy plan or an integrated resource plan. Sectoral interventions may also be developed and coordinated by government agencies or utility companies.

Energy intensity and energy consumption indicators are used to identify target priority areas—e.g. sectors, specific industries. In many countries, the share of energy consumed by industry is often large although the share of the domestic and commercial buildings sector will often be almost as large. Transport is a growing energy consumer in most countries. Energy efficiency activities are therefore increasingly important in many sectors, depending not only on the total amount of energy consumed but also on the potential for cost effective improvements (broadly reflected in the current level of energy efficiencies of different sectors).

In setting priorities, account has to be taken of the measures applicable in a given sector (including cost implications) and on the means of promoting energy efficiency action. The buildings and transport sectors may be complicated to address because the energy consumers are very widely dispersed and typically consume small amounts of energy individually. Industry—while perhaps also having many small consumers—will often include a relatively modest number of big consumers. It can therefore prove easier, at least administratively, to reach those consumers that represent a large proportion of sectoral energy use.

Examples of proven measures in demand-side sectors include:

Supply side segment	Examples of energy efficiency measures
Domestic and commercial buildings	• For heating and cooling services—use of efficient equipment, adjustments in use patterns (behavioural changes, temperature modifications, etc.) and good maintenance. • Lighting—using efficient light-bulbs, changing types of light sources, maximum use of natural lighting, behavioural changes (e.g. switching off when not needed, manually or automatically). • Office equipment and domestic appliances—installing energy efficient items, switching off when not used (e.g. reducing waste when on standby), and adopting good operating practices (e.g. running appliances only when full). • Construction materials—ensuring that appropriate materials and controls are utilized in new and retrofitted buildings (e.g. insulation, building orientation, double glazed windows).
Industry	• Operations in general—routine data collection and regular analysis of energy performance, improved maintenance, good energy management using skilled and experienced staff. • Boilers and furnaces—proper combustion control with appropriate instrumentation, insulation and refractory brought up to good modern standards, burners well maintained.

Supply side segment	Examples of energy efficiency measures
Industry	• Industrial processes—operated in accordance with design standards, heat losses minimized by good insulation, waste heat recovered for use elsewhere in the plant. • Industrial buildings—similar to the buildings sector, including attention to heating, cooling, lighting, etc. • Equipment—utilizing existing equipment well (e.g. electric motor speed and load controls) and replacing obsolete items with new higher efficiency equipment (motors, fans, boilers, pumps, etc.)
Transport	• Modal shifting—ensure freight and passenger transport is carried out in the most energy efficient mode (e.g. consider switching from road to rail, encouraging public transport over individual vehicles, etc., whenever possible). • Vehicles—encourage fleet replacement to modern higher efficiency equipment, improve maintenance, driver education. • Improved road maintenance.
Resources and resources preparation	• Clean coal technologies—they allow improving the efficiency of the extraction, preparation and use of coal. They offer various solutions for coal cleaning as well as reducing noxious emissions and improve the efficiency of power generation. • Fuel substitutions—also referred to as fuel switching, is simply the process of substituting one fuel for another. This could be either a fossil fuel that allows for using more efficient conversion technologies (i.e. natural gas) or renewables (i.e. wind. solar, biomass, hydro, etc.).
Power generation and energy conversion	• Plant operations in general—these include routine data collection and regular analysis of energy performance, improved maintenance, improved logistics, good energy management using skilled and experienced staff. • Improved boilers and furnaces control—proper combustion control with appropriate instrumentation, insulation and refractory brought up to good modern standards, burners well maintained. • Upgrading generating units—it includes installation of new and improved burners, extra flue gas heat recovery, additional heat recovery from hot blow-down water as well as modernization of instrumentation and combustion control systems. • Cogeneration—the combined production of electricity and heat can bring about major efficiency gains wherever a demand for heat exists next to a power plant (process heat for industrial factories, district heating, etc.).[1]
Transmission and distribution	• Transmission and distribution line upgrading—this includes replacement/upgrade of equipment (transformers, switchgear, insulators, system control and data acquisition systems, etc.) as well as substations. • Improved control and operations—this includes data and system monitoring, power factor improvement, voltage regulation, phase balancing, preventive maintenance and other measures to reduce technical losses while increasing reliability.

[1]It has to be noted there are also cogeneration systems, usually part of big industrial factories, for which high temperature heat is the primary output of the generating plant, while electricity is the secondary product.

6. OVERVIEW OF ENERGY EFFICIENCY ACTIONS

Energy efficiency improvements particularly focus on available technology to make such improvements, with some technology options being well-known and proven over many years of application, and some of which may be relatively new and less well-known. Indeed, lack of information is a key barrier to energy efficiency improvements in many situations. However, experience in many countries of supply and demand-side activities shows that existing plants, buildings and equipment can often be improved substantially through simple low-cost/no-cost actions that have little bearing on technology.

Put simply, there are important opportunities for raising energy efficiency throughout the economy in every country, developed or developing, by adopting better "energy management" practices. It is certainly not true to claim that energy efficiency cannot be raised without investment in new technology, a claim made all too often by managers of companies who have failed to grasp the opportunities offered by good management.

At a national (or regional) level, energy efficiency interventions are best promoted in a strategic and integrated manner to use more efficient energy technologies and management practices within the context of an energy efficiency programme. For convenience, technologies and management programmes can be split into those applied to supply-side and those to demand-side activities. There are of course many similarities amongst the measures actually adopted for such activities.

Supply-side interventions are typically technical or management interventions, which are implemented by generators, grid operators and/or energy distributors, i.e. on the utility side of the meter or fuel pump. Demand-side interventions address aspects of energy efficiency, which can be implemented and achieved through changes in operating procedures and technologies by the customer/ energy user, i.e. on the customer's side of the meter.

6.1. Technologies and practices

Energy efficiency technologies and energy management practices are discussed in more detail in module 13: supply-side energy management and module 14: demand-side energy management. Module 17 addresses the specific area of industrial energy systems efficiency and optimization. Module 18 addresses energy efficiency in buildings. In all situations, energy efficiency actions must be carefully costed and undertaken only when it is profitable to do so.

In brief, measures typically include:

On the supply side

- More efficient generation/conversion, including:
  - Minimizing waste heat generation and recovering waste heat to an economic maximum;
  - Improving maintenance practices;
  - Utilizing equipment that has been manufactured to the best modern standards of efficiency, e.g. electric motors, steam and gas turbines, transformers, boilers;
  - Applying modern process technologies including clean coal processes;
  - Cogeneration (particularly where this can be combined with biomass fuel from a renewable source, e.g. bagasse, or with the utilization of waste heat);
  - Better control systems and metering of key operating parameters.

- More efficient transmission and distribution systems, including:
  - Closer and improved control of existing systems, e.g. better balancing of phases, voltage regulation, power factor improvement, SCADA systems for better routine data acquisition and analysis;
  - Increased use of distributed generation;
  - Higher transmission voltages;
  - State-of-the-art technologies such as low-loss transformers, fibre optics for data acquisition, smart metering, etc.

On the demand side

- More efficient equipment and appliances in all sectors, e.g. motors, boilers, furnaces, industrial dryers, pumps, compressors, lighting, domestic appliances, air conditioning systems. This is particularly important for equipment that is operated over long periods or continuously.

- Improved maintenance of all equipment.

- Improved metering of fuel, electricity and steam flows and of key operating parameters such as temperatures. Such figures feed into routine monitoring and performance analysis, activities that can be applied in all sectors. Information on energy usage and related levels of “activity” such as production data allows energy consumers to appreciate better the quantities of energy consumed and the time and purpose of such consumption: this is an essential initial step to improving energy efficiency,

- Control and energy system optimization, often made practical by the improved metering mentioned above. This can include variable speed drives for electric motors, thermostats in buildings and industrial equipment, ripple control, smart appliances and power factor improvement.

- Behavioural change on the part of the energy user, such as:
  - Monitoring energy efficiencies in major energy-consuming industrial processes and equipment to ensure design operating parameters and performance are respected.
  - Reporting leaks and equipment failures systematically, e.g. in industrial plants, and checking the cost incurred through such deficiencies to ensure priority attention is given to repairs and replacement.
  - Changes in work practices such as working from home and/or flexitime.
  - Changes in equipment usage both at home and in the office, such as switching off appliances which are not needed and avoiding excessive use of "standby mode" for many types of equipment.
  - Electricity load shifting by industrial or commercial energy users is a demand-side intervention but it has implications for improving energy efficiency of the grid network that supplies the electricity (supply-side). This is because peak loads can be reduced if electricity demand is spread out over a longer time period or if it is moved to another time of day. Since many electricity systems are forced to operate their least efficient generators to meet peak demand, this allows them to reduce the use of lower efficiency generating equipment in favour of greater use of their more efficient equipment over a longer period of time.
  - Choosing different modes of transport, e.g. public transport versus cars for individuals, rail versus road for freight, where such alternatives are available.

An example of demand-side controls to save peak period electricity is given in box 4. The concept of ripple control is well established in some countries and is technically proven. However, it does not always meet with an entirely favourable customer response.

Box 4. **Ripple control of electrical storage water heaters in South Africa**

Ripple control has been used in South Africa to control electrical storage water heaters and street lighting. Ripple control is a technology that enables an electricity distributor to control appliances, for example in this case, an electrical storage water heater in a customer's home.

It operates on the principle of sending control signals as a pulse, which is superimposed on the frequency of the grid supply. A relay on the appliance is programmed to operate the appliance in response to signals transmitted through the electricity distribution network. In South Africa, ripple control is used extensively to control domestic water heaters for demand-side management by switching off the electrical heaters at a large number of consumers for a short time during maximum demand periods.

Although ripple control appears to be a simple and effective means of demand-side management, it has not generally been very successful due to the negative perceptions of "big brother" control of the customer's life on the part of the utility. Consequently, customers are found to have by-passed the ripple control devices.

Source: Hot water load control in South Africa, N. Beute, J. Delport, Engineering Faculty, Cape Town 2006

6.2. Energy efficiency programmes

It is not possible to list all types of energy efficiency programmes here but the section will give some examples of situations where government action can be particularly effective. There is a very wide variety of possible actions and many of these are explored in the other energy efficiency modules (particularly modules, 13, 14 and 17). Typical programmes include:

- Development of energy efficiency policies and strategies.
- Energy awareness—raising awareness of energy consumption and related aspects of energy efficiency among consumers/users. This can cover many topics, from training of energy professionals to appliance labelling and consumer education for the domestic sector.
- Encouraging energy auditing and energy assessment both in the public and private sector. This is a logical next step after raising energy awareness.
- Development of, and publicity for, energy efficiency best practices, and information on norms and standards applicable to different sectors, such as good modern practice for electric motor efficiencies, comparisons of industrial process energy consumption per unit of output. This activity can be applied in various ways to all sectors.
- Development of the institutional capacity and human resources for implementation of energy efficiency interventions. This can range from teaching at schools and colleges, to requiring demonstrated competence at professional levels (e.g. air conditioning and heating engineers).

- Support for technology R&D, and especially for the demonstration of proven technologies to increase energy efficiency.
- Introduction of incentive/penalty mechanisms to support improved energy efficiency.
- Promotion and facilitation of international collaboration and cooperation.

While the above items are written in the context of government-led programmes, many of the concepts are also valid for energy efficiency programmes organized and implemented by the private sector. For example, staff energy awareness is important for all companies, industrial and commercial. Raising staff—and even customer—awareness can have valuable benefits to most firms. Manufacturing companies should be active in promoting good management and energy efficiency practices at all their sites and offices.

Demand-side management and energy efficiency

A distinction can be made between the terminology of demand-side management (DSM) and energy efficiency. In conventional usage, DSM is often applied to electricity load management, such as peak lopping or load shifting only, and not to the more general range of interventions included under the topic of demand-side energy efficiency, which is discussed in this module. This is particularly the case for DSM programmes implemented by utilities concerned with the management of load profile and peak-power demand. While it might seem desirable for a power utility to improve its load factor and postpone costly capacity expansion, in practice utilities companies tend to be unenthusiastic towards load shifting and DSM in general. This is because they foresee a reduction of electricity and power demand, and consequently a reduction in sales and revenues.

? Review questions

1. Describe the difference between demand-side and supply-side interventions and name a technique of each.

7. COMMON BARRIERS TO IMPLEMENTATION OF ENERGY EFFICIENCY MEASURES

Despite the fact that energy efficiency appears to make good sense in many situations—both in terms of cost savings and reductions in environmental damage—it is often very difficult to get managers of companies (and individuals) to take action. It is even more difficult to achieve effective implementation over a long period. All stakeholders are inclined to accept the status quo, which is usually a less efficient scenario, and only respond in terms of energy efficiency once a crisis forces the issue, such as in the case of insufficient energy supplies. For private firms, other priorities are often quoted, such as capital investments to increase plant capacity and market share, leaving no funds for energy efficiency expenditures.

This inherent inertia against acting to improve energy efficiency is reinforced by numerous institutional, financial and technical barriers to energy efficiency programmes, either real or perceived. These include:

- Policy and regulatory barriers;
- Lack of information and awareness of the potential for energy efficiency;
- Lack of industry initiatives to emphasize energy management as an integral part of total management systems;
- Lack of technical capacity to identify, appraise, develop and implement energy efficiency projects;
- Financial and investment barriers;
- Technology barriers.

These barriers are reviewed below.

7.1. Policy and regulatory barriers

Policy and regulatory oversight systems can influence the priorities and manner in which energy efficiency measures are implemented. In the case of policies, these include both national and local government policies. In many countries, especially in Africa, there simply is no policy or, if there is, it can be indifferent (and thus perhaps counter-productive) to energy efficiency.

Regulations that support inappropriate tariffs can limit interest in energy efficiency. For example, it is common to see tariffs that provide for declining energy prices for incremental energy consumption by big consumers. This acts as a disincentive for such consumers to undertake energy efficiency actions.

Supportive policy and regulatory environments for energy efficiency include setting targets—mandatory or voluntary should be considered—from which strategies for encouraging increased levels of energy efficiency can be developed.

7.2. Lack of awareness and information

This barrier is the most common problem in almost all countries. Easy access to up-to-date and relevant information is typically lacking even in developed countries. Company managers are frequently observed stating that they have a particular problem that is adversely affecting their energy efficiency, yet the problem has already been solved—sometimes many times—in other countries and indeed in other locations in the same country.

In Africa especially, there may be a lack of awareness of proven energy efficiency measures and programmes. The information about these is often not well disseminated and the users are simply unaware of energy efficiency measures or their benefits to their company or the country.

End-users need to be informed of the availability of efficient equipment and the respective energy cost savings and their positive environmental impacts from proper adoption. In the United Republic of Tanzania, the existing market of energy efficient equipment is immature and is characterized by limited supplies from tradesmen and inadequate technical personnel.

Sometimes the information to end-users (energy customers) is incorrectly perceived as being an attempt by government to restrict their energy use or deny them the right to energy, or manipulation on the part of utilities to make higher profits. Industry trade associations could play a positive role in encouraging the sharing of relevant information.

7.3. Lack of initiatives to emphasize energy management

This barrier is particularly important for the industrial and commercial sectors. Since energy management is a continuing process, it is essential that it becomes part of total management system. Most industries have management systems that address production, accounting, maintenance, environment and safety, but many do not include energy management as part of their management systems. As energy management requires a knowledge and skills base, medium and small industries often claim to have no staff resources to undertake energy management tasks. While this must be true for many firms, it may be possible to cover some aspects of energy management by using part-time staff—a full-time person may not always be justified.

7.4. Lack of technical capacity to identify, evaluate and implement energy efficiency actions

There is a lack of qualified individuals and organizations to identify energy efficiency projects in many companies. Required skills include the ability to carry out energy audits, analyse performance data, from which opportunities to implement effective actions can be evaluated and properly justified in terms of the benefits achievable compared with the costs involved. This barrier is particularly relevant to most African countries.

In some countries, there are organizations that address this barrier by offering services to conduct energy audits or advising clients on energy efficiency measures. These service organizations need to:

- Have a knowledge and understanding of energy efficiency systems and opportunities, especially in the local context;
- Be aware of proper financial evaluation techniques and be experienced in analysing rates of return, life cycle costing, etc;
- Demonstrate the quality and comprehensiveness of their work;
- Have a knowledge of the production and safety constraints of the client plant/company.

A lack of technical capacity within such service organizations could result in an incorrect assessment and misdirected measures, which would be counterproductive. In many African countries there will be a need for training at a national level and for a technical certification scheme in order to improve technical capabilities and provide incentives for acquiring official qualifications.

7.5. Financial and investment barriers

The cost of implementing energy efficiency measures in industry, commercial or residential sectors is sometimes said to be a barrier to effective energy efficiency. Often however, a manager will have little or no ability to evaluate energy efficiency measures properly and may not appreciate that no-cost/low-cost measures are available that require very little capital to implement. All too often the lack of awareness of potential benefits from EE actions prevents management from doing the no-cost measures first and using the cost savings to build up capital for reinvestment later in energy efficiency.

In some cases of course, there are companies that really do not have funds to undertake even modest investments, even though the measures might have very short payback periods.

For example, energy suppliers may need to invest in upgrading to more efficient electricity generators or transmission lines, while energy users may need to upgrade to more efficient appliances or install capacitors to increase power factors (and hence reduce the power needed for induction motors). Unfortunately these investments may not be made because there is a genuine lack of capital and interest rates on loans may not be favourable enough in most African countries to justify borrowing. Financing considerations are addressed further in module 19.

7.6. Technology barriers

While great progress in achieving energy efficiency improvements is almost always made by improving energy management, there will be on occasions a real need for tackling deficiencies from a technology point of view. A barrier may be encountered because of a lack of availability of high efficiency equipment made to good modern standards in any particular country. There may also be insufficient cooperation amongst researchers or research organizations, making it difficult to build effective energy efficiency research, development and demonstration programmes, particularly in a local context in Africa. Thus even where research may have been effectively conducted there can be difficulty in transferring research prototypes into industrial scale working products.

Examples of technology barriers include the continuing use of obsolete and inefficient equipment in the industrial, commercial and residential sectors. At times this is due to unavailability of more energy efficient technologies. It is perhaps more likely that weak marketing strategies exhibited by equipment manufacturers or importers are contributing to the problem, especially where these do not address the inertia of customers who are reluctant to move away from obsolete and traditional products. Lack of confidence in local installers of new technologies can also be a barrier. Certainly inadequate marketing will do little to promote efficient energy use even though better technologies might actually be available in Africa.

Review questions

1. Name the common barriers to implementation of energy efficiency measures.

8. COMBINING RENEWABLES AND ENERGY EFFICIENCY TO IMPROVE SUSTAINABILITY OF ENERGY DEVELOPMENT

Renewable energy technologies tend to have a higher profile than energy efficiency actions. This is mainly for the obvious reason that they are more visible as new installations and perceived as more "cutting-edge" technologies. This occurs even though they often have higher initial capital costs than energy efficiency measures (and may have less favourable operating costs too). However, one of the benefits of adopting renewables is the ensuing increase in awareness of energy production and consumption in the owner of the installation and also often with the public who can see or might interact with the technology. For example, solar PV or solar water heating panels on a public building raises the awareness of renewable energy use in the building users and other members of the public.

This increased awareness of energy consumption may be used to stimulate awareness of energy efficiency by introducing energy efficiency measures simultaneously with a new renewable energy installation. As the renewable energy installation has a significant capital costs people can become more sensitive to the idea of "wasting" the energy from the system, especially if they feel a strong level of ownership of the renewable energy system.

In addition, a renewable energy system supplier/installer could make recommendations on how to use the energy produced in the most efficient manner, so output from the system could generate the most benefit in terms of services to the end-users. This is often a good opportunity to introduce demand-side energy savings measures.

From the supply-side perspective, a switch to renewables supports sustainable energy generation and contributes to reducing dependency on imported energy. For large scale operations, currently available renewable technologies are biomass-based cogeneration for electricity generation, on-shore and off-shore wind, geothermal energy and large-scale hydro. For small-scale side installations, the following types of technologies can offset the need for electricity or gas taken from a national grid:

- Solar water heaters for water heating;
- Small-scale wind generators and mini-hydro systems for electricity;
- Solar PV for electricity;
- Small-scale biomass technologies for heat and electricity.

Discussion questions/exercises

Are there, in your country, any barriers that may be constraining the implementation of energy efficiency measures? Consider, but don't be limited to, the existing practices as well as policy framework, availability of funds, technology level, energy management, levels of capability and awareness.

Discuss these and propose simple plans to overcome the barriers and enhance energy efficiency in your country.

9. CONCLUSION

The implementation of energy efficient measures at all stages of the supply/demand chain could reduce significantly the negative impacts of energy use on the environment and human well-being, and increase the availability of primary energy reserves while achieving maximum benefits in terms of outputs from the available energy. The cost to both suppliers and consumers can be reduced, while maintaining the same level of energy-dependent activities.

We have seen how the overall efficiency of an energy-dependent activity, from the primary energy resource to the final output, is a figure that represents the cumulative effect of all the inefficiencies along the supply-demand chain. Measures to improve energy efficiency of each step will contribute to increasing the final figure, so even small improvements can have significant impact.

While improving demand-side energy efficiency will clearly bring reduced energy costs directly to the energy end-users, improvement of generating, transmission and distribution efficiencies—supply-side actions carried out by utility companies—can also bring cost benefits to the end-users in the typical regulatory environment by ensuring energy prices are well controlled.

Indeed, the combined effect of supply and demand-side energy efficiency improvement means that the load on generating facilities is lowered, and this can help keep older systems and equipment in good condition. This is because lower overall loads often allow the equipment to run below maximum capacity or be shut down more frequently (or for longer periods) for preventive maintenance. Older equipment will usually need more maintenance: depending on system characteristics, forced shutdowns for repair can be reduced and system operating efficiency can be raised. Overall system reliability can be improved as a result.

Barriers to achieving a good level of energy efficiency improvement include the lack of policy or regulatory measures, the lack of information and awareness of potential benefits, a failure to emphasize good energy management, and a lack of technical capacity to identify, evaluate and implement energy efficiency measures. Technology and financing barriers are also seen in some situations. Of these barriers, the failure to practise good energy management is typically one of the most important factors for enterprises. Improving energy management is almost always a low-cost action that achieves valuable benefits in the short term. Maintaining good management ensures these benefits are continually contributing to enterprise profits (and the national economy) in the long term.

LEARNING RESOURCES

Key points covered

The following theme are covered in this module:

- Defining energy efficiency and appreciating the benefits of increased energy efficiency;
- The energy supply-demand chain and where the energy losses and inefficiencies occur;
- Target sectors for energy efficiency programmes and typical actions;
- The most common barriers to the implementation of energy efficiency measures;
- The importance of good energy management as a contribution to energy efficiency improvement.

Answers to review questions

Question: Describe the main difference between demand-side and supply-side interventions and name a technique of each.

Answer: Demand-side interventions address the aspects of energy efficiency, which can be implemented or achieved through changes in the technologies on the customer/user end of the supply chain, i.e. on the customer's side of the meter. The techniques include:

(a) Substituting more efficient appliances for less efficient ones
(b) Influencing/encouraging customers to change their usage patterns
(c) Adopting good energy management practices

Supply-side interventions are typically those that are implemented by generators, grid operators and/or energy distributors, i.e. on the supply-side of the meter (or fuel pump). These measures include also load shifting, aimed to reduce daily peak-power demand while improving the grid load factor and ultimately the overall electricity supply side efficiency.

Question: Name the common barriers to implementation of energy efficiency measures.

Answer: The barriers to achieving energy efficiency are lack of policy or regulatory measures, lack of information and awareness, lack of emphasis on good energy management, lack of technical capacity to identify, evaluate and implement EE opportunities, financial factors and technology barriers.

Exercises

Energy efficiency measures can be applied through the supply chain as well as at the end-user. Consider the different points in the supply chain where energy efficiency measures can be applied and the types of techniques that can be used to achieve energy efficiency.

Write a 2-page essay discussing these options and their techniques as well as the benefits to industrial, commercial and residential sectors.

Presentation/suggested discussion topics

Presentation:

ENERGY EFFICIENCY – Module 12: Energy efficiency technologies and benefits

Suggested discussion topic:

1. Discuss the DSM and SSM options in relation to the sectors of your country economy and situation

REFERENCES

Energy and Energy Efficiency, Tanzania Country Report, Lugano Wilson, Tanzania Industrial Research and Development Organization (TIRDO), March 2006

UNIDO, Capacity Building in Energy Efficiency and Renewable Energy Regulation and Policy-Making in Africa, Ghana—Energy Efficiency Country Profile, Alfred K. Ofosu Ahenkorah, Accra, January 2006.

Industrial Demand Side Management in South Africa, Tsholo Matlala, Eskom DSM, Paper presented at ICUE Conference 2004, Cape Town, South Africa.

UNIDO, Report on Capacity in Energy Efficiency and Renewable Energy Regulation and Policy, Project no: YA/FRA/05/016, Zambia Country Report on Energy Efficiency, March 2006, Prof F.D Yamba, National Expert in Energy and Energy Efficiency, Centre for Energy Environment and Engineering Zambia

INTERNET RESOURCES

General

www.reeep.org/index.cfm?articleid=1390

www.watergy.org/activities/countries/southafrica/southafrica.html

www.reegle.info—information gateway for renewable energies and energy efficiency

Building energy use

Commercial Buildings Energy Consumption Survey (CBECS). A service of the U.S. Department of Energy's Energy Information Administration. Provides regionally specific energy use data for different types of commercial buildings; **www.eia.doe.gov/emeu/cbecs**

Energy efficiency

Note that although some sites are country specific, the information they provide is relevant to individuals and businesses globally.

Centre for Analysis and Dissemination of Demonstrated Energy Technologies (CADDET) Infostore. A searchable database of more than 1,500 renewable energy and energy efficiency projects and activities from all over the world. Several case studies highlight actions taken in the commercial sector that involve green buildings, cleaner transport fleets, and better lighting technologies. This service is maintained by the International Energy Agency; **www.caddet.org/infostore/index.php.**

Collaborative Labeling and Appliance Standards Program (CLASP). A clearing house for global information on efficiency standards and product labeling programs. CLASP provides information on which countries have mandatory or voluntary energy efficiency standards and which products are covered, as well as labeling programs to help consumers obtain energy-efficient products;
www.clasponline.org/main.php.

Emprove. A service of the New Zealand government, Emprove is an energy management and efficiency portal that provides information about the best energy management practices as well as incentives available to New Zealand businesses;
www.emprove.org.nz/index.aspx.

Energy Star Business Improvement. A programme jointly administered by the U.S. Environmental Protection Agency and the U.S. Department of Energy. The site provides a wealth of information about energy-efficient products and services as well as tools, calculators, and online training sessions that facilitate cost-effective energy use reduction strategies; **www.energystar.gov.**

European Commission Joint Research Centre. Information about energy efficiency, renewable energy, and green building programmes throughout the EU; **energyefficiency.jrc.cec.eu.int**.

Greentie. An international searchable directory of suppliers whose products and services help reduce greenhouse gas emissions. The directory is maintained by the International Energy Agency and contains listings for countries in every region of the world;
www.greentie.org/index.php.

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Energy Information Portal. Provides comprehensive information about various energy-efficient and renewable energy technologies as well as the best practices for implementing them;
www.eere.energy.gov.

Green buildings

Guidelines and resources for reducing the environmental impact of commercial buildings;
www.greenerbuildings.com.

UNEP Division of Technology, Industry and Economics (DTIE): Sustainable consumption product criteria database. Searchable database with links to ecolabeling and green procurement programmes around the world at every level of government;
www.uneptie.org/pc/sustain/design/green_find.asp.

U.S. Department of Energy, Energy Efficiency and Renewable Energy, Building Technologies Program. Resources, tools, data, and case studies regarding green buildings.
www.eere.energy.gov/buildings.

U.S. Green Building Council. Dedicated to promoting environmentally responsible buildings; **www.usgbc.org.**

World Green Building Council. An umbrella group providing information about green building councils in Asia, Europe, and North and South America; **www.worldgbc.org.**

Industrial energy efficiency

The *U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Industrial Technologies Program* has a section on best practices for industrial energy efficiency that provides resources and tools to industrial energy users.
www1.eere.energy.gov/industry/bestpractices/bestpractices_resources.html

American Council for an Energy-Efficient Economy has an industry and agriculture programme where information can be found on energy efficiency for manufacturing, combined heat and power, agriculture and water and wastewater.
www.aceee.org/industry/index.htm

The *Malaysian Industrial Energy Efficiency Improvement Project (MIEEIP)* was developed to remove barriers to efficient industrial energy use. This website provides a good example of a national industrial energy efficiency programme.
http://www.ptm.org.my/mieeip/indexabout.html

The *Iowa Energy Center* provides a number of industrial energy efficiency case studies and projects. **www.energy.iastate.edu/efficiency/industrial/cs-index.html**

GLOSSARY/DEFINITION OF KEY CONCEPTS

Activity	Used in this module in the context of "energy-dependent activity", such as the production level in an industrial plant, heating or cooling of a building, lighting in any sector, number of cooked meals, etc.
Bagasse	The fibrous waste remaining from the extraction of sugar from sugar cane, typically around half being fibre and half moisture with minor amounts of unextracted sugar. Can be used to manufacture paper, or burnt to produce steam and electricity (usually for the sugar plant itself).
Biomass	Can be an important renewable energy resource when managed in a sustainable way, for example, wood from sustainably grown forests.

Demand-side management	DSM is typically used in the specific sense of actions to modify electricity loads to achieve higher system efficiency.
Energy audit	Evaluation of the energy-related performance of a manufacturing plant or building, used to identify energy efficiency opportunities.
Energy efficiency	The utilization of energy in a cost-effective way to carry out a manufacturing process or provide a service. Depending on the context, typically expressed as an amount of energy consumed per unit of output (e.g. tons of cement, square metres of heated building, cubic metres of water pumped).
Energy intensity	Often used as an indicator of the energy efficiency of a national economy (or sector) and expressed as the ratio of energy consumption to GDP e.g. tons of standard coal per dollar GDP.
Stakeholder	Organization or individual with a strong interest in achieving improved energy efficiency, e.g. industrial enterprises, trade associations, building owners and operators, equipment manufacturers, the general public.
Supply-side management	SSM is the efficient utilization of energy for the generation, transmission and distribution of energy. SSM applies in particular to electricity systems but can also apply to gas and liquid fuel systems.

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Efficiency

Module 12:
ENERGY EFFICIENCY TECHNOLOGIES AND BENEFITS

Module 12

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- Introduction to the concept of energy efficiency (EE)
- There are many approaches available—together with the associated technologies—to achieve higher energy efficiency for both energy supply and demand
- EE measures can unlock economic and environmental benefits. EE is a high priority in supporting greater sustainable energy supplies for development
- By using energy more efficiently, African nations can maximize the effective use of available resources for the economic benefit of their populations

Module 12

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

- Introduce the role of energy efficiency (EE) in the energy supply-demand chain
- Briefly describe the associated benefits of applying EE
- Introduce a range of energy efficiency (EE) approaches—including technologies
- Briefly describe the barriers to implementation of EE

Module 12

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- To be able to define energy efficiency in all sectors of the economy
- To understand the energy supply-demand chain
- To appreciate means of increasing energy efficiency throughout the supply chain and at the level of the energy consumer who is undertaking a specified activity
- To appreciate the range of approaches and technologies available
- To understand the typical barriers to achieving higher energy efficiency

Module 12

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reminder!

- Aim of this module is to provide general background and information—and to provoke discussion
- Other Modules in the Training Package, references and websites offer further information and research in specific areas
- There are a wide variety of EE actions, to match the needs of different sectors and individual countries

Module 12

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Why Energy Efficiency?

- Inefficient use of energy = higher costs
  - To companies and industry
  - To the end-user
  - To the environment
- Energy use is environmentally detrimental
  - Locally (soil degradation, poor air quality)
  - Globally (climate change)
- Conventional energy resources are finite
- More efficient use of energy => greater availability of a scarce resource

Module 12

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

What do we mean by Energy Efficiency?

- More effective (minimum waste) utilization of **primary energy** resources to provide a desired **energy service***:*
  - **Manufacture of a product**
  - **Transportation**
  - **Cooking, lighting**
- Seek to **maximize the benefits** of energy use while **minimizing the cost and impact on the environment**

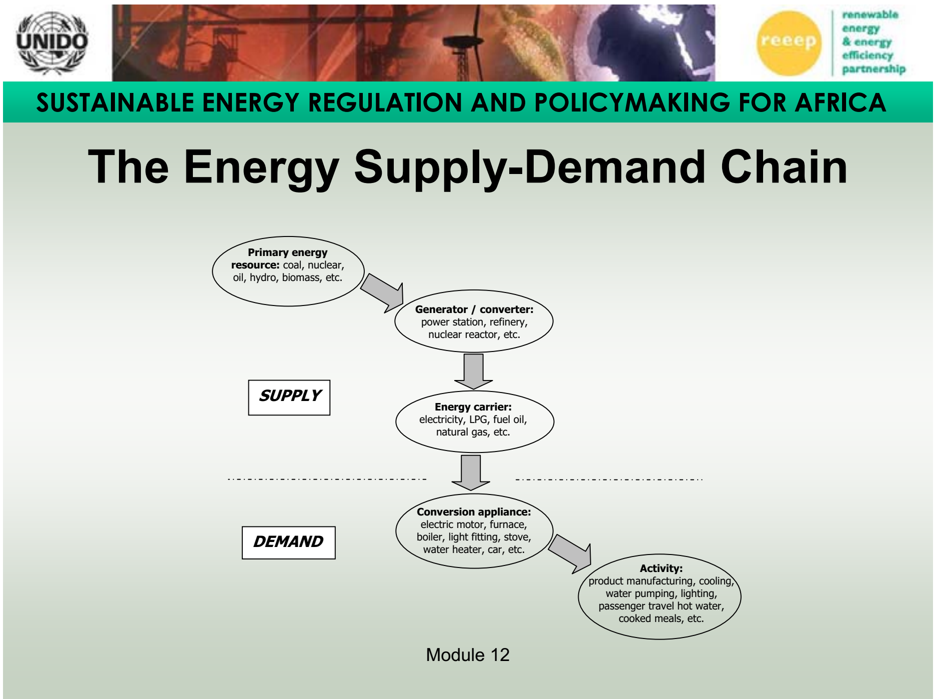
Module 12

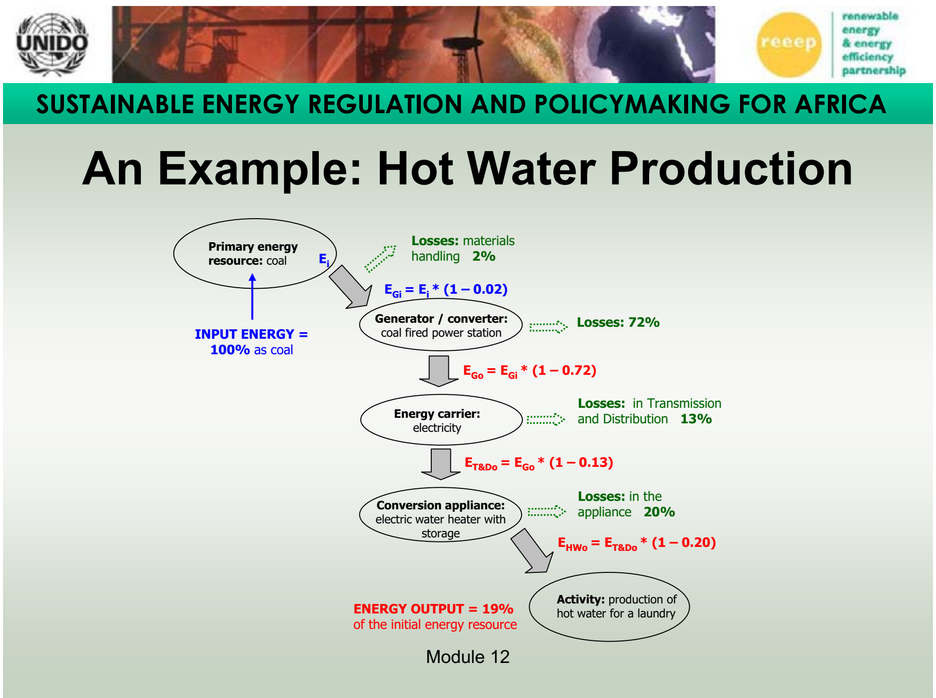
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Who Cares?

- The impacts of energy use affect us all
- Often the **state** needs to take the lead to provide guidance and regulatory oversight
- The main players—in terms of leadership—include:
  - The Ministry of energy
  - The energy/ (or electricity) regulator
  - The energy utility(s) – in some cases…

Module 12


UNIDO
reeep
renewable energy & energy efficiency partnership
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA
The Energy Supply-Demand Chain
Primary energy resource: coal, nuclear, oil, hydro, biomass, etc.
Generator / converter: power station, refinery, nuclear reactor, etc.
SUPPLY
Energy carrier: electricity, LPG, fuel oil, natural gas, etc.
DEMAND
Conversion appliance: electric motor, furnace, boiler, light fitting, stove, water heater, car, etc.
Activity: product manufacturing, cooling, water pumping, lighting, passenger travel hot water, cooked meals, etc.
Module 12


UNIDO
reeep
renewable energy & energy efficiency partnership
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA
An Example: Hot Water Production
Primary energy resource: coal
E_i
INPUT ENERGY = 100% as coal
Losses: materials handling 2%
$E_{Gi} = E_i * (1 – 0.02)$
Generator / converter: coal fired power station
Losses: 72%
$E_{Go} = E_{Gi} * (1 – 0.72)$
Energy carrier: electricity
Losses: in Transmission and Distribution 13%
$E_{T\&Do} = E_{Go} * (1 – 0.13)$
Conversion appliance: electric water heater with storage
Losses: in the appliance 20%
$E_{HWo} = E_{T\&Do} * (1 – 0.20)$
Activity: production of hot water for a laundry
ENERGY OUTPUT = 19% of the initial energy resource
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Where does Energy Efficiency fit in?

- To minimize the various cumulative losses—which result in 81% of the primary energy being “lost”
- To maximize the overall ratio of “units” of energy service (litres of hot water) per unit of primary energy (kg of coal)
- Increases in EE need not affect the experience of the customer in using the energy service
- To increase cost-effectiveness

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Energy Flows in National Economies

- An overall goal for a national energy efficiency programme would be:

To reduce the energy intensity of the economy, namely decrease the ratio of primary energy per unit of economic activity (measured in GDP)

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Benefits of Increased Energy Efficiency?

- Reducing the costs of energy services—to companies, individuals and to economies as a whole
- Reduced dependency on energy imports
- Achieving best service benefits from the available energy
- Reducing the negative impacts on the environment
- Extending the life of primary energy reserves
- Reducing the risks—due to greater predictability of cost and environmental impacts

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Target sectors

- Interventions generally developed in response to **priorities identified**—either at a **national level** or within the **domain of a company or energy utility**
- Typical target sectors include:
  - Utilities
  - Buildings
  - Industry
  - Commerce
  - Domestic appliances
  - Transport

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Supply-Side Management (SSM)

- Efficiency improvement interventions implemented on the utility's side of the meter
- These interventions can be undertaken either at the generation or within the transmission / distribution infrastructure
  - Upgrading existing generation
  - Improved maintenance
  - Cogeneration
  - Improved technologies
- Decisions to proceed are guided by financial returns and technical considerations

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SSM Technologies and Measures

- More efficient generation/conversion:
  - Minimizing waste heat and recovering waste heat
  - Improving maintenance practices
  - Utilizing equipment that has been manufactured to the best modern standards of efficiency
  - Applying modern process technologies
  - Cogeneration
  - Better control systems and metering of key parameters

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SSM Technologies and Measures (2)

- More efficient transmission and distribution systems:
  - Closer control of existing systems
  - Increased use of distributed generation
  - Higher voltage transmission
  - More energy-efficient technologies

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Demand-Side Management

- Interventions on the customer's side of the meter:
  - Efficient appliances
  - Energy management
  - Influence / encourage customers to change their use patterns
- DSM interventions can be implemented by incentive schemes or pricing signals
- DSM activities can be a challenge for utilities:
  - They are outside the direct control of the utility
  - They often impact negatively on revenues

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DSM Technologies and Measures

- More efficient appliances—e.g. motors, boilers, furnaces, refrigerators and lighting
- More informative metering
- Improved maintenance of equipment
- Better control systems—variable speed drives for motor speed controls; thermostats; fuel metering systems; smart appliances
- Behavioural change on the part of the customer

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Energy Efficiency Programmes

- Development of EE policies and strategies (i.e. standards)
- Raising awareness of energy consumption
- Encouraging energy auditing and energy assessment
- Development of energy efficiency best practices
- Development of institutional capacity and human resources for implementation of EE interventions
- Support for technology R&D

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Energy Efficiency Programmes (2)

- Introduction of incentive/penalty mechanisms to support improved EE
- Promotion and facilitation of international collaboration and cooperation

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Common Barriers to Implementation

- Policy and regulatory barriers
- Lack of information and awareness of the potential of EE
- Lack of industry initiatives to emphasize energy management as an integral part of total management systems
- Lack of technical capacity to identify, evaluate, justify and implement EE projects
- Financial / investment barriers
- Technology barriers

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Common Barriers to Implementation (2)

From a country undergoing 24h rolling load-shedding

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Energy Efficiency and Renewables

- Renewable energy can complement EE actions
- Renewables as the supply option will benefit sustainable energy generation
- The following types of technologies can offset the need for electricity imported from the grid:
  - Biomass-based cogeneration for electricity generation
  - Solar water heaters for water heating
  - On-site renewables such as wind, solar or geothermal for electricity and/or heating

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CONCLUSIONS

- EE can reduce the negative impacts of energy use on the environment and human well-being
- EE can increase the availability of primary energy reserves while achieving maximum service benefits from the available energy
- Reduced energy costs to companies, individuals and the economy generally
- Increasing EE does not affect the users, who essentially receive the same service

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