State of the art

HOTELS

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1 STATE OF THE ART IN HOTELS

The Hotels sector belongs to the so called service sector, which includes all activities that do not produce material goods directly, but services offered to meet the needs of the population. This Includes subsectors such as trade, transport, communications, finance, tourism, bars and restaurants, leisure, culture, entertainment and public services (health, education, etc.).

1.1 Energy consumption profile

The sector as a whole, excluding transportation, is responsible for 12% of national energy consumption.

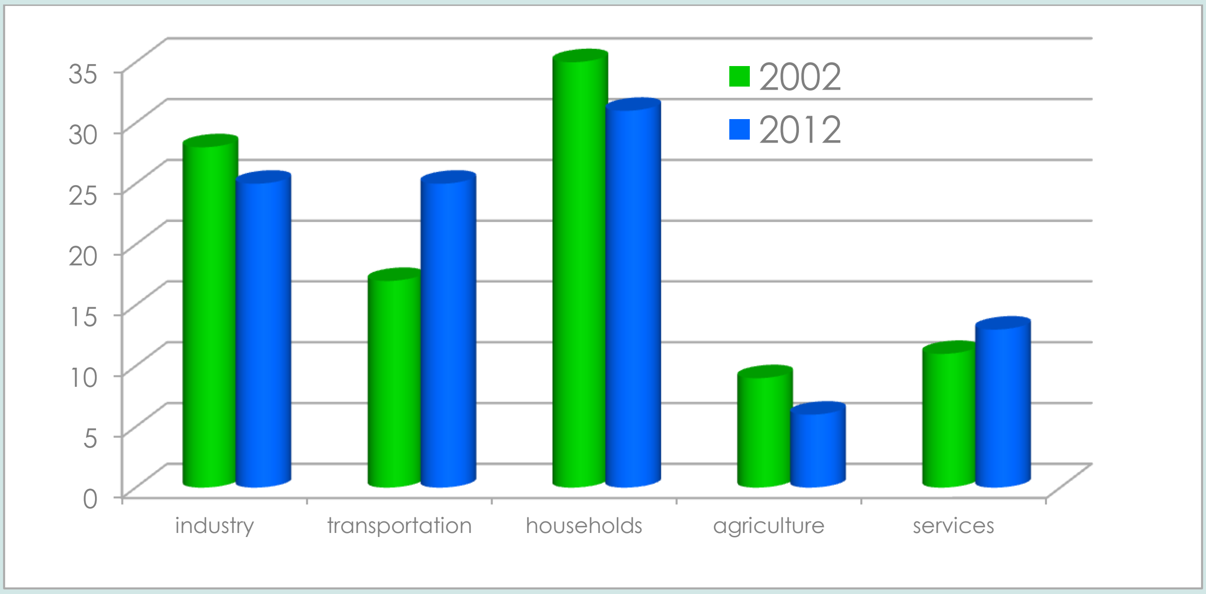

Figure 1. *Distribution of energy consumption in Poland.*
GUS: Energy efficiency in 202-2012

According to the Polish statistics small and medium enterprises are responsible for 75% of GDP - in 2013 it was 1 165 355 mln PLN, in which hotels and tourist accomodation takes 6,7%, what means 78 078 mln PLN. Figure 2 shows the contribution to GDP per sector.

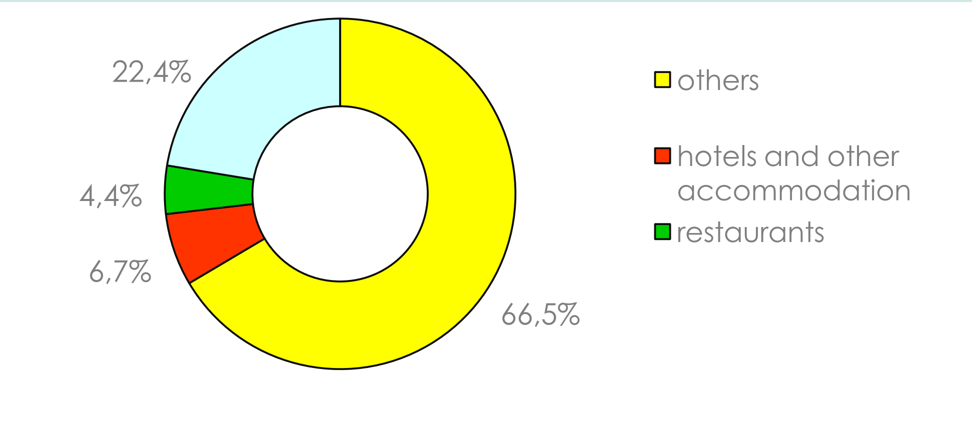

Figure 2. Contribution to GDP per sector. Report on SME in Poland 2012-2013

Number of Polish hotels and accommodation places presents figure 3.

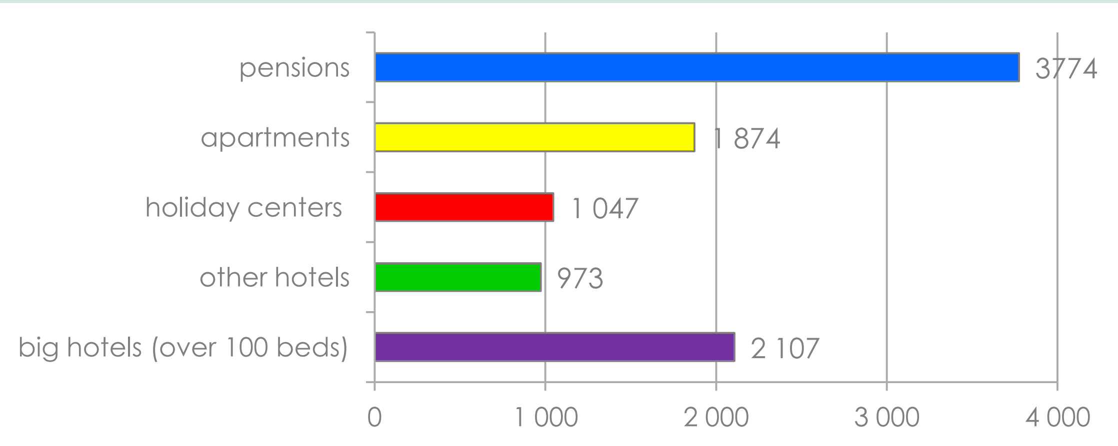

Figure 4 Number of accommodation places in Poland in 2013
GUS "Turystyka 2013"

Figure 4 shows a breakdown of energy consumption in an average hotel in Poland.

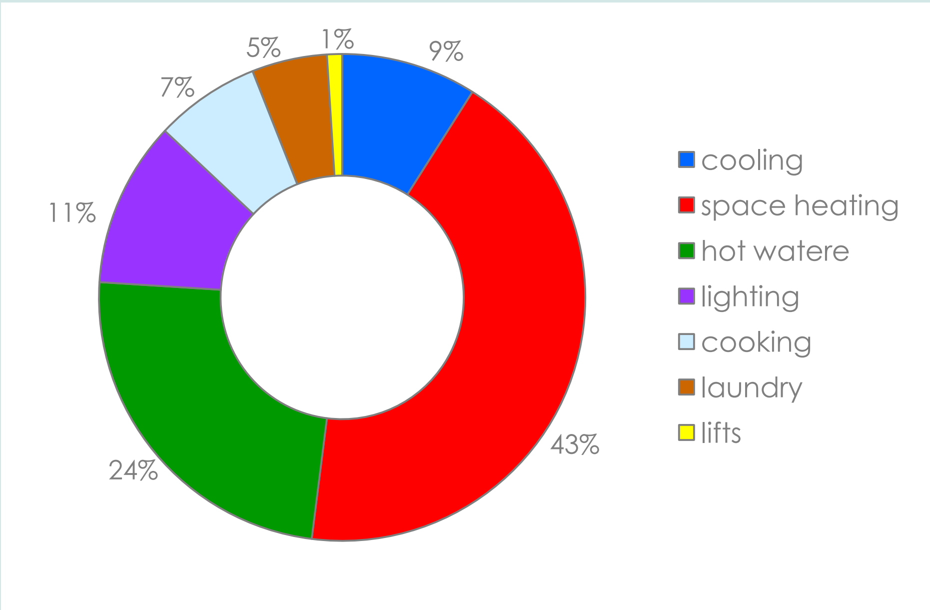

Figure 3. Breakdown of energy consumption in an average hotel depending on its location.

Source: Polish Japanese Energy Efficiency Center -Energy savings in services sector

Figure 4 shows the distribution of the electricity consumption in an average Polish hotel.

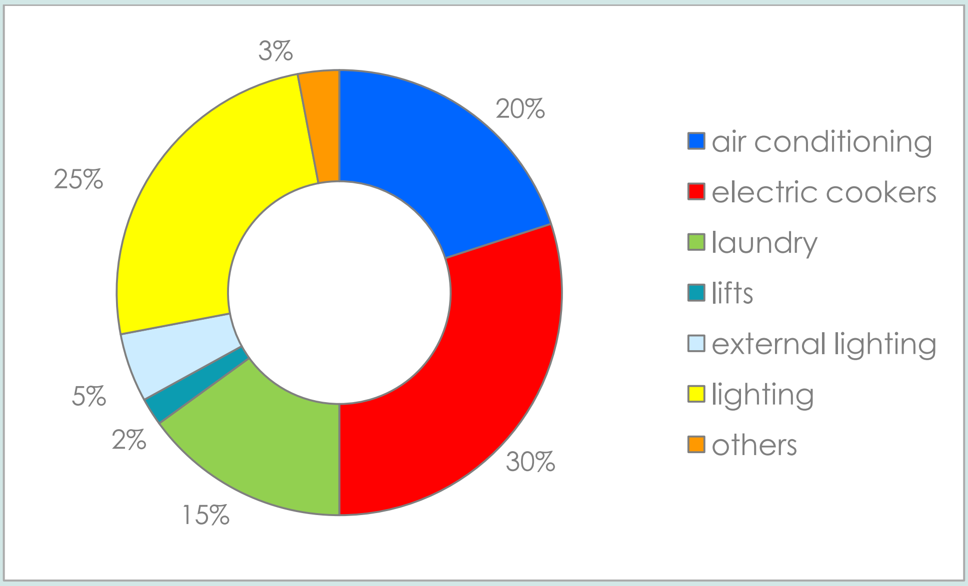

Figure 4. Distribution of the electricity consumption.

Source: Polish Japanese Energy Efficiency Center -Energy savings in services sector

1.2 European Level overview

At European level, according to the Hotel Energy Solutions project[1], hotel accommodation sector is formed by SMEs hotels, which provide about 90% of the total numbers of rooms, being only 10% of rooms provided by large hotel chains. Europe has the world's largest hotel stock (aprox. 5.45 million hotel

[1] Hotel Energy Solutions (2011), Key Energy Efficiency Technologies Database for SME Hotels,Hotel Energy Solutions project publications. First edition: 2010. Revised version, July 2011 (http://hes.unwto.org/sites/all/files/docpdf/keyeetdatabaseforsmehotelsaout-2-2.pdf) (http://hes.unwto.org/sites/all/files/docpdf/analysisonenergyusebyeuropeanhotelsonlinesurveyanddeskresearch2382011-1.pdf)

rooms). The tertiary sector, including hotels, has the potential to achieve 30% savings on energy use by 2020 (EU Action Plan for Energy).

In terms of energy consumption, the energy use falls in the range 200-400 kWh/m2/y. The energy consumption is influenced by:

- physical parameters: size, structure and design of the building, geographical and climatic location, age of the facility, type of energy systems installed, operation and maintenance, resource availability (locally energy and water), also, local energy-use regulations and costs.
- Operational parameters: number of facilities (restaurants, kitchens, in-house laundries, swimming pools and sports centres, business centres, etc.), operating schedules of these facilities, services offered, occupancy levels, and awareness of resource consumption among personnel and guests.

A typical distribution of energy consumption by end use is as shown in the next Figure:

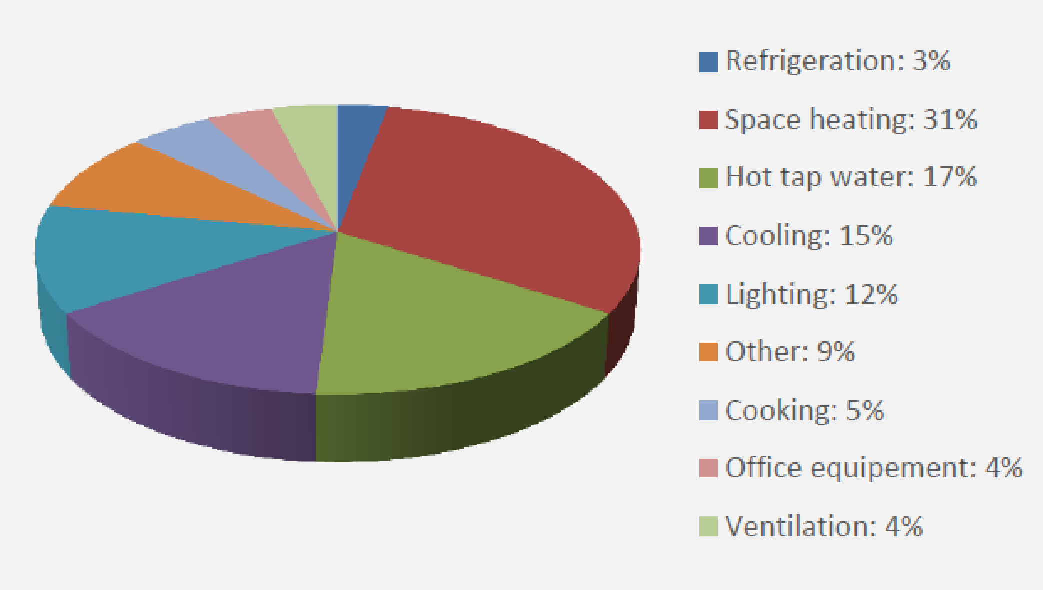

Figure 5. Energy consumption by end-use in hotels. Leonardo energy, 2008.

Considering the energy carriers the energy consumption is distributed as electricity (47% of total energy consumption) and heat (53% of total energy consumption). Figure 6 and Figure 7 show the distribution of end-uses considering electricity and heat consumption, respectively.

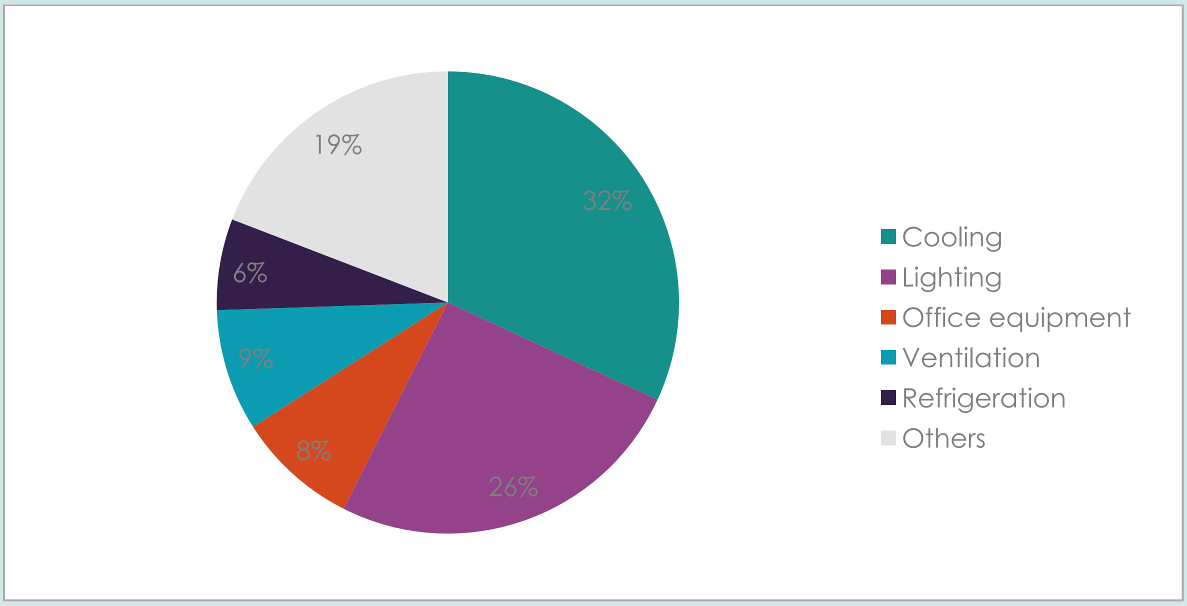

Figure 6. End-uses involving electricity consumption. Hotel Energy Solutions, 2011.

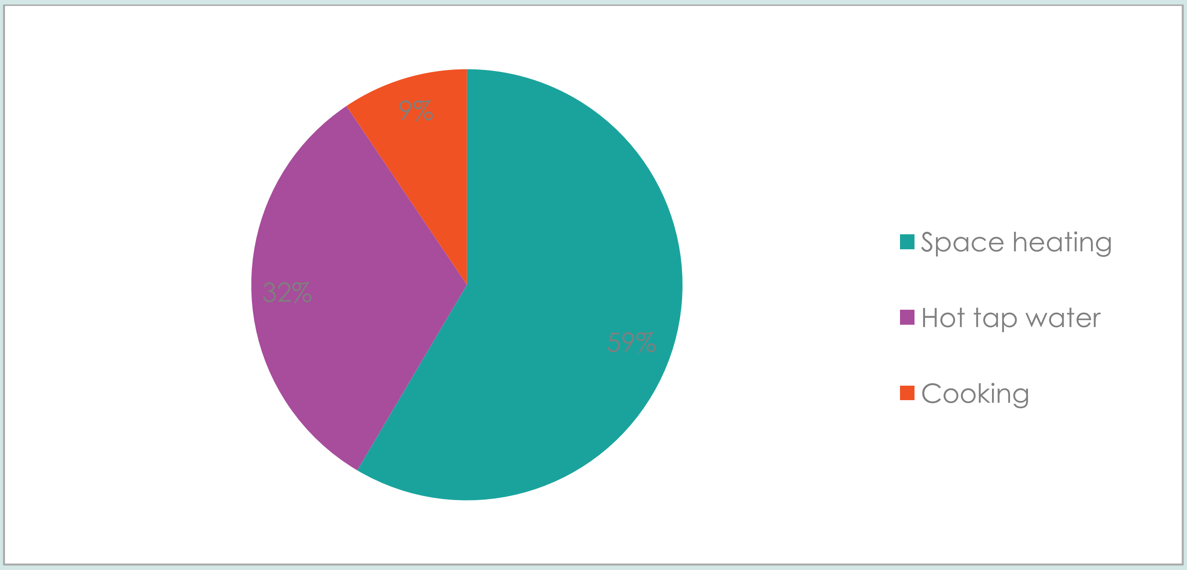

Figure 7. End-uses involving gas consumption. Hotel Energy Solutions, 2011.

1.2.1 Energy consuming equipment

To work hotels need energy. The main responsible for energy consumption are:

- Lighting (outdoor and indoor);
- Heating, ventilation and air conditioning (from here HVAC);
- Domestic hot water (DHW) production;
- Restaurant/Bar;
- Laundry;
- Minibars;
- Elevators.

For each entry shortlisted above, devices and energy efficiency measures have been classified.

Note: with "energy efficiency measures" is meant both systems of regulation and/or control and measures for improving energy efficiency

LIGHTING (OUTDOOR/INDOOR) (O=OUTDOOR, I=INDOOR)

Devices

- Halogen spotlight (O/I)
- Light sign (O)
- Fluorescent light (electronic and not) (O/I)
- Compact fluorescent light (electronic and not) (O/I)
- Mercury light (patio or path light) (O/I)
- Low pressure sodium light (O)
- High pressure sodium lamp (O)
- LED (O/I)
- Halogen light (O/I)

Energy efficiency measures

- Twilight sensor (O)
- Astronomical clock (O)
- Presence detector (O/I)
- Differentiated circuits (I)
- Dimmer (I)
- Light detector (I)
- Timer (I)
- Switch/keypad/remote-control/touch-screen (I)

HVAC

Devices

- Boiler/condensing boiler
- Geothermal, water, air - heat pump
- District heating
- Cogeneration/tri-generation
- Air conditioner
- Solar cooling

Energy efficiency measures

- Heat recovery systems
- Solar shading, glass film
- Thermal insulation
- Thermostatic valve
- Temperature adjustment and/or control for generator, emission system and environment.

DHW PRODUCTION

Devices

- Solar thermal panels
- Boiler/condensing boiler
- Biomass boiler
- Heat pump
- Electric boiler
- Cogeneration plants

Energy efficiency measures

- Heat recovery (from cooling system, i.e.)
- Temperature set point adjustment
- Water saving measures
- Efficient boilers
- Solar thermal panels

RESTAURANT/BAR

Devices (cold)

- Freezer
- Refrigerators /Refrigerating room
- Ice machine
- Display case
- Blast chiller

Devices (hot)

- Oven
- Microwave oven
- Griddle
- Toaster
- Grill
- Display case

Devices (other)

- Food processors
- Glass/Dishwasher
- Extractor fans

Energy efficiency measures

- High energy class appliances
- Insulation for oven, washing machine, etc.
- Heat recovery
- Temperature set point adjustment

LAUNDRY

Devices

- Washing machine
- Dryer
- Sterilizing machine
- Ironing

Energy efficiency measures

- Wash water recovery system
- Variable Speed Drive (VSD)
- Optimization drying/ironing system
- Condensate drain system

ELEVATORS

Devices

- Hydraulic elevators
- Electric traction elevators

Energy efficiency measures

- VSD
- Control systems' optimisation

MINIBARS

Devices

- Absorption/compression-based/Thermoelectric systems

Energy efficiency measures

- High efficiency class applicances

In the following section a deeper description of the activities labelled for being the main responsible of energy consumption in the hotels' facilities is reported.

1.2.2 DHW

In the hotels, the domestic hot water production requires a relevant amount of energy. The systems mainly used for this purpose are:

- Boilers
    - Biomass boiler;
    - Electric boiler;
    - Condensing boiler;
    - Traditional boiler;
- Heat pumps;
- Heat recovery from cooling / refrigeration systems;
- Cogeneration systems;
- Solar thermal panels;

A study carried out by ENEA on the energy consumption various 3 and 4 stars hotels showed that the production of domestic hot water accounts for approximately 25% of the total energy consumption realized within the facility [1].

The systems for hot water production are distinguished in instantaneous and accumulation ones. The difference between the two types is the installation, for the latters, of accumulation tanks. In the case of the hotels, the tanks for the water storage are crucial in order to guarantee the required quantity and temperature supply (especially in the case of simultaneous draws by several users). On the contrary, when the water demand is occasional and located far away from the central system the instantaneous technology might represent the most suitable solution.

Given the importance in some situations, the use of accumulation systems may, however, introduce relevant losses as consequence of prolonged periods of low demand; moreover, if not managed properly, accumulations systems can cause human health concern: tanks (and also distribution systems) represent the ideal habitat for the development of the bacteria legionella.

1.2.2.1 Boilers

In the fuel fired boilers the water is warmed up using the energy produced by the combustion of a fuel (natural gas, oil, biomass, etc.). In the electric boilers, on the other hand, the increase in water temperature is effect of the joule heating i.e. the heat resulting from the passage of electric current through an electric resistance.

In the case of the hotels, given the high quantity of water required, the choice and the design of the thermal power plant and of the boiler to integrate it with are particularly relevant. Capacity, performance, fuel availability and production costs are among the main parameters to consider for the installation.

In general, the various types of boilers are distinguished according to several parameters such as: operative conditions (pressure and temperature), capacity, fuel used, specific design of the device.

In particular, in order to achieve higher values of efficiency so to reduce the consumption, condensing boilers should be evaluated. A condensing boiler is able to exploit a higher share of the heat produced from the combustion reaction by condensing the water present in the exhausts [5]. The scheme in Figure 8 represents the energy losses of a traditional boiler. As showed in the figure, the thermal efficiency for the boiler is reduced by the losses taking place inside the device (A, B, C, D are the percentage of the various types of energy losses). Because of the lower losses in the flue gases, condensing boilers are more performing than the traditional ones. Typical values of the efficiency for the traditional boilers are around 90-95%; while, condensing type devices, can obtain values of efficiency around 105%.

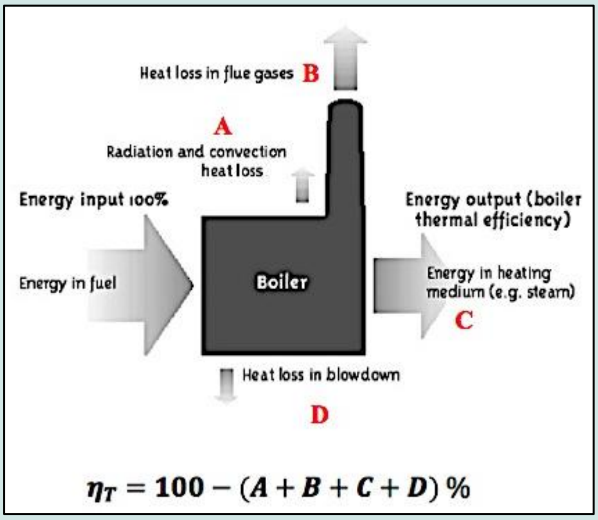

Figure 8. Typical energy losses from a traditional boiler (Source: www.cleanboiler.org).

As far as electric boilers are concerned, in the Italian context, they are less used than the fuel fire models mainly because of the higher running costs. However, generally speaking, similar installations are usually preferred where small quantities of water are needed. Moreover, this type of systems has on their advantage: low maintenance, less noises and a simpler design; therefore, it is preferred when very strict limitations about local emissions are in force and the other options are not convenient (for instance, when there is no availability of oil or other types of fuels). When the thermal energy is produced by the combustion of biomass the boiler takes the name of biomass boiler. The biomass used for this purpose is usually on the form of wood, chips or pellets. Biomass boilers are more diffused outside the cities.

1.2.2.2 Heat pumps

Heat pumps are devices allowing, by using energy, the heat transfer from a source at lower temperature (cold source) to another at higher temperature (hot source).

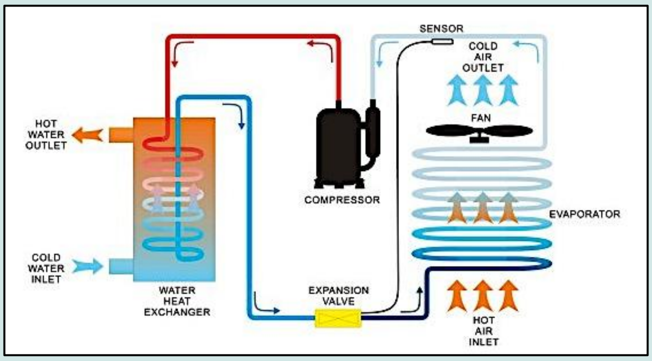

Figure 9. Schematic representation of a heat pump's thermodynamic cycle (Source: www.dheemanthsolar.com).

Figure 9 depicts a schematic representation of a heat pump's cycle. The refrigerant at low pressure goes through the evaporator where vaporises absorbing heat from a cold source (ground, water, air); subsequently, after the compression stage, the refrigerant enters in the condenser where liquefies releasing thermal energy to the water to warm up.

The heat pump is usually integrated with an accumulation tank and a backup boiler. This latter may be also present when there is the need to increase the water temperature above the maximum values reachable with the only use of the heat pumps (around 50°C for the electric and 70°C for the absorption types). Typical value of the Coefficient of performance (COP) of a heat pump varies in the range 3-5; while typical values of the Gas utilization efficiency (GUE) for the absorption heat pumps are around 1,5 [6].

1.2.2.3 Heat recovery from refrigeration/cooling systems

Recovering waste heat from refrigeration/cooling systems is a possible way to produce domestic hot water in the hotels cutting down the energy costs and the emission of pollutants otherwise produced [7]. Refrigeration systems consist of several stages according to which the refrigerant undergoes to variations of pressure and temperature; in particular, in order to close the loop the refrigerant is cooled down in the condenser. The heat generated in this last stage can be recovered with a heat exchanger producing hot water at various levels of temperature depending on the grade of heat recovery. When, for instance, the refrigerant goes through the exchanger for heat recovery (desuperheater) before passing through the condenser the final temperature reaches can be as high as 110°C, but only around 30% of the heat (normally exchanged in the condenser) can be recovered at this temperature; this is the case of high grade heat recovery. Figure 10 shows the representation of a high-grade heat recovery system.

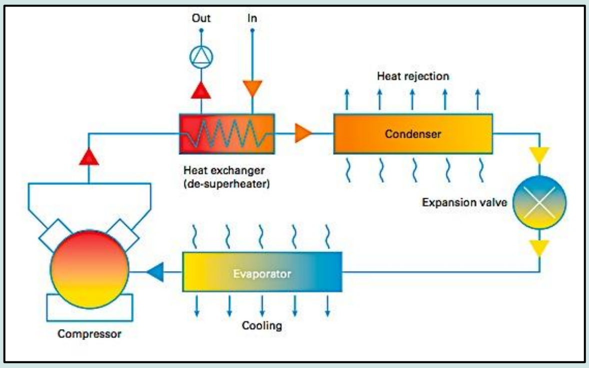

Figure 10. Representation of a high-grade heat recovery system (Source: Carbon Trust).

When, on the contrary, the heat recovery takes place in the condenser, the final temperature of the water out is approximately 50°C; is this the case of low-grade heat recovery [7].

1.2.2.4 Cogeneration systems

The hotels with over than three stars are usually characterized by a large demand of both hot water and electricity (fitness centre, spa, swimming pool, restaurant, bar, etc. are usually present). In these cases, a cogeneration plant, i.e. a plant producing simultaneously heat and electricity usually represents the best solution to satisfy the energy needs within the facility [8].

Depending on the electrical power needed at the output, the systems commonly used for cogeneration purposes vary. The plats installed in the hotels produce power and hot water by mean of an internal combustion engine or micro turbines. Figure 11 shows a schematization of a CHP plant.

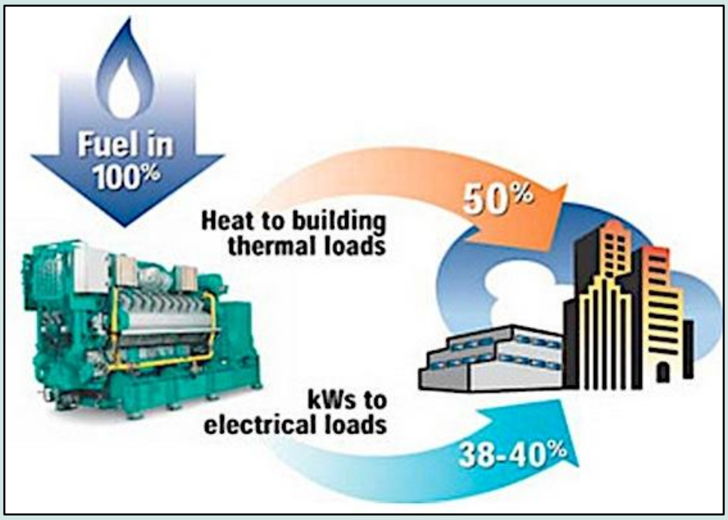

Figure 11. *CHP schematic diagram (Source: www.ipsi.net).*

1.2.2.5 Solar thermal panels

According with this technology, cold water flows through collectors exposed to the sun, increasing its temperature. Depending on the final use of the water and in order to reach the desired temperature the installation of a backup boiler and of an accumulation tank can be considered too. Figure 12 shows a schematic representation of the installation of a solar thermal system.

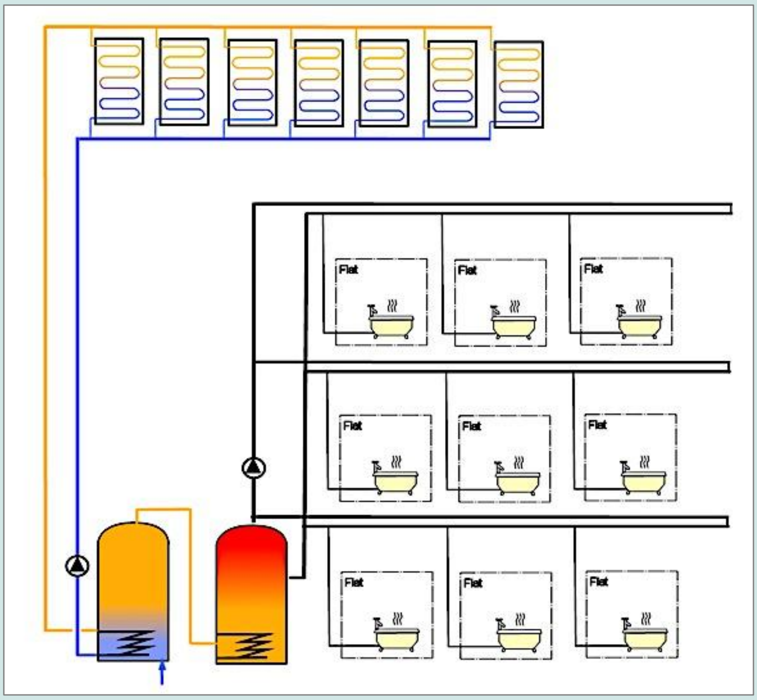

Figure 12. Sketch of a solar thermal system integrated to a hotel facility (Source: www.viridiansolar.co.uk).

1.2.3 Minibars

Nowadays, almost all the hotels from three stars upward have their rooms equipped with minibars (In particular, their presence is compulsory in certain UE countries). Although these appliances represent an important element in relation to the comfort that the hotels is able to guarantee to the customers, the electrical consumption due to their use not marginally influences the global electricity consumption of the facility and, consequently, its running costs.

The types of minibars commercially available are classified in accordance with the refrigeration system adopted. In particular, it is possible to distinguish between:

- Absorption system;

The absorption system is based on a thermodynamic cycle in which the refrigerant is subject to the physical change from saturated vapour to liquid (in form of solution with water). The refrigerant, on the basis of the endothermic absorption process, dissolves in the solvent absorbing heat from the external environment (the process takes place in the absorber) that, in its turn, cools down.

- Compression based system;

This system represents the most commonly used in the domestic fridges. According with this system, the cold is produced through a thermodynamic cycle in which the environment, releases heat to vaporize the fluid (the environment represents the evaporator) decreasing, as consequence, its temperature.

- Thermoelectric system (also known as Peltier).

The minibars based on the thermoelectric system work because of the thermoelectric phenomenon known with the name of Peltier effect (from the name of the French physicist Jean Charles Athanase Peltier). On the basis of this thermoelectric effect, direct current goes through two conductive metal foils linked through an electrified junction (usually bismuth telluride is the material used) with the result that one of them absorbs heat while, the other, releases heat.

TopTen.eu, the website dedicated to information about the energy efficient products on the European market (for more information see www.topten.eu), has recently published a report regarding, among the other things, energy efficient minibars.

In particular, a comparison among the most used types within the hotels facilities is reported in the document. Three types of minibars, belonging to the three different systems reported above, have been compared on the base of the energy efficiency class and the annual energy consumption. The data provided in the report are summarized in Table 1.

	Energy efficiency class	Annual Energy consumption [kWh/year]
Absorption (30lt)	E	295
Peltier (30lt)	C	219
Compressor (40lt)	A+++	55

Table 1. *Energy efficiency class and annual energy consumption of the minibars compared. (Source topten.eu)*

The capacity being approximately constant, the compressor type minibars are those characterized by the minimum annual energy consumption. Following, in terms of most performing device, it has the Peltier model that, anyway, slightly differs from the absorption based technology.

Despite the higher efficiency, the compressor minibars have the inconvenience of being quite noisy during the operation. For this reason, in the past years the other two technologies, quieter due to their construction (the thermoelectric has no moving parts) were much more used as equipment in the hotels rooms. However, nowadays, the use of specific systems of control based on the use of sensors of presence as well as on the set up of the working time has made the compressors minibars more competitive, in terms of comfort, with the absorption and Peltier ones

1.2.4 Elevators

The first prototype of elevator was patented in 1853 by the American manufacturer Elisha Otis [8]. Building taller facilities helped to promote the spread of this new technology allowing people to reach the highest floors of the building [8].

Nowadays almost all the buildings with more than one floor are equipped with, at least, one elevator. In particular, in the case of the hotels sector, it is easy to realise the importance played of such a type of devices inside the buildings. More than allowing people to move to highest floors of the buildings, elevators, make possible to move things from a floor to another. If it is true, and it is, that the elevators play a fundamental role within the facilities they are installed in, the expenditure to make them to work represent one of their main weak points.

The energy consumption of elevator ranges between 5 and 8% of the total energy consumption within a building [9]. It is therefore clear that, in the perspective of improving the energy efficiency of a facility, a lot more can be done regarding these machines.

Regarding the Italian situation, a study carried out by ENEA [10] as Italian partner of the project Energy-Efficient Elevators and Escalators (for more details about the project see the website www.e4project.eu), evaluated that the energy consumption of the elevators is the 1,4% of the total electric consumption of the tertiary sector and the share of standby on total consumption is over half for the offices and less than one third in the hotels.

Regardless the specific type considered, the main parts of a lift are [9]:

- Car;
- Doors;
- Light;
- Ventilation;
- Motor;
- Control device.

Even though currently there are several types of elevators to install inside a building; all the different models can be classified in:

1.2.4.1 Hydraulic lifts

Figure 13 reports a schematic representation of a hydraulic elevator.

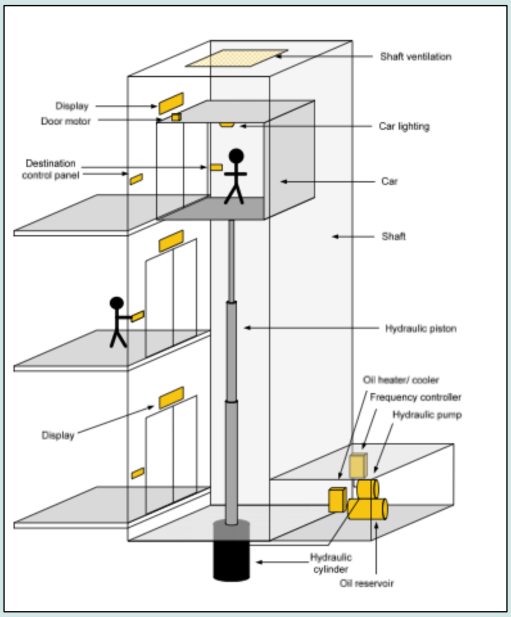

Figure 13. Schematic representation of hydraulic lift. (Source [2]).

In this type of machines the car is made in motion through a fluid (usually oil) pumped with a hydraulic cylinder.

1.2.4.2 Electrical traction elevators

A Schematic representation of an electrical traction lift is depicted in Figure 14.

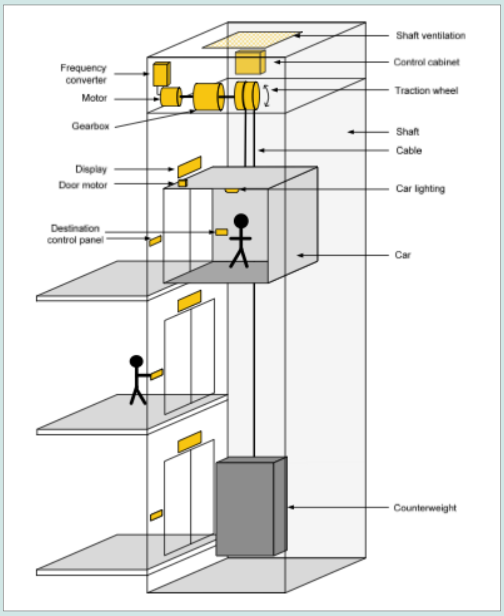

Figure 14. Schematic representation of an electric traction lift. (Source [2]).

In this type of machines the car moves because of a counterweight. As aforementioned, the category of the electrical traction lift, also identified simply with traction lift, is distinguished between geared and gearless machine, depending if it is whether or not equipped with a gear. In the geared machine the gear is the mean of connection of the motor and the sheave; while, in the gearless machine, sheave and motor are connected directly rotating, therefore, at the same speed.

One of the most relevant concerns about the elevator design regards the space occupied by the various elements composing the machines (motor, system of control, etc.). This space is located on top of the elevators in the traction type ones, while it is at the bottom in the hydraulic model. Machines that do not have this space are called machine roomless (MRL). This category of machines can reach height up to 80m with a speed up to 2,5m/s and a capacity ranging from about 600kg to 1600kg. In the MRL, the absence of the room, allows the use of simpler constitutive elements with the further advantage for the gearless devices, of having higher efficiencies [9].

The speed and the typical application of the three types of elevators described above are summarised in Table 2.

	Speed [m/s]	**Application**
Geared machine	1 – 2,5	Mid rise (b/w 7 – 20 floors)
Gearless machine	2,5 – 10	High rise (20 floors)
Hydraulic	Up to 1	Low rise (\7 floors)

Table 2. Typical speed and application of geared, gearless and hydraulic lifts.

The main advantages and drawbacks of hydraulic elevators are listed below [9].

Advantages:

- Simple installation;
- The smaller space needed for the motor and the control device allows the use of space at the bottom of the structure rather than on top of it with the advantage of requiring lower costs and less problems for the structure stability;
- The emergency procedures are simpler.

Besides those positive characteristics, the main ***disadvantages*** are:

- Limited use in taller buildings;
- Higher energy consumption and higher power needed during the operation;
- According with the frequency of use, sometimes, a system of control of the fluid temperature is required in order to avoid problems related to the variation of the fluid viscosity that could damage the normal device operation.

1.2.4.3 Energy efficiency improvement

Generally speaking, the efficiency of a device is limited by the losses characterizing its operation. Concerning the elevators, the main causes of their inefficiency are [9]:

- Friction losses;
- Transmission losses;
- Motor losses;
- Brake losses,
- Lighting losses;
- Control losses.

However, it's worth noting that the users' behaviour, as well as the maintenance and the way of using the machine, represent fundamental parameters that can strongly penalise the efficiency.

Despite the new installations, for which several actions for highly energy efficiency designs are possible; the structure of the already existing machines can be made more energetically efficient with the use of:

- Variable speed drives (VSD);
- An improved control system;
- More efficient lighting.

It's worth noting that, in case a substitution of the motor is needed, the choice of a higher efficient one is strongly recommended.

For the new installations, the measures to be taken in order to improve the energy efficiency consist in choosing [10]:

- Suitable car size, speed and load;
- Most suitable technology (traction or hydraulic);
- High efficiency motors;
- VSD or regenerative drives;
- Optimisation of the auxiliaries (car lighting, doors motion; ventilation etc.);
- Emergency power supply.

In addition, measures to prevent energy waste can be adopted also during the operation like:

- Power outages (when possible) for traction elevators;
- Control of the thermal treatment of the oil for hydraulic machines.

Finally, for buildings equipped with more than one lift, a system of control of the machines operation could be a good action to minimise the energy use keeping the same service to the users [10].

Within the European directive for the energy use of products (2009/125/CE) no regulation has been defined yet to assess the energy consumption, and therefore the efficiency, of the elevators. However, in 2008, the union of the German engineers (VDI) defined the guidelines VDI 4707 to classify lift energy use as function of its operation, both in stand-by and in motion.

1.2.5 Lightning

A summary of the different types of lamps used for out and indoor lighting is reported in Table 3**Błąd! Nie można odnaleźć źródła odwołania.**. In particular, unlike the offices, hotels have also the problem of the outdoor lighting; therefore, high and low-pressure sodium lamp have also been included in the table.

	Lamp type	Efficiency (Lm/W)	Lifetime (h)	T (K)	CRI* (%)	Rated power (W)	Light shade	Auxiliary equipment
	**Traditional**	**8-16**	**1.000**	**.000 – 3.000**	**100**	**15 - 1000**	**Warm**	**Not needed**
	**Halogen reflector**	**18-22**	**2.000 - 4000**	**2.900-3.000**	**100**	**5 - 150**	**Warm**	**Transformer**
	**LED**	**10-120**	**30.000-100.000**	**3.000-7.000**	**75-95**	**3-25**	**Neutral Cold**	**Transformer or integrated system**
	**LED**	**10-120**	**30.000-100.000**	**2.700-3.000**	**85-95**	**3-25**	**Warm**	**Transformer or integrated system**

	Linear fluorescent	55 -120	10.000 – 24.000	.700 – 6.500	60-90	10-80	Warm Neutral Cold	Starter Ballast and condenser
	Linear fluorescent triphosphor	78 - 105	17.000	3.000-6.000	>80	14-80	Warm Neutral Cold	Starter Ballast and condenser
	Energy saving compact fluorescent	70 - 90	6.000-15.000	2.700-6.000	80-90	3-25	Warm Neutral Cold	Integrated
	HPL-High Pressure Mercury	30 – 60	25.000	3.400-5.900	50 – 60	50 – 2.000	Warm Neutral	Starter Ballast and condenser
	Metal halide lamps	40 – 100	.000 – 20.000	000 – 6.000	65 - 90	Up to 1.000	Warm Neutral Cold	Starter Ballast and condenser
	Induction – fitting based	Up to 71	60.000	2.700-4.000	>80	100-150	Warm Neutral	Ballast
	Induction – Self-ballasted	~50	10.000	3.000	~80	-	Warm Neutral	Integrated
	LPS - Low-Pressure Sodium	125-200	10.000-12.000	1.800	0	18-180	Warm	Ballast
	HPS - High-Pressure Sodium	70-150	12.000-28.000	.500 – 2.000	~82	50-1000	Very Warm	Starter and ballast/ the ballast can be also integrated

Table 3. Characterization of the main types of lamps used for lighting purposes.

1.2.6 HVAC

1.2.6.1 Solar cooling systems

The acronyms HVAC stands for heating ventilation and air conditioning; most of the systems used for this purpose are based on the same technologies described in the section dedicated to the DHW production. However, among the aforementioned systems it is important to include the solar cooling systems.

A solar cooling is a particular type of solar system made of solar collectors used to warm up a fluid (water or air) but, unlike the collectors used for DHW applications, the operating temperature is higher (for this reason, more efficient collectors are used for this application) and the hot fluid, rather than being made available to the users, is sent to an absorption chiller where cools down a refrigerant then used for space cooling [11]. Figure 1 shows a schematic of a solar cooling system.

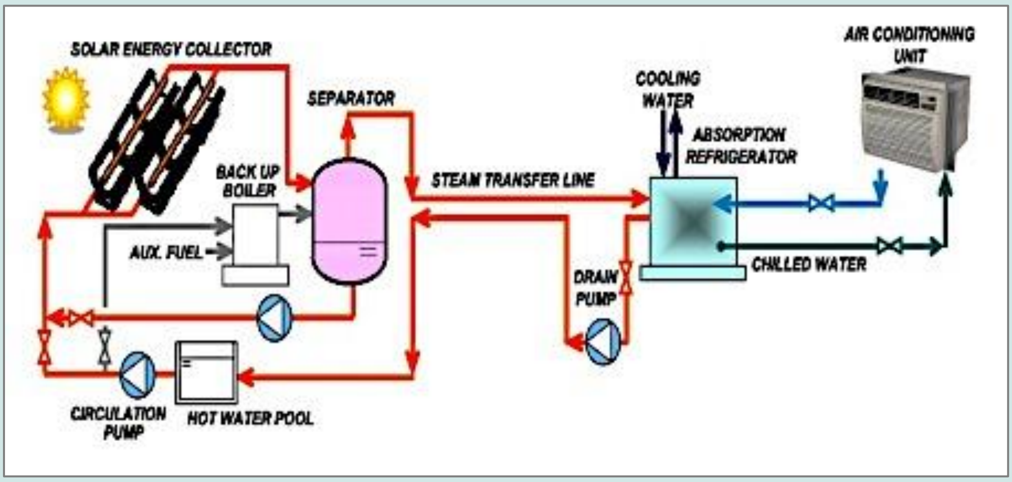

Figure 1 - Schematic of a solar cooling system (Source: FIG).

1.2.6.2 Trigeneration systems

Like the cogenerations systems, the trigeneration allow the simultaneous production of heat and power; however, in this case, the heat generated is used for space cooling. Therefore in such a type of systems the hot source works in the same way in which it does in the solar cooling system. Figure 2 depicts a very simple schematic of a trigeneration system.

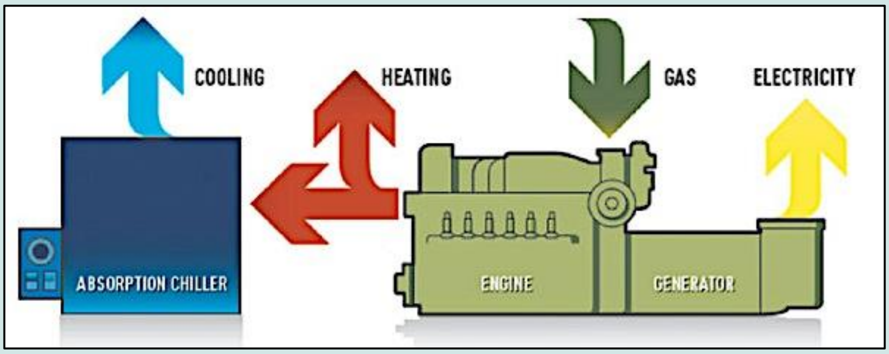

Figure 2 - Schematic of a trigeneration system (Source: www.cesenergy.com).

1.2.6.3 Energy efficiency measures for DHW and HVAC systems

As described above, systems used for hot water production and for space heating/cooling are, with a few exceptions, the same. For this reason, it has been decided to bring them together to describe measures to be taken in order to guarantee the energy efficiency of their operation.

Undoubtedly for all the systems dealing with thermal energy it is fundamental a good thermal insulation of both the all building, of the pipes and of the storage tanks. Still regarding the DHW production, a temperature control may be integrated to the system in order to lower the water temperature when the demand is low and when the thermal treatment to prevent the bacteria legionella development is off. In the specific case of the boilers, **Błąd! Nie można odnaleźć źródła odwołania.** shows that part of the thermal energy is lost with the exhausts. In that regard, it has been explained that the use of condensing boiler is the best solution to reduce this type of losses improving the device's thermal efficiency. On the other hand, for the heating/cooling space operation, a system of control of the set-point temperature, related to the specific use of the spaces to be treated, represents a valid way of save energy without compromising the comfort for the users. In particular, the temperature of the room can be increased/reduced accordingly to its occupation and, when empty, it can be simply left to a stand-by value defined in such a way to be quickly brought to the right value when it is needed.

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