



ENERGY EFFICIENCY GUIDELINES

1. Main concepts and definitions on energy efficiency in public buildings



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ABBREVIATIONS

AC	Alternate current
ASHREA	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BPIE	Buildings Performance Institute Europe
DC	Direct current
DOE	US Department of Energy
EEM	Energy efficiency measures
EPA	Environmental Protection Agency
ESCO	Energy services company
EU	European Union
EUI	Energy Utilization Index
IEA	International Energy Agency
IEC	International Electrochemical Commission
IRENA	International Renewable Energy Agency
ISO	International Organization for Standardization
KPI	Key performance indicator
kW	Kilowatt
kWh	Kilowatt-hour
NZEB	Nearly zero-energy buildings
O&M	Operation and maintenance
ROI	Return on investment
SLD	Single line diagram
SPP	Simple payback period
TTA	Trama Tecnoambiental

1 INTRODUCTION

This report provides simple definitions and the basic concepts of terms related to energy efficiency in general and specifically in public buildings. It sets a common ground for all building users, from decision makers to building users, interested in incorporating these concepts on their daily basis work environment. The comprehension of those terms can help take decisions on direct technical interventions or behavioural changes, with the objective to reduce the energy usage of the building.

Energy efficiency is considered to be the cheapest energy source possessed by all countries in the world. According to a report from the International Energy Agency (IEA), in 2016, the world would have used 12% more energy had it not been for improvements achieved in energy efficiency since the year 2000. The benefits of energy efficiency are numerous and include reduction of greenhouse emissions, use of less infrastructure to produce energy, or improvements on energy resilience and security due to the avoidance of short-term peak gas power plants.

Energy efficiency is also the counterpart of renewable energy; one does not make sense without the other. Renewable energy technologies and energy efficiency combined can reduce the demand of fossil fuels but also help achieve goals faster; according to the International Renewable Energy Agency (IRENA), increasing the share of renewables results in faster improvement of energy efficiency improvement rate.

2 ENERGY EFFICIENCY

Energy efficiency means the reduction in the energy usage to produce a given service, process or activity; with other words, perform the same task by using less energy and eliminating energy waste. In economic terms, energy efficiency is the reduction of energy in order to produce one unit of economic activity. Energy efficiency techniques is usually associated with technological interventions, but it can also result from better organisation and management or improved economic conditions or behavioural changes, the so-called non-technical factors.

Technological interventions to improve energy efficiency may include the substitution of existing appliances with more efficient ones and manual or automatic thermal regulation of room temperature or deactivation of lights in unoccupied hotel rooms are actions and mechanisms that can result to a reduction of energy consumption without decreasing individual welfare.

According to the International Electrochemical Commission (IEC), energy efficiency can be achieved in three ways; by reducing energy, increasing outcome or reducing energy waste, as seen in Figure 1.

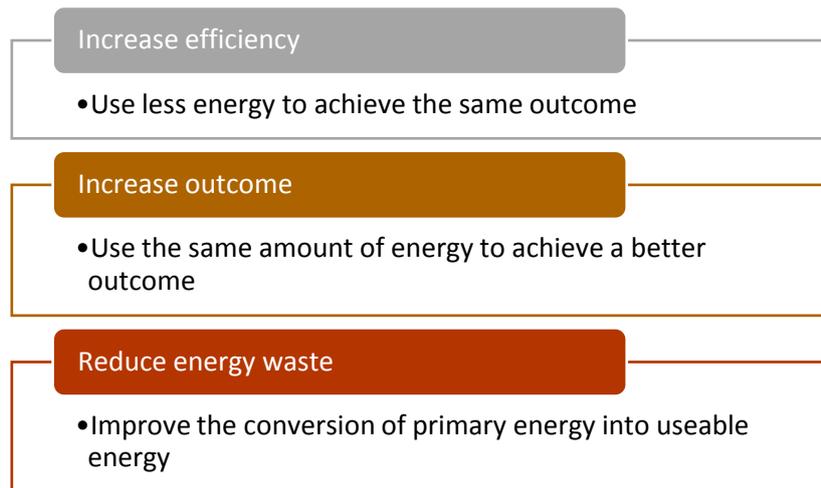


FIGURE 1: ENERGY EFFICIENCY ASPECTS ACCORDING TO IEC

3 ENERGY EFFICIENT APPLIANCES

Energy efficient appliances are those which perform the same amount of work but consume less energy. Innovation in energyefficient appliances is an ongoing trend of research applicable to all electricity sectors. Programs such as Energy Star in the United States or Energy Labelling of the European Commission have set targets for appliances that are driving manufacturers to design appliances that lower energy needs through technological innovations.

3.1 Energy Labelling and Eco-design

The EU energy labels provide a clear and simple indication of the energy efficiency of products at the point of purchaseand is a key driver for helping consumers choose products which are more energy efficient. It was first introduced for a number of household appliances in 1994 and was subsequently expanded in 2004. The labelling is done with a comparative scale from A to G where A is the most efficient andGthe least efficient. Figure 2 below explains how to read the energy labels.

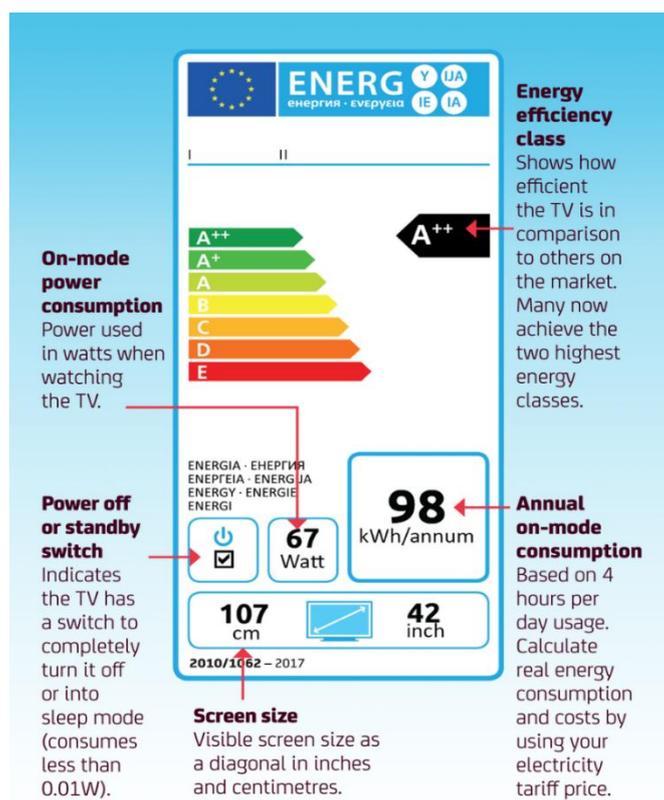


FIGURE 2: HOW TO READ ENERGY LABEL

The European Commission provides information on energy savings, energy labelling and ecodesign requirements for a list of products under the following categories:

- Lighting
- Heaters
- Fridges and freezers
- Vacuum cleaners
- Washing machines and driers
- Air conditioners and fans
- Televisions and TV boxes
- Kitchen appliances
- Pumps
- Transformers and converters
- Computers and servers
- Imaging equipment
- Game consoles
- Electric motors
- Welding equipment

3.2 Energy Star

ENERGY STAR® is a program run by the U.S. Environmental Protection Agency and U.S. Department of Energy that promotes energy efficiency and provides information on the energy consumption of products and devices using different standardized methods. It provides simple,



FIGURE 3: ENERGY STAR LOGO (USA)

credible, and unbiased information for consumers and businesses to make well-informed decisions. ENERGY STAR offers programs for commercial buildings to reduce their energy costs through the Portfolio Manager® tool that measures and tracks their energy use, water use, and waste and materials.

Products that earn the ENERGY STAR label are independently certified to meet strict standards for energy efficiency set by the Environmental Protection Agency (EPA). The figure below shows the energy star logo to be recognized while purchasing products.

4 ENERGY EFFICIENCY STANDARDS FOR COMPANIES

Energy efficiency standards are mandatory programmes that prescribe the energy performance of products or companies. For example, the International Organization for Standardization (ISO) issues the standard ISO 50001, which is a company level certification that helps organisations reduce energy consumption, environmental footprint and costs. The standard requires the use of an *energy management system* with the main purpose of using energy more efficiently. The standard is based on a management system model of continuous improvement, similar to some other common ISO standards. The certification calls for a company to develop an energy policy, establish goals to meet the policy, utilize data to meet goals, measure policy effectiveness, and continually make improvements to the policy.

ISO 50001 is not industry specific and is intended for any organization that wants to implement and maintain an energy management system. Certifications are issued by third party certifying bodies. Audits can be conducted regularly to ensure that the management system is continually improving.

5 EUROPEAN DIRECTIVES FOR ENERGY EFFICIENCY

There is a set of binding measures to help EU reach its energy efficiency targets, which was 20% reductions for 2020. For the year 2030, the new binding target is at least 32.5% energy reduction, which has to be further adjusted due to the withdrawal of the United Kingdom.

There are two EU Directives that aim to boost the energy performance of buildings, namely the Energy Performance of Buildings Directive 2010/31/EU, amended by the 2018/844/EU, and the Energy Efficiency Directive 2012/27/EU. They promote policies in order to achieve a highly energy efficient and decarbonised building stock by 2050, create a stable environment for investment decisions and enable consumers and businesses to make more informed choices to save energy and money. Since 2018 all new public buildings are required to be nearly zero-energy buildings (NZEB).

Within the framework of the EU Green Deal, the Commission has published the Renovation Wave for Europe to green the buildings and double the annual energy renovation rates in the next ten years. Furthermore, it introduces the *smart readiness* indicator aims to promote digitally friendly renovations, integrate renewable energy and enable measurements of actual energy consumption.

Additional to energy efficiency, there are other alternative policy measures that can give incentives to reduce energy consumption. Such measures are:

- Taxes on energy or CO₂ emissions
- Energy labelling schemes

- Financial incentives for the replacement of technologies, appliances, etc with more efficient ones or incentives for shifting energy usage at other time intervals (demand shift)
- Regulations
- Training and education

6 LOW ENERGY AND NEARLY ZERO-ENERGY BUILDINGS

Low-energy or nearly zero energy buildings are buildings with very low energy consumption that mostly comes from renewable energy technologies. According to Buildings Performance Institute Europe (BPIE), *low energy buildings* are defined by a well-insulated and maintained fabric and efficient windows, natural ventilation and efficient heat recovery. Additional measures like integrating solar water heaters or PV panels for energy generation, rainwater collection systems or heat exchange with the environment (absorb heat in winter and reject heat in the summer) can further add to the efficiency of the building.

7 ENERGY EFFICIENCY AND TARIFFS

Energy efficiency measures (EEM) are adjustments to building systems and controls, or equipment installations that result in lower energy use. Broadly any EEM can be divided into two categories: a) cost related decisions b) energy efficiency policies and measure that are “non-price measures”.

The cost related decisions are based on a trade-off between the immediate cost and the future decrease in energy expenses expected from increased efficiency. There will be more savings achieved through EEMs when energy prices are higher. For this it is key to understand the invoicing and pricing structure. Tariffs can be purely energy-based (e.g. USD/kWh) or can have a power component (USD/kW contracted power) and result to a binomial tariff. Energy savings from energy efficiency measures can decrease one part of the energy bill. Some energy efficiency measures can target to decrease the contracted power of the building and, thus, achieve additional savings to the monthly invoices.

8 ENERGY SERVICES COMPANY (ESCO)

A company that identifies energy improvements, provides the capital required to install improvements, offers turn-key installation services, and guarantees energy savings

9 ENERGY AUDIT

An energy audit is an inspection, survey, and analysis of energy flows in a building, process, or system with the objective of understanding the energy dynamics of the system under study. Typically, an energy audit is conducted to seek opportunities to reduce the amount of energy input into the system without negatively affecting the output(s).

9.1 Investment grade audit

A comprehensive energy audit that seeks to identify all cost-effective investment opportunities through a combination of engineering analysis of energy-using systems and economic analysis of possible energy saving measures

9.2 Who carries out energy audits?

Energy audits are usually led by energy consultants, engineering companies or energy services companies (ESCOs). The inputs and data are retrieved with the participation of building staff and other participants, who will also participate in the design of the EEMs.

10 UNDERSTANDING LOADS

It is crucial to understand the different categories of loads when it comes to energy efficiency and user behaviour. Automatic or manual, the energy efficiency techniques and interventions should respect the users' comfort and not disturb their convenience.

There are various ways to categorize appliances. They can be categorised into:

- Cold: refrigerators, freezers, walk-in cold rooms, packaged condensing units, process chillers
- Wet: washing machines, tumble dryers, dish washers
- Comfort: air conditioning, fans, heating, air distribution systems
- Cooking: stoves
- Lighting: light bulbs
- Entertainment: TV, video, DVD
- Miscellaneous loads: power adapters, doorbells, computers, phone/fax machines, etc

Each of these loads is further characterised as critical and non-critical. Critical loads include devices whose function time cannot be altered without violating the consumers' convenience, while non-critical loads offer some degree of flexibility. The combination of the different types of appliances can be seen below.



FIGURE 4: LOADS CATEGORISATION

For a more in-depth analysis of loads and comprehension, appliances can be further defined as semi-automatic, fully automatic and individually modelled appliances. Semi-automatic are the wet appliances which are shiftable, but consumer's interaction is necessary. For example, a consumer has to load the dishwasher. Fully automatic are the natural thermal storage devices (cold appliances) and individually modelled are those used on demand. Individually modelled include cooking, lighting, and miscellaneous appliances which in this specific case represent the non-shiftable loads.

11 DIRECT CURRENT DISTRIBUTION AND LOADS

Direct current (DC) distribution and devices, as opposed to alternate current (AC) are proposed as a way to achieve higher energy efficiency in buildings, cost savings and resiliency. Many

end-user devices, such as electronics (phone chargers and laptop chargers), solid-state lighting, efficient motors and electric vehicles work in DC, hence a converter is always needed to convert the AC from the grid to useful DC.

12 ENERGY PROFILES

Additional to the type of loads, it is crucial to understand the load profiles or patterns of energy usage within an interval of time (daily, weekly, monthly). Loads can be generated readings made at regular intervals, which can be as small as one minute to as large as one hour. When higher the resolution is, more detail on the demand can be revealed.

Figure 5 shows a load profile of one week of a hospital in Palestine, captured with data loggers at the main distribution board of the hospital. The measurements were taken every minute and captured the average power (black line) but also the maximum power that occurred over one minute (grey dash line).

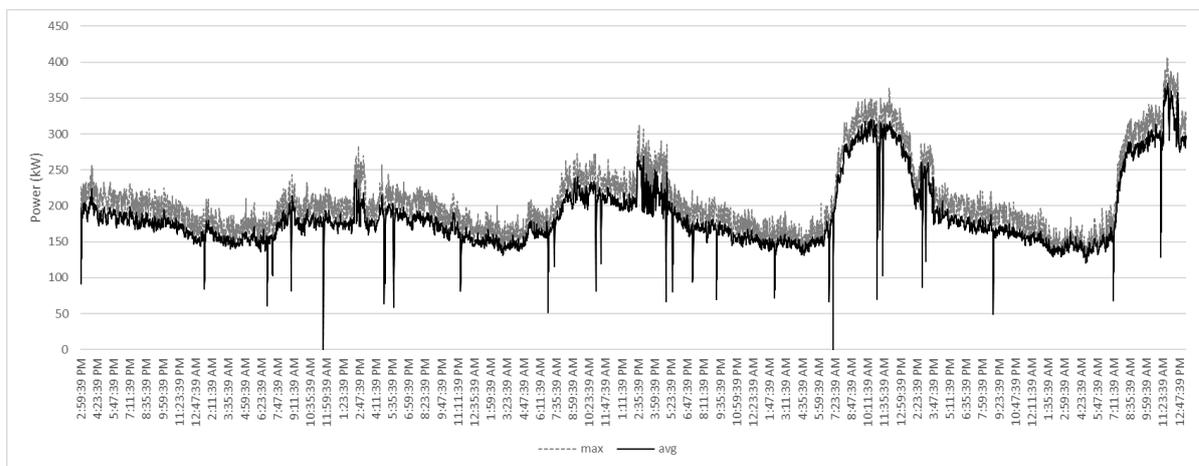


FIGURE 5: WEEKLY LOAD PROFILE OF A HOSPITAL IN PALESTINE (SOURCE: TTA)

If the auditor has knowledge of the way that the building is operated, then looking at the energy profiles and linking the patterns of energy usage with the operations of the building can help identifying energy wastes. If the profiles show energy being used on times or days when there is no good reason for energy to be used, that is an indication that energy is possibly being wasted, and something worth investigating.

To interpret and assess the energy profiles, one has to identify usual patterns in the usage of public buildings. Every building is different, but the following factors are commonly relevant:

TABLE 1: FACTORS DETERMINING THE ENERGY USAGE IN A PUBLIC BUILDING

Factors	Description
Occupancy	<p>When people come and go:</p> <ul style="list-style-type: none"> • What are the core occupancy hours (e.g. 9am to 5pm)? Are there multiple shifts (e.g. a day shift and a night shift)? • Do people ever work on-site outside of the core occupancy hours? Do certain staff stay on after official closing time? Does anyone come in on weekends or holidays? • In case of the public buildings like offices and schools; is the seating arranged in a way that favours the comfort and minimizes the heating and cooling needs?

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Factors	Description
HVAC	<p>Heating, Ventilation and Air Conditioning:</p> <ul style="list-style-type: none"> • Is there air conditioning? Is it used just for cooling in summer, or is it used all year round (e.g. to keep equipment cool)? • Where are the cooler and air conditioners installed in the building? • Does the timer and temperature of the cooler and air conditioners vary on the peak occupancy and non-occupancy hours? • What fuels are used for heating (e.g. gas, electricity etc.)? • How is the heating controlled? Is it on a timer? When is it set to come on and off? Are there different timer settings for weekends and holidays? • Does the timer and temperature vary of the heaters vary during the occupancy and non-occupancy hours? • Where are the heater installed in the space, is it optimal for the purpose of space heating?
Lighting	<ul style="list-style-type: none"> • Where are the position of the lights installed? Are there enough intensity of light near the place it is most needed? • What controls when the lights come on and off? Are they automatically controlled (e.g. by a sensor that detects movement or light-levels), or are they turned on and off by staff? • Do lights remain on when they are not needed (e.g. when staff have gone home, or when they are on lunch-break)? • Are there enough light-switches? For example, if one person is working late in a large open office, will 100 lights remain on to light just one desk?
Water consumption	<ul style="list-style-type: none"> • What is source of drinking water? • How is the water pumped to different floors? And does the building have its own water pumping and storage facility? • Does the building have facilities to store and use the rainwater? • Is the wastewater recycled and reused? (e.g. using sink water for toilet flush) • What is the source of water used for irrigation? Is drinking water used for irrigation? • Is there other equipment that use water such as washing machine?
Office equipment	<ul style="list-style-type: none"> • Do staff turn their computers off when they leave work? • Is there office equipment such as photocopiers / printers? Is it turned off when not in use?
Other energy-consuming	<p>This could include anything from a printing room, to charging a fork-lift truck, to a special pump of water for storage.</p>

Factors	Description
equipment/processes	<ul style="list-style-type: none"> • What processes or items of equipment exist that use energy? • What sort of energy do they use (e.g. electricity, or gas, or both)? • When do they use energy? When do the processes run? When is the equipment switched on and off? <p>It is important to note that industrial processes can often dwarf all other types of energy consumption in a building. If a building has processes or items of equipment that consume a lot of energy, even small changes to the way that they are operated can often make a big difference to the energy bill.</p>
Building material characteristics	<ul style="list-style-type: none"> • What are the materials used in the outside walls of the building with respect to their thermal insulation? • Are the windows double sided and well insulated? • Is the roof properly insulated? • Are the plumbing system and pipes properly insulated?

13 NEGAWATTS

The amount of power saved by implementing energy efficiency measures is expressed by the term “**negawatt**”. A negawatt is an imaginary unit of power first devised by the American physicist Amory Lovins in 1989. Nonetheless, the electricity end users shall not change their consumption profile and risk their comfort unless they are compensated for the negawatts accordingly. This compensation of negawatts can be achieved through giving financial incentives by charging different prices during different times of the day.

14 THERMAL TRANSMITTANCE

Thermal transmittance, or U-value, is a term that measures the thermal performance of a surface; it shows how well a material insulates. It is defined as the rate of heat transfer through a surface divided by the temperature difference across the surface (in W/m^2K). The higher the U-value is, the lower its insulation performance and vice versa. It can be measured using a heat flux meter.

15 INTERNET OF THINGS (IOT)

In general terms, the Internet of Things (IoT) refers to the allocation of unique identifiers (such as IP addresses) to physical objects. Those identifiers enable objects to connect to a network allowing the transfer of data to and from those entities. These objects can potentially be anything: people, animals, vehicles, plants, appliances, building components, etc., and they are often described as *smart* objects, for example, a smart meter, a smart phone, a smart home, etc.

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