Appliances in buildings - energy conservation

Introduction

Energy is the capacity to do work. The rate at which energy is used or supplied is known as power.

Sources of energy.

Energy can be classified into two categories:

1. Renewable
2. Non-Renewable

Renewable sources of energy are those that are inexhaustible, such as the energy from the sun, wind, waves and tides, and geothermal heat. Non-Renewable sources of energy are those that are exhaustible and cannot be quickly replaced, such as fossil fuels and biomass.

Measurement of energy

• Heat energy is measured in J (joules) one joule is the amount of energy exerted when a force of one N (newton) is displaced through a distance of one meter.

• Power is, measured in J/s (joules/second) which is knows as watt (W). thus, J/s = W and 1000W = 1kilowatt.

• Electrical energy is measured in kWh (kilowatthour).

• One kWh is the electrical energy used or supplied when one kW of power is used or supplied for one hour

<u>Examples of energy Appliances in buildings</u>

- Refrigerators. ...
- Dishwashers. ...
- Clothes Washers. ...
- Ceiling Fans. ...
- Heat Pumps. ...
- Smart Thermostats. ...
- Whole-Home Dehumidifiers. ...
- Air Purifiers.

Efficient energy use

Efficient energy use, sometimes simply called **energy efficiency**, is the goal to reduce the amount of energy required to provide products and services and can also reduce effects of air pollution. For example, insulating a building allows it to use less heating and cooling energy to achieve and maintain a thermal comfort. Installing light-emitting diode bulbs, fluorescent lighting, or natural skylight windows reduces the amount of energy required to attain the same level of illumination compared to using traditional incandescent light bulbs. Improvements in energy efficiency are generally achieved by adopting a more efficient technology or production process or by application of commonly accepted methods to reduce energy losses. There are many motivations to improve energy efficiency. Decreasing energy use reduces energy costs and may result in a financial cost saving to consumers if the energy savings offset any additional costs of implementing an energy-efficient technology. Reducing energy use is also seen as a solution to the problem of minimizing greenhouse gas emissions. An important solution could be to remove government-led energy subsidies that promote high energy consumption and inefficient energy use in more than half of the countries in the world. Energy efficiency and renewable energy are said to be the *twin pillars* of sustainable energy policy and are high priorities in the sustainable energy hierarchy. In many countries energy efficiency is also seen to have a national security benefit because it can be used to reduce the level of energy imports from foreign countries and may slow down the rate of energy at which domestic energy resources are depleted.

Energy efficiency has proved to be a cost-effective strategy for building economies without necessarily increasing energy consumption. For example, the state of California in the United States of America began implementing energy-efficiency measures in the mid-1970s, including building code and appliance standards with strict efficiency requirements. During the following years, California's energy consumption has remained approximately flat on a per capita basis while national US consumption doubled. As part of its strategy, California implemented a "loading order" for new energy resources that puts energy efficiency first, renewable electricity supplies second, and new fossil-fired power plants last. States such as Connecticut and New York have created quasi-public Green Banks to help residential and commercial building-owners finance energy efficiency upgrades that reduce emissions and cut consumers' energy costs. The energy intensity of a country or region, the ratio of energy use to Gross Domestic Product or some other measure of economic output", differs from its energy efficiency. Energy intensity is affected by climate, economic structure (e.g., services vs manufacturing), trade, as well as the energy efficiency of buildings, vehicles, and industry.

Benefits

From the point of view of an energy consumer, the main motivation of energy efficiency is often simply saving money by lowering the cost of purchasing energy. Additionally, from an energy policy point of view, there has been a long trend in a wider recognition of energy efficiency as the "first fuel", meaning the ability to replace or avoid the consumption of actual fuels. Moreover, it has long been recognized that energy efficiency brings other benefits additional to the reduction of energy consumption. Some estimates of the value of these other benefits, often called multiple benefits, co-benefits, ancillary benefits or non-energy benefits, have put their summed value even higher than that of the direct energy benefits. These multiple benefits of energy efficiency include things such as reduced climate change impact, reduced air pollution and improved health, improved indoor conditions, improved energy security and reduction of the price risk for energy consumers. Methods for calculating the monetary value of these multiple benefits have been developed, including e.g., the choice experiment method for improvements that have a subjective component (such as aesthetics or comfort) and Tuominen-Seppänen method for price risk reduction. When included in the analysis, the economic benefit of energy efficiency investments can be shown to be significantly higher than simply the value of the saved energy.

Appliances

Modern appliances, such as, freezers, ovens, stoves, dishwashers, clothes washers and dryers, use significantly less energy than older appliances. Installing a clothesline will significantly reduce one's energy consumption as their dryer will be used less. Current energy-efficient refrigerators, for example, use 40 percent less energy than conventional models did in 2001. Following this, if all households in Europe changed their more than ten-year-old appliances into new ones, 20 billion kWh of electricity would be saved annually, hence reducing CO_2 emissions by almost 18 billion kg. The replacement of old appliances is one of the most efficient global measures to reduce emissions of greenhouse gases. Modern power management systems also reduce energy usage by idle appliances by turning them off or putting them into a low-energy mode after a certain time. Many countries identify energy-efficient appliances using energy input labelling. The impact of energy efficiency on peak demand depends on when the appliance is used. For example, an air conditioner uses more energy during the afternoon when it is hot. Therefore, an energy-efficient air conditioner will have a larger impact on peak demand than off-peak demand. An energy-efficient dishwasher, on the other hand, uses more energy during the late evening when people do their dishes. This appliance may have little to no impact on peak demand.

Building design

Buildings are an important field for energy efficiency improvements around the world because of their role as a major energy consumer. However, the question of energy use in buildings is not straightforward as the indoor conditions that can be achieved with energy use vary a lot. The measures that keep buildings comfortable, lighting, heating, cooling and ventilation, all consume energy. Typically, the level of energy efficiency in a building is measured by dividing energy consumed with the floor area of the building which is referred to as specific energy consumption or energy use intensity:

$$\frac{\text{Energy consumed}}{\text{Built area}}$$

However, the issue is more complex as building materials have embodied energy in them. On the other hand, energy can be recovered from the materials when the building is dismantled by reusing materials or burning them for energy. Moreover, when the building is used, the indoor conditions can vary resulting in higher and lower quality indoor environments. Finally, overall efficiency is affected by the use of the building: is the building occupied most of the time and are spaces efficiently used — or is the building largely empty? It has even been suggested that for a more complete accounting of energy efficiency, specific energy consumption should be amended to include these factors:

$$\frac{\text{Embodied energy} + \text{Energy consumed} - \text{Energy recovered}}{\text{Built area} \times \text{Utilization rate} \times \text{Quality factor}}$$

Thus, a balanced approach to energy efficiency in buildings should be more comprehensive than simply trying to minimize energy consumed. Issues such as quality of indoor environment and efficiency of space use should be factored in. Thus, the measures used to improve energy efficiency can take many different forms. Often, they include passive measures that inherently reduce the need to use energy, such as better insulation. Many serve various functions improving the indoor conditions as well as reducing energy use, such as increased use of natural light. A building's location and surroundings play a key role in regulating its temperature and illumination. For example, trees, landscaping, and hills can provide shade and block wind. In cooler climates, designing northern hemisphere buildings with south facing windows and southern hemisphere buildings with north facing windows increases the amount of sun (ultimately heat energy) entering the building, minimizing energy use, by maximizing passive solar heating. Tight building design, including energy-efficient windows, well-sealed doors, and additional thermal insulation of walls, basement slabs, and foundations can reduce heat loss by 25 to 50 percent. Dark roofs may become up to 39 °C (70 °F) hotter than the most reflective white surfaces. They transmit some of this additional heat inside the building. Proper placement of windows and skylights as well as the use of architectural features that reflect light into a building can reduce the need for artificial lighting. Increased use of natural and task lighting has been shown by one study to increase productivity in schools and offices. Compact fluorescent lamps use two-thirds less energy and may last 6 to 10 times longer than incandescent light bulbs. Newer fluorescent lights produce a natural light, and in most applications, they are cost effective, despite their higher initial cost, with payback periods as low as a few months. LED lamps use only about 10% of the energy an incandescent lamp requires. Effective energy-efficient building design can include the use of low-cost passive infra reds to switch-off lighting when areas are unoccupied such as toilets, corridors or even office areas out-of-hours. In addition, lux levels can be monitored using daylight sensors linked to the building's lighting scheme to switch on/off or dim the lighting to pre-defined levels to take into account the natural light and thus reduce consumption. Building management systems link all of this together in one centralised computer to control the whole building's lighting and power requirements. In an analysis that integrates a residential bottom-up simulation with an economic multi-sector model, it has been shown that variable heat gains caused by insulation and air-conditioning efficiency can have load-shifting effects that are not uniform on the electricity load. The study also highlighted the impact of higher household efficiency on the power generation capacity choices that are made by the power sector. The choice of which space heating or cooling technology to use in buildings can have a significant impact on energy use and efficiency. For example, replacing an older 50% efficient natural gas furnace with a new 95% efficient one will dramatically reduce energy use, carbon emissions, and winter natural gas bills. Ground source heat pumps can be even more energy-efficient and cost-effective. These systems use pumps and compressors to move refrigerant fluid around a thermodynamic cycle in order to "pump" heat against its natural flow from hot to cold, for the purpose of transferring heat into a building from the large thermal reservoir contained within the nearby ground. The end result is that heat pumps typically use four times less electrical energy to deliver an equivalent amount of heat than a direct electrical heater does. Another advantage of a ground source heat pump is that it can be reversed in summertime and operate to cool the air by transferring heat from the building to the ground. The disadvantage of ground source heat pumps is their high initial capital cost, but this is typically recouped within five to ten years as a result of lower energy use. Smart meters are slowly being adopted by the commercial sector to highlight to staff and for internal monitoring purposes the building's energy usage in a dynamic presentable format. The use of power quality analysers can be introduced into an existing building to assess usage, harmonic distortion, peaks, swells and interruptions amongst others to ultimately make the building more energy-efficient. Often such meters communicate by using wireless sensor networks. A deep energy retrofit is a whole-building analysis and construction process that uses to achieve much larger energy savings than conventional energy retrofits. Deep energy retrofits can be applied to both residential and non-residential ("commercial") buildings. A deep energy retrofit typically results in energy savings of 30 percent or more, perhaps spread over several years, and may significantly improve the building value. Energy retrofits, including deep, and other types undertaken in residential, commercial or industrial locations are generally supported through various forms of financing or incentives. Incentives include pre-packaged rebates where the buyer/user may not even be aware that the item being used has been rebated or "bought down". "Upstream" or "Midstream" buy downs are common for efficient lighting products. Other rebates are more explicit and transparent to the end user through the use of formal applications. In addition to rebates, which may be offered through government or utility programs, governments sometimes offer tax incentives for energy efficiency projects. Some entities offer rebate and payment guidance and facilitation services that enable energy end use customers tap into rebate and incentive programs.

Industry

Industries use a large amount of energy to power a diverse range of manufacturing and resource extraction processes. Many industrial processes require large amounts of heat and mechanical power, most of which is delivered as natural gas, petroleum fuels, and electricity. In addition, some industries generate fuel from waste products that can be used to provide additional energy. Because industrial processes are so diverse it is impossible to describe the multitude of possible opportunities for energy efficiency in industry. Many depend on the specific technologies and processes in use at each industrial facility. There are, however, a number of processes and energy services that are widely used in many industries. Various industries generate steam and electricity for subsequent use within their facilities. When electricity is generated, the heat that is produced as a by-product can be captured and used for process steam, heating or other industrial purposes. Conventional electricity generation is about 30% efficient, whereas combined heat and power (also called co-generation) converts up to 90 percent of the fuel into usable energy. Advanced boilers and furnaces can operate at higher temperatures while burning less fuel. These technologies are more efficient and produce fewer pollutants.

Energy conservation

Energy conservation is broader than energy efficiency in including active efforts to decrease energy consumption, for example through behaviour change, in addition to using energy more efficiently. Examples of conservation without efficiency improvements are heating a room less in winter, using the car less, air-drying your clothes instead of using the dryer, or enabling energy saving modes on a computer. As with other definitions, the boundary between efficient energy use and energy conservation can be fuzzy, but both are important in environmental and economic terms. This is especially the case when actions are directed at the saving of fossil fuels. Energy conservation is a challenge requiring policy programmes, technological development and behavior change to go hand in hand. Many energy intermediary organisations, for example governmental or non-governmental organisations on local, regional, or national level, are working on often publicly funded programmes or projects to meet this challenge. Psychologists have also engaged with the issue of energy conservation and have provided guidelines for realizing behavior change to reduce energy consumption while taking technological and policy considerations into account. Commercial property managers that plan and manage energy efficiency projects generally use a software platform to perform energy audits and to collaborate with contractors to understand their full range of options.

Sustainable energy

Energy efficiency and renewable energy are considered as main elements in sustainable energy policy. Both strategies must be developed concurrently in order to stabilize and reduce carbon dioxide emissions. Efficient energy use is essential to slowing the energy demand growth so that rising clean energy supplies can make deep cuts in fossil fuel use. If energy use grows too rapidly, renewable energy development will chase a receding target. Likewise, unless clean energy supplies come online rapidly, slowing demand growth will only begin to reduce total carbon emissions; a reduction in the carbon content of energy sources is also needed. A sustainable energy economy thus requires major commitments to both efficiency and renewables.

Rebound effect

If the demand for energy services remains constant, improving energy efficiency will reduce energy consumption and carbon emissions. However, many efficiency improvements do not reduce energy consumption by the amount predicted by simple engineering models. This is because they make energy services cheaper, and so consumption of those services increases. Similarly, an extensive historical analysis of technological efficiency improvements has conclusively shown that energy efficiency improvements were almost always outpaced by economic growth, resulting in a net increase in resource use and associated pollution. These are examples of the direct rebound effect.

Reference

Tuominen, P., Seppänen, T. (2017): Estimating the Value of Price Risk Reduction in Energy Efficiency Investments in Buildings. Energies. Vol. 10, p. 1545.

Energy Use Can Be Cut by Efficiency, Survey Says By Steve Lohr https://www.nytimes.com/2006/11/29/business/29energy.html

The Intergovernmental Panel on Climate Change (IPCC) 2001 - https://en.wikipedia.org/wiki/Intergovernmental_Panel_on_Climate_Change

Najar Salighe, M. (2005), Modeling Building Consistent with Chabahar City Climat, Geography and Development Journal, No. 2, pp. 147-170.

2019 Kenya Population and Housing Census.https://www.knbs.or.ke/?wpdmpro=2019-kenya-population-and-housing-census-volume-iv-distribution-of-population-by-socio-economic-characteristics

Kenya's 2022 universal electrification goal bets on off-grid solar. Dec 2018 https://www.pv-magazine.com/2018/12/07/kenyas-2022-universal-electrification-goal-bets-on-off-grid-solar/

Kenya National Electrification Strategy 2018. http://pubdocs.worldbank.org/en/413001554284496731/Kenya-National-Electrification-Strategy-KNES-Key-Highlights-2018.pdf

2019 Kenya Population and Housing Census. - https://www.knbs.or.ke/?wpdmpro=2019-kenya-population-and-housing-census-volume-iv-distribution-of-population-by-socio-economic-characteristics