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Obuda University

Electricity Supply

Dunakeszi Tesco Project

Visit to Dunakeszi Tesco in five October 2009

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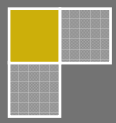

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Introduction

In five October 2009 we visit Dunakeszi Tesco, a supermarket 16 Km from Budapest, Hungary.

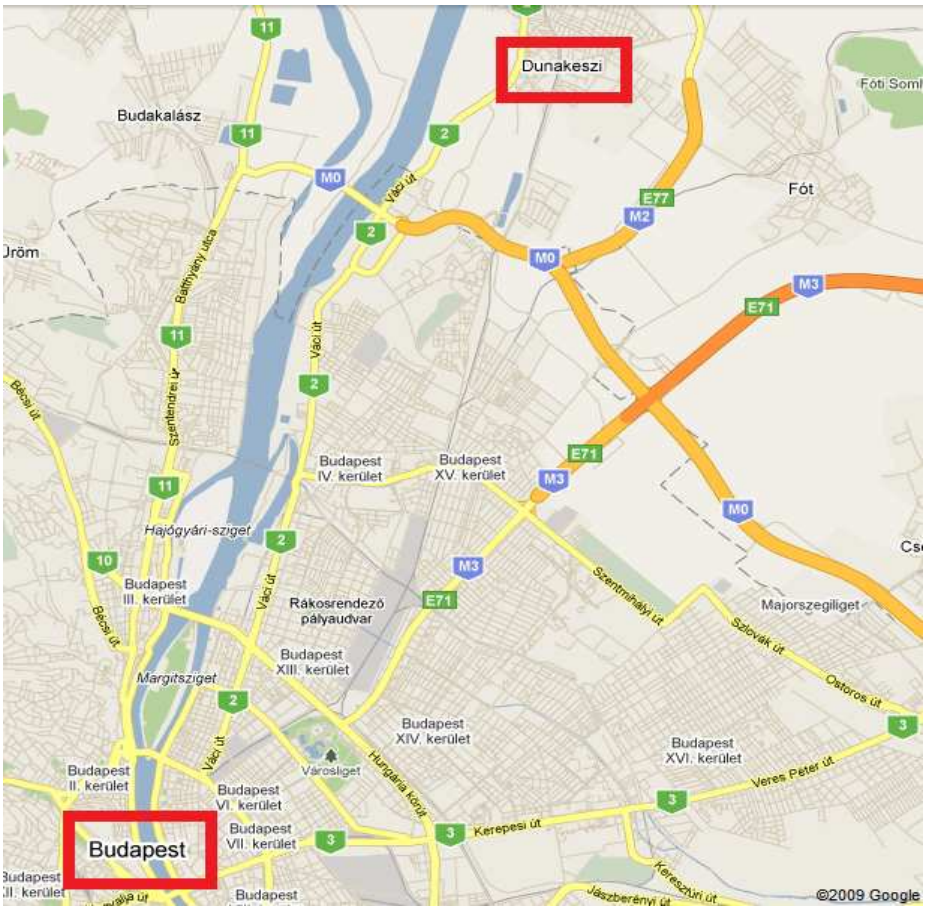


Image 1 – Dunakeszi [13]

Tesco is a big chain of super markets spread across Europe, and like others big chains of super markets they want to improve their own efficiency. This facility was built from the beginning thinking in new technology, new systems, with the objective to improve the inefficiency, reduce the consumption of energy and be ecologically friendly. Systems like, solar collectors, photovoltaic panels, lightening, heating and cooling management systems, are some of the new technologic that it was installed in this super market.

The objective for this work is to describe the systems that we saw, for that we use some schemes that it was provided from the technical team of Dunakeszi Tesco to help us on the description of the systems. There for, some of those systems, like lightening and photovoltaic panels, don't have schemes like the others, with that, we try to describe the propose of those and how they work.

Tesco phenomenon

In Dunakeszi Tesco supermarket even the building was constructed thinking about the best way to save energy. The building have a low stature, compared with other supermarkets, this is a way to save energy because as lower the stature of the building, lower will be the energy lost by the walls and by the roof. The walls and the roof were constructed thinking about saving energy too, the walls are ticker than normal and the roof was made with a special isolation, both measures made with the intention of reduce the energy losses.

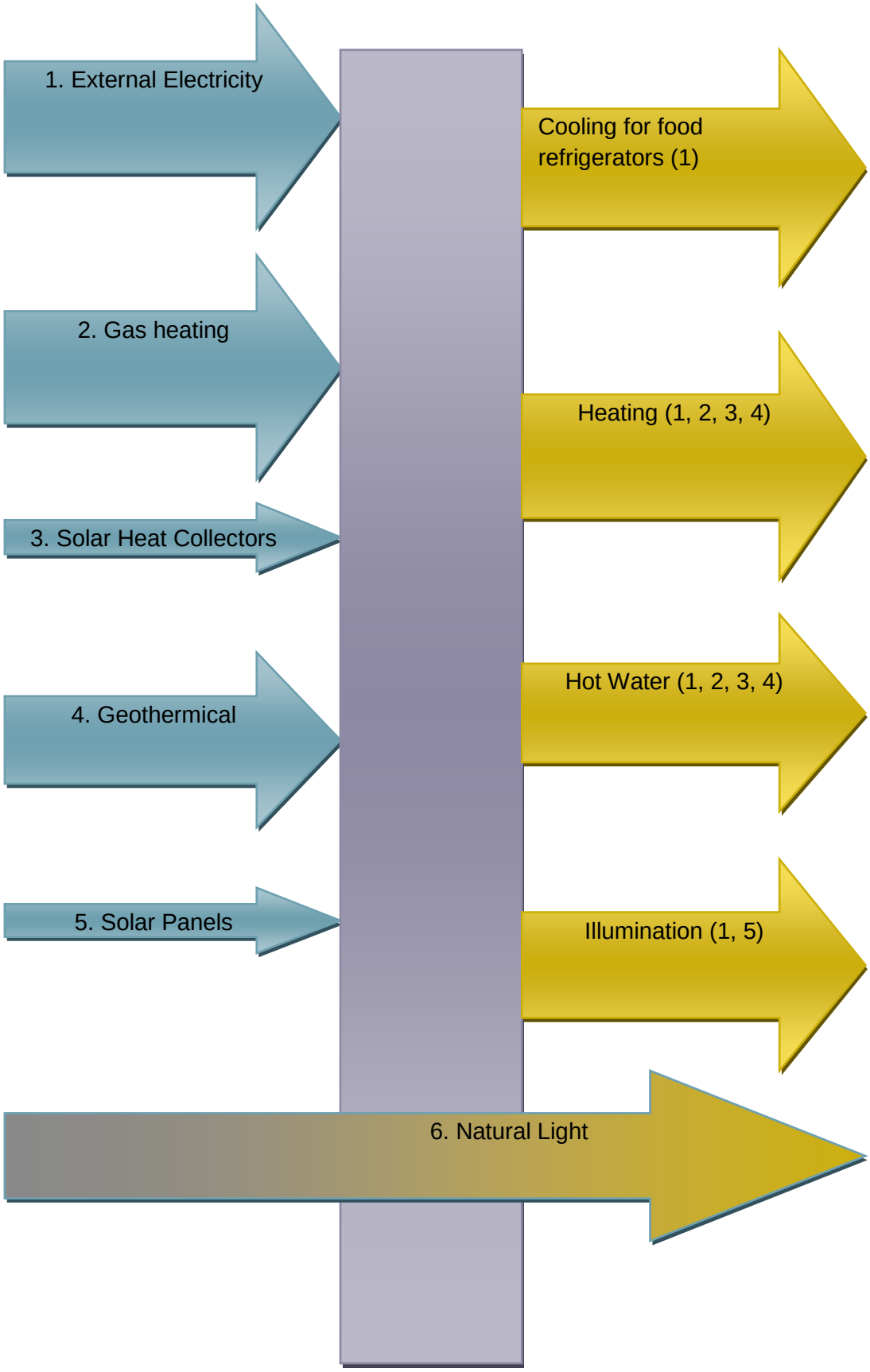
New ecological technology implemented in Tesco supermarket's have systems like heat collectors that produce and storage hot water with solar energy, using roof´s with glass windows, new light technology using T5 fluorescent lamp with electronic ballast, electronically more efficient and movement sensors in the areas of connection between the store and the backs where is the storage room save about forty percent of light energy, the photovoltaic system installed in Tesco producing electric energy help in the way to reduce the consumption and systems to reduce the heating and cooling to save more energy. All this systems together save about fifty percent of energy comparing with a normal supermarket.

Each store has 2-6 people, which pays special attention to energy use and draws attention to the workers of any waste.

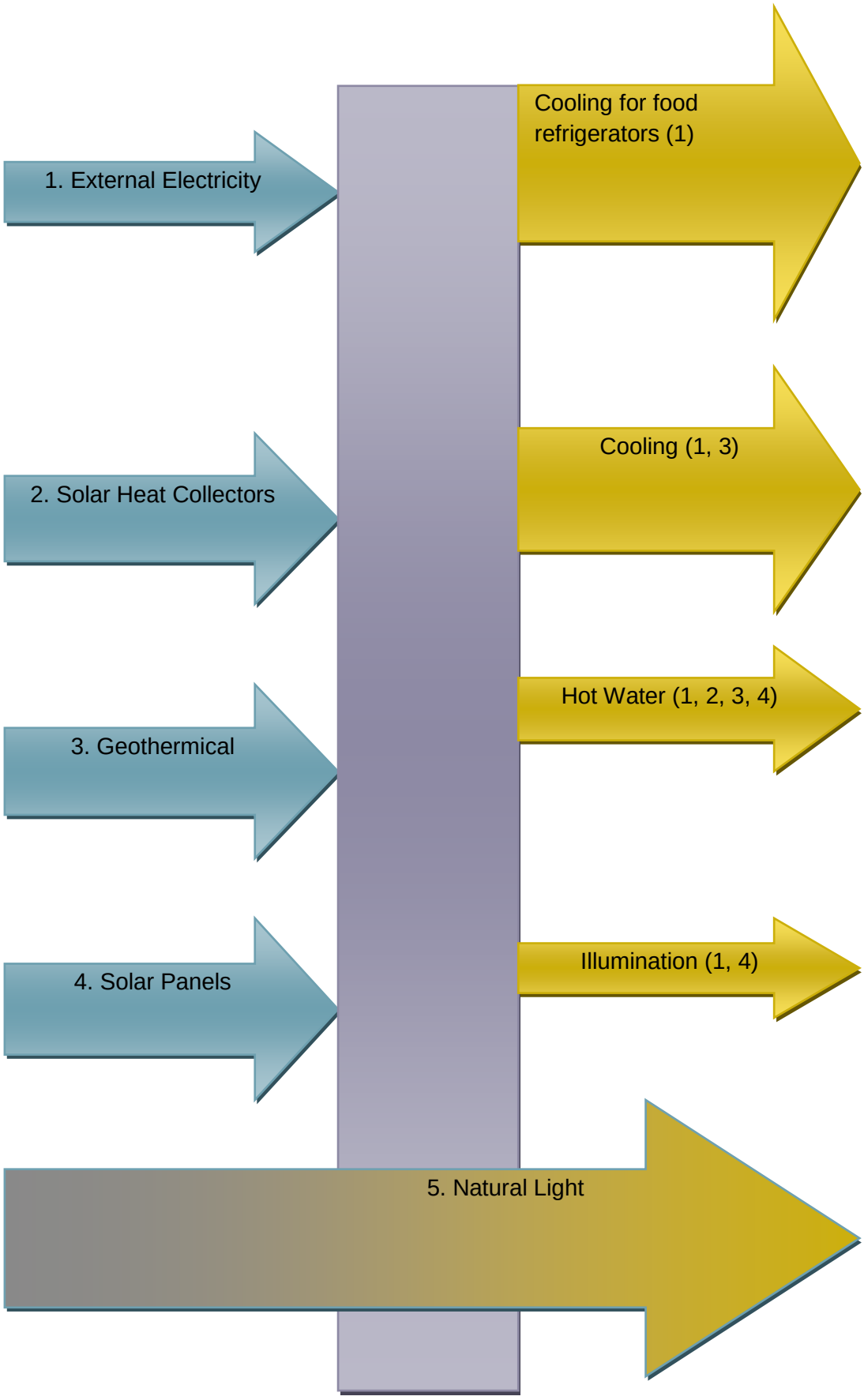
In our opinion this concept of eco-efficiency was well implemented in Tesco supermarkets and should be adopted for all the others chains of supermarkets, for those ones who are already built and for those who will be build in the future. The initial coasts to implement this type of technology are very expensive, but the investment is monetize in some ears and even for the consumer is good to know that this supermarket is environmental friendly.

Energy Balance for winter

In the next energy balances the numbers in the right side correspond to the sources that can be used to produce the needs.



Energy Balance for summer



Comparison between the energy balance for winter and for summer

As we can see in the graphics all the systems can work with external electricity, but Tesco objective is to use the less external electricity possible. Comparing the use of external electricity in the winter and in the summer is possible to notice that in the winter the use of external electricity is bigger because there's not so many sun as in the summer, and is not possible to use the solar panels and solar heat collectors systems so much in the winter than in the summer. Because of this we can observe that in the summer solar heat collectors and solar panels systems are more used. We can see too that in the winter there's a gas heating system that don't exist in the summer because in the summer is not necessary to heat the building. The geothermical system is used in the same way in the summer and in the winter because the temperature of the water of the geothermical system is the same in both times.

Lighting System

Dunakeszi Tesco have some different types of lighting system, the idea or objective is to reduce fifty per cent of the all consumption energy, not only with lightening systems, but with all systems together.

In Tesco it was used several ways to optimize the lightning system, for example, it was installed many special equipments to measure the quantity of light and with this data measure make a rational use of the light adjusting between fifty and one under per cent light intensity in the interior of the building.

Image 2 - Measure the quantity of light [(11)]

It was installed many tubular skylights like the next pictures show. Many of these tubular skylights were installed in strategic places to let the sun light enter inside the building and reduce the consumption of the artificial lightning. This type of tubular skylights only let the sun light enter and block any heating transfer from the outside to inside or the opposite.

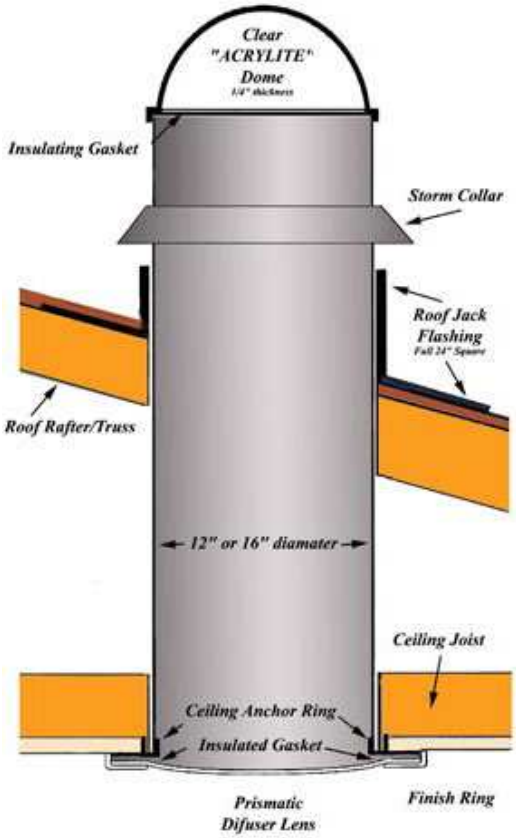


Image 3 - Tubular Skylight [10]

Image 4 - Tubular Skylights on roof of Tesco [11]

Using LED lights it was a good idea to save energy, LED means light emitting diode. LEDs are a solid state device and do not require heating of a filament to create light. Instead of, electricity is passed through a chemical compound that is excited and that generates light.

Image 5 - LED lights in Tesco [11]

In Tesco, the LED lightning was used in exhibitors of fresh and frozen products, the light emitted by Led´s is Very clear and very pleasant.

Image 6 - LED lights in Tesco 1 [11]

LEDs present many advantages over traditional light sources including lower energy consumption, longer lifetime, improved robustness, smaller size and faster switching. However, they are relatively expensive and require more precise current than traditional light sources.

Image 7 - LED lights in Tesco 2 [11]

Another way to reduce the consumption was installing special windows that only let enter sun light and block the transference of eating from outside to inside and the opposite.

These windows are equipped with special curtains that can be controlled from the control center to manage the quantity of sun light that enters in the building. They are built with the big size to let enter as much sun light as possible.

Image 8 - Windows with special curtains from inside [11]

Here we can see from inside how they look and the next picture show us from outside how they are.

Image 9 - Windows with special curtains from outside [11]

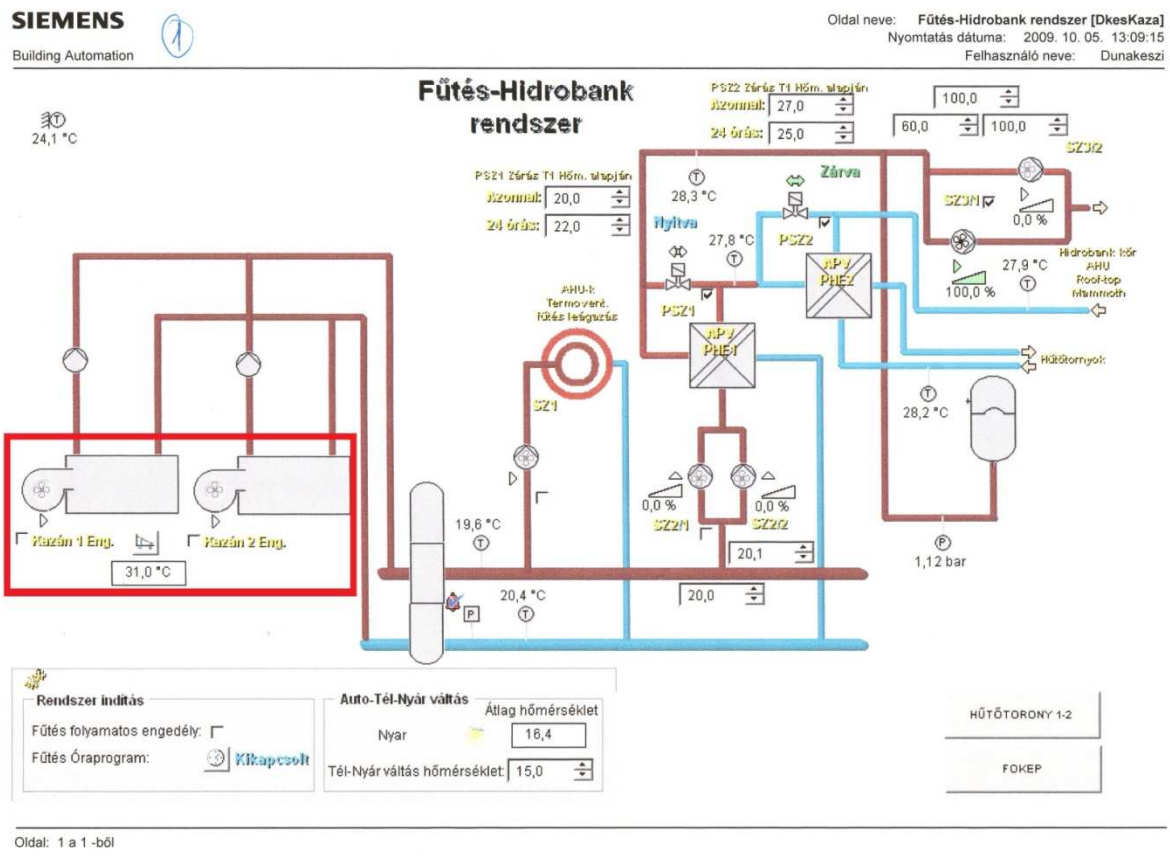
Natural light it was not forgotten, as we see above, if the natural light enter inside the building is a good way to save energy and reduce the consumption of electricity.

Image 10 - Natural light [11]

As we can see in this picture, a special window was built with way that natural light can give some advantage in the illumination.

Image 11 - Natural light 1 [11]

Scheme A – Boiler or Gas Boiler



Scheme A - **Boiler or Gas Boiler** [12]

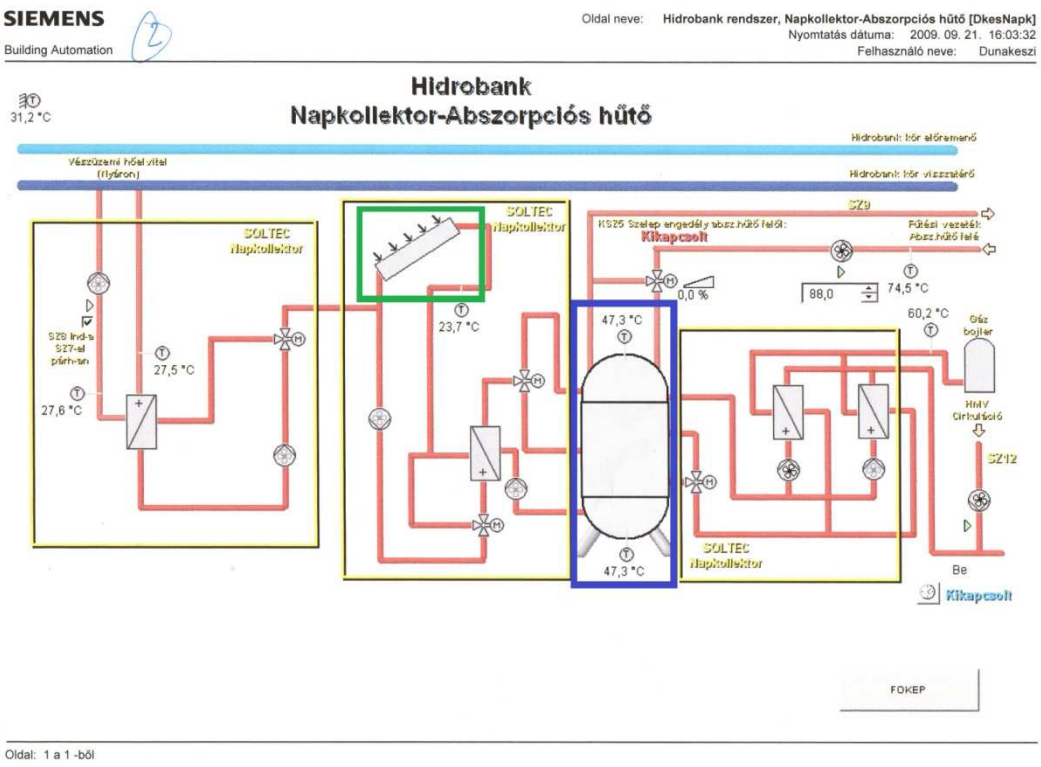
The machine that we can see is a Boiler or Gas Boiler, the function of this machine is to produce steam, for that the boiler use gas, this steam cam be used for several things, like to run production equipment, to sterilize, provide heat, to steam-clean and more things. In Tesco this steam is used to provide heat and this is used to Climatization or to produce hot water.

Several definitions of boiler:

"A closed vessel in which water or other liquid is heated, steam or vapor is generated, steam is superheated, or any combination thereof, under pressure or vacuum, for use external to itself, by the direct application of energy from the combustion of fuels, from electricity or nuclear energy." [1]

“Is a closed vessel in which water or other fluid is heated. The heated or vaporized fluid exits the boiler for use in various processes or heating applications” [2]

Scheme B – Solar Collectors Scheme



Scheme B - **Solar collectors** and **heat container** [12]

Image 12 - Solar collectors in Dunakeszi Tesco supermarket [11]

Solar heat collectors are one of the most environmental friendly ways to heat water. In Dunakeszi Tesco supermarket the solar heat collectors used are the ones with vacuum tubes, the most efficient, but the most expensive too. In the next image we can see the efficiency of the vacuum tubes solar heat collectors comparing with flat solar heat collectors:

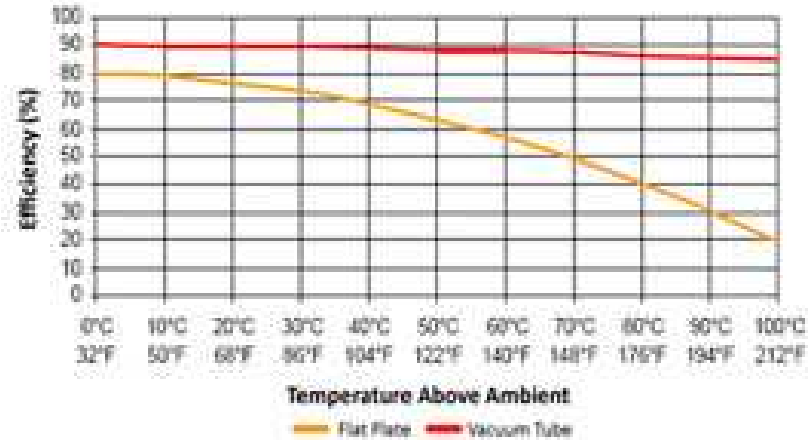


Image 13 - Graph comparing the vacuum tube solar collectors efficiency with the flat solar collectors efficiency [3]

In the next images is possible to see the vacuum tube and the collector header construction:

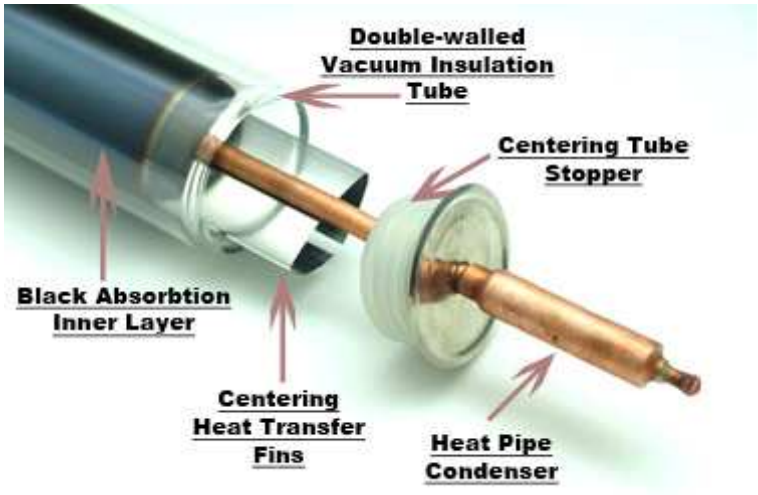


Image 14 - Vacuum tube construction [3]

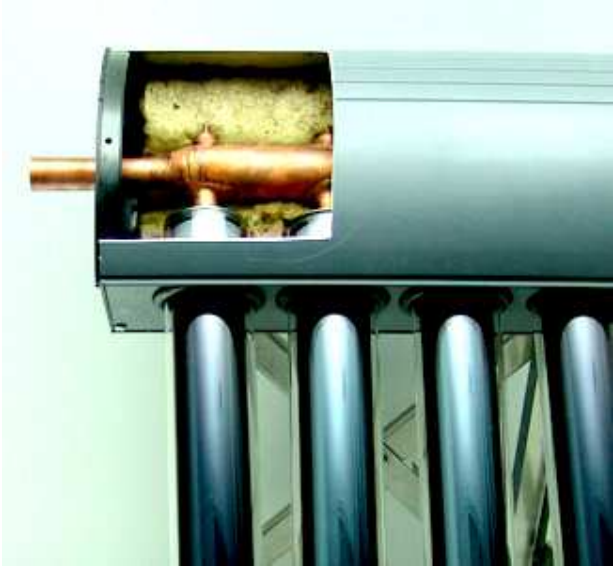


Image 15 - Collector header construction [3]

The water actually fills the inner vacuum tube and is heated internally by the sun. As warm water is lighter than cold water it rises to the top of the tube where it fills the collector. The heavier cold water fills the bottom of the vacuum tube to replace the heated water and to be reheated by the sun. We can see this process in the next image:

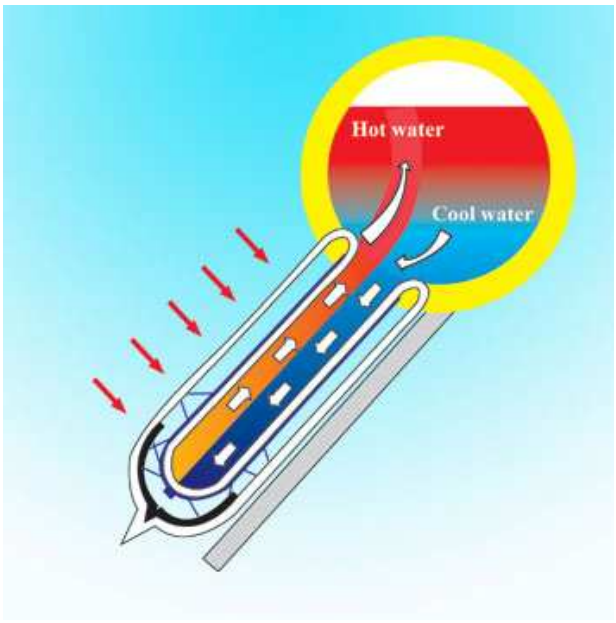


Image 16 - How a vacuum tube works [3]

As we see in the scheme B the water that is heated in the solar heat collectors will be stored in a heat container, to continue to be hot and be used after that. The next image shows how it works in a basic way:

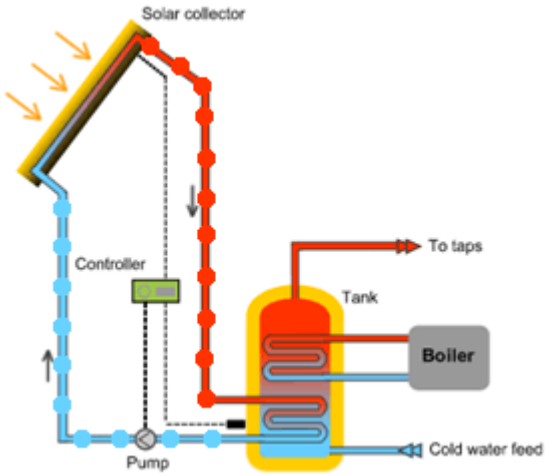
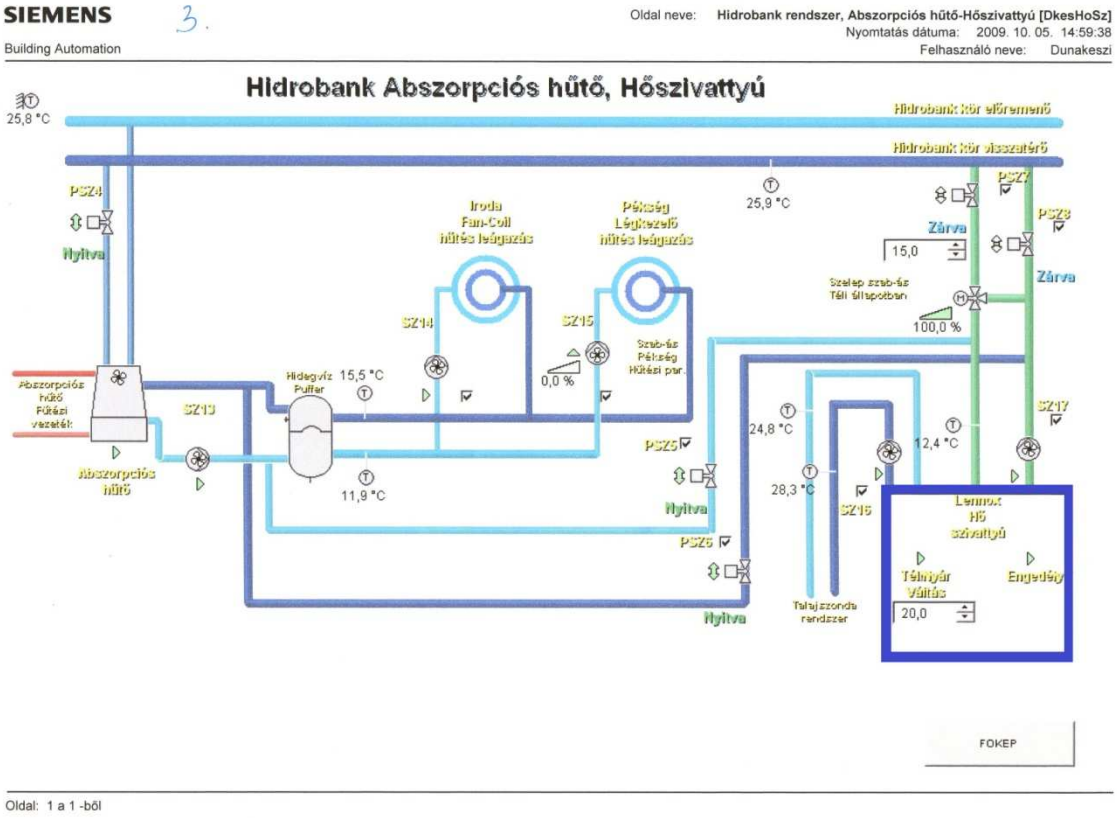


Image 17 - How a solar collector-boiler system works [8]

We can see in the image that the heat container have a boiler to maintain the water always at the same temperature. In the next image we can see the heat container used in Dunakeszi Tesco supermarket:

Image 18 - Heat container used in Dunakeszi Tesco supermarket [11]

Scheme C – Heat Pump and Absorbing Cooling Machine



Scheme C - **Heat Pump** [12]

How does a heat pump work?

“As the term "pump" implies, a heat pump moves heat from one place to another. It reverses the natural flow of heat from a warmer to a cooler place. Heat pumps use the refrigeration cycle to accomplish this. The advantage of pumping heat is that it takes less electrical energy than it does to convert electrical energy into heat. In fact in winter temperatures you can get three times as much heat out of each watt of electricity as you get from an electric furnace. Properly sized and installed heat pumps can reduce heating costs by 30 to 50 percent compared to electric furnaces. Heat pumps are named for their source of heat. Air-source heat pumps get heat from the outdoor air. There also are water-source heat pumps, which get heat from water. Ground-source heat pumps get their heat from ground below the frost line. Most heat pumps have two main parts: the outdoor unit and the indoor unit. The outdoor unit includes the outdoor heat exchanger, the compressor and a fan. This is where the heat from the air outside is picked up during the heating season, and where the heat from inside the house is rejected during the cooling season. The indoor unit contains the indoor heat exchanger and the fan that distributes heated or cooled

air to the distribution system of the house. Some systems have a second indoor cabinet that contains the compressor. “ [4]

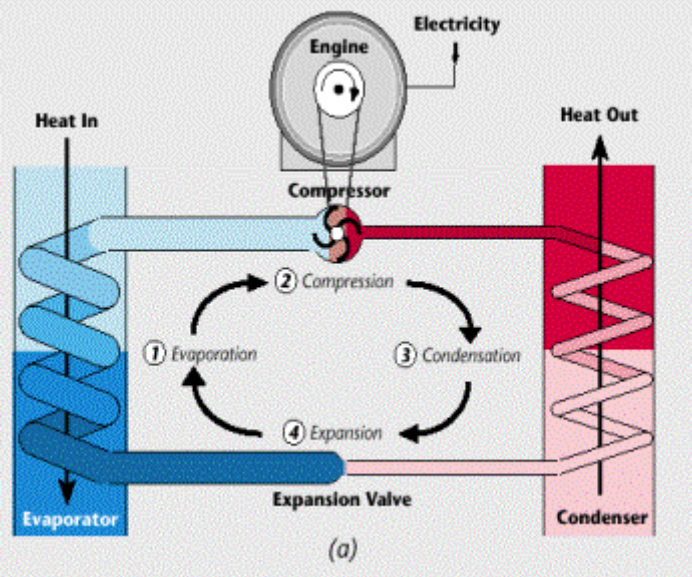


Image 19 - Heat Pump [4]

The heat pump refrigeration cycle

“A refrigerant is a fluid, which vaporizes (boils) at a low temperature. The refrigerant circulates through tubes (refrigerant lines) that travel throughout the heat pump. We'll begin our description of the refrigeration cycle at point A on the illustration below, which describes the heat pump when it is heating the house. At point A the refrigerant is a cold liquid, colder than the outdoor air. The refrigerant flows to the outdoor coil (point B). This coil is a "heat exchanger" with a large surface area to absorb heat from the air into the colder refrigerant. The heat added to the refrigerant causes the fluid to vaporize, so this heat exchanger is called the "evaporator coil" during the heating cycle. When materials change state (in this case from liquid to gas), large amounts of energy transfer take place. At point C the refrigerant is a cool gas, having been warmed and vaporized by the outdoor air. It is too cool to warm the house, so that's where the compressor (point D) comes in. The compressor raises the pressure of the gas. When that happens, the gas temperature rises. One way to think about it is that the compressor concentrates the heat energy. The compressor is often thought of as the "heart" of the heat pump, since it does most of the work of forcing heat "uphill." The compressor also forces the now hot gas (point E) further into the cycle. The indoor coil (point F) is where the refrigerant gives up its heat to the indoor air. A fan blows air past the indoor coil to distribute heat to

the house. This cools the refrigerant to the point where much of it condenses, forming a liquid. In the heating season, the indoor coil is called the "condenser coil." This change of state results in a large transfer of heat energy. The warm mixture of liquid and gas (point G) continues through the cycle to point H, the expansion device (sometimes called a "metering device"). This device reduces the pressure, causing the refrigerant, to become cold again - cold enough so that it is once again ready to absorb heat from the cool outdoor air and repeat the cycle." [4]

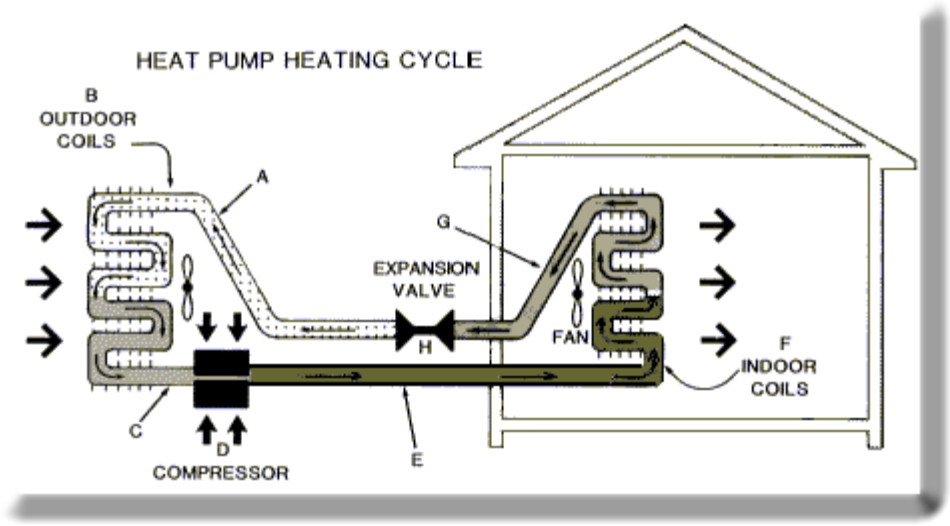


Image 20 - Heat Pump 1 [4]

Heat pump efficiency

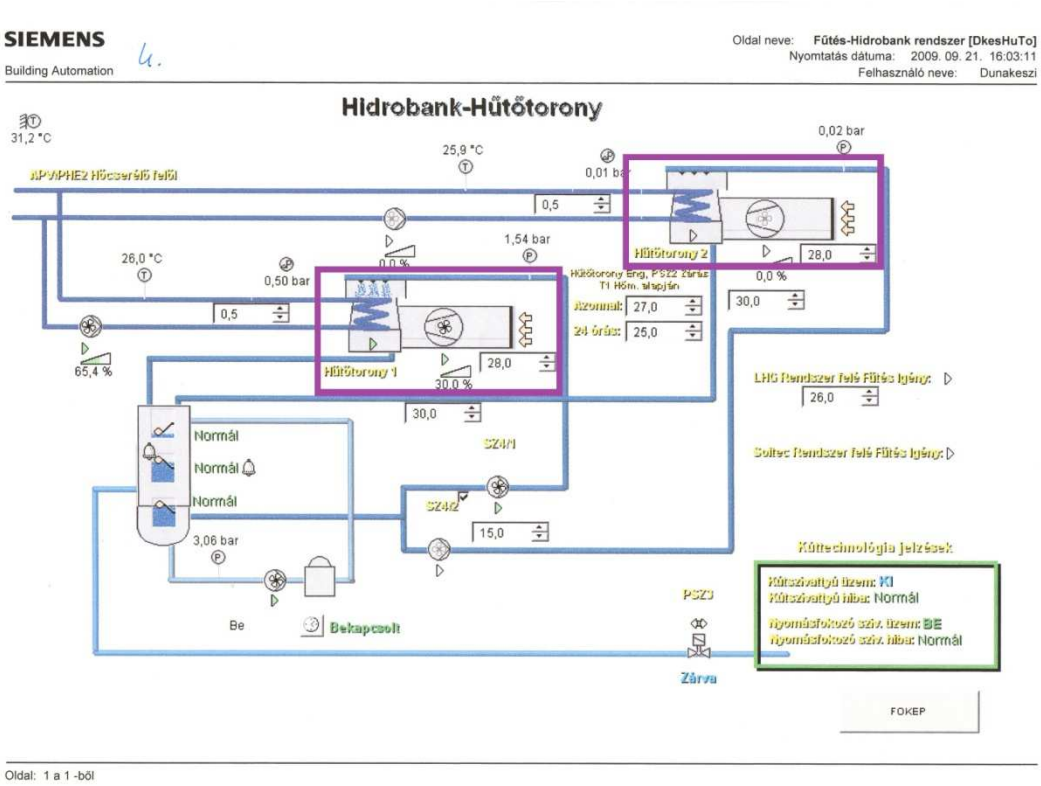
A heat pump uses only one-third as much energy as electric resistance heat during winter weather. In the heat pump industry, this is described as a COP (Coefficient of Performance) of 3. COP is the ratio of heat output, to electrical energy input. At some outdoor temperature it will be too cold for the heat pump to provide all the heat the house needs. To make up the difference, heat pumps have a supplemental heating system, usually electric resistance coils (basically an electric furnace inside the heat pump indoor cabinet). This part of the system is sometimes called "back-up" or "emergency" heat because the same coils can be used to provide some or all the heat in the event of heat pump failure. Since the supplemental electric heating system doesn't operate with the same efficiency as the heat pump (the COP of electric resistance heat is 1), the total heat pump COP will be much lower when the supplemental heating is on.

Heat pumps in Dunakeszi Tesco supermarket

In order to save energy in Dunakeszi Tesco supermarket the heat pumps are used to heat and to cool the building, because as was already showed before heat pumps have a higher efficiency than electric resistance heat.

In Dunakeszi Tesco supermarket there's a heat pump system combined with the geotermical system, that way, if the water temperature is under 12ºC and it need to be heated, it goes first to the geotermical system to be heated to 12ºC and after it goes to the heat pump system to be heated until the desired temperature. This is a way of save energy, because while the water is being heated in the geotermical system, it doesn't spend energy (electricity) like if it was only heated in the heat pump system.

Scheme D – Dry Coolers Scheme



Scheme D – **Dry Coolers** scheme [12]

Image 21 - Dry cooler installed in Dunakeszi Tesco supermarket with a water spray system [11]

These dry coolers are used in Dunakeszi Tesco supermarket for water cooling. They basically cool the water with the air from the outside air. The cold water that results from this process can be used for cooling. In the next image we can see how a dry cooler works:

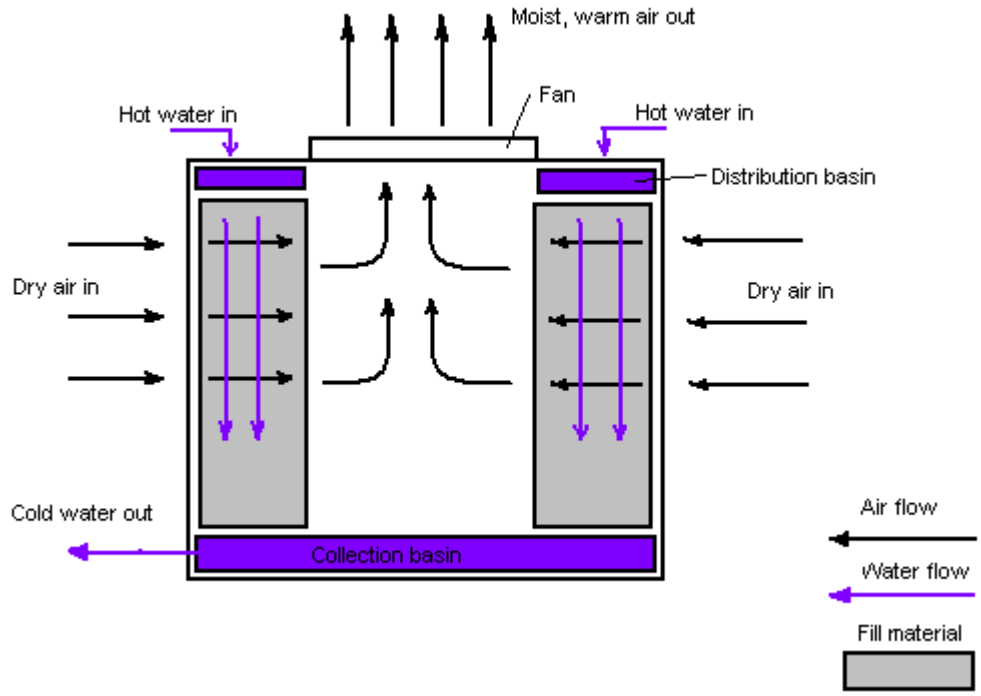


Image 22 – Dry cooler working diagram [5]

As we can see in the image the air flow enters in the dry cooler to meet the fill material. Water flows (perpendicular to the air) through the fill by gravity. The air continues through the fill and after goes out with the help of the fan. The distribution basin consists on a deep pan with holes in the bottom. Gravity distributes the water through the holes uniformly across the fill material, the water is cooled by the dry air in the fill material and after goes out by the collection basin.

In addition to this Dunakeszi Tesco supermarket have a water spray system in the dry cooler that brings more efficiency. The Water Spray System mounted on the dry cooler sprays water finely nebulized in opposite direction to the air inlet. With this system is possible to cool the air entering in the dry cooler and by this way increase its efficiency.

Photovoltaic

The photovoltaic system installed in Dunakeszi Tesco Supermarket use the Kyocera KD210GH-2P polycrystalline solar panels with the characteristics in the next image:

Electrical data

Nominal output Pmpp:	210 [W]
Max. power tolerance:	+/-5 [%]
Max. Voltage system:	1000 [V]
Nominal Voltage Umpp:	26,6 [V]
Nominal current Impp:	7,9 [A]
Open circuit voltage Uoc:	33,2 [V]
Short circuit current Isc:	8,58 [A]
Temperature coefficient of open circuit Voltage Uoc:	-120 [mV / °C]
Temperature coefficient of short circuit current:	5,15 [mA / °C]
Temperature coefficient Output:	k.A.
Cell conversion efficiency:	k.A.
Module conversion efficiency:	k.A.
Certificates:	IEC 61215 Schutzklasse II CE-Konformität ISO 9001 und ISO 14001

Dimensions

Length:	1500 [mm]
Breadth:	990 [mm]
Height:	36 [mm]
Height, incl. junction box:	36 [mm]
Weight:	18,5 [kg]
Junction:	MC Typ3

Cells

Number of cells per module:	54
Cell technology:	polycrystalline
Cell form:	rectangular
Cell size:	156 x 156 [mm]
Cell contacting:	3 Bus Bar

Image 23 - Kyocera KD210GH-2P characteristics [6]

The Tesco building have eighteen solar panels installed on the sidewall of the building and thirty solar panels installed on the roof of the building as we can see in the images:

Image 24 - Solar Panels on the roof of Dunakeszi Tesco Supermarket [11]

Image 25 - Solar Panels on the sidewall of Dunakeszi Tesco Supermarket [11]

The polycrystalline solar panels are not the most efficient but they are the most common nowadays because of their low price per watt compared with the other solar panels.

In Dunakeszi Tesco Supermarket they use two different inverters, two SMA Sunny Boy 3000TL and one SMA Sunny Boy 4000TL.

Image 26 - Sunny Boy inverter used in Dunakeszi Tesco Supermarket [11]

With the characteristics that we can see in the next image:

Input (DC)	Sunny Boy 3000TL	Sunny Boy 4000TL
Max. DC power	3200 W	4200 W
Max. DC voltage	550 V	550 V
PV-voltage range, MPPT	125 V – 440 V	125 V – 440 V
Recommended range at nominal power	188 V – 440 V	175 V – 440 V
Max. input current	17 A	2 x 15 A
Number of MPP trackers	1	2
Max. number of strings (parallel)	02. Jan	2 x 2
Output (AC)		
Nominal AC ouput	3000 W	4000 W
Max. AC power	3000 W	4000 W
Max. output current	16 A	22 A
Nominal AC voltage / range	220 V – 240 V / 180 V – 280 V	220 V – 240 V / 180 V – 280 V
AC grid frequency / range	50 Hz, 60 Hz / ± 5 Hz	50 Hz, 60 Hz / ± 5 Hz
Phase shift (cos φ)	1	1
AC connection	single-phase	single-phase
Efficiency		
Max. efficiency	97.0 %	97.0 %
Euro-eta	96.0 %	96.2 %

Image 27 - Sunny Boy 3000TL and 4000TL characteristics [7]

The three inverters are connected to the network, so when the supermarket has excess of generated electricity, that excess can be injected into the network and that way Tesco is saving some money because it is selling energy to the energy company, it is not discarding energy and it is injecting green energy into the network.

Real Remote Measurements from the Photovoltaics in Dunakeszi Tesco Supermarket

All the inverters from Dunakeszi Tesco Supermarket are remotely connected, so anyone can see in the internet the values of energy that the photovoltaics produce. The next images will be taken from the internet site of the company who produce the inverters (http://www.sunnyportal.com/Templates/PublicPageOverview.aspx?page=07b626b3-55f1-4bad-96a8-d13e0b7e5948&plant=e6d8d22f-8de8-4dd6-bbda-baf6993c7743&splang=en-gb).

We will start to show the annual measurement of energy, since February of 2009 until January of 2010:

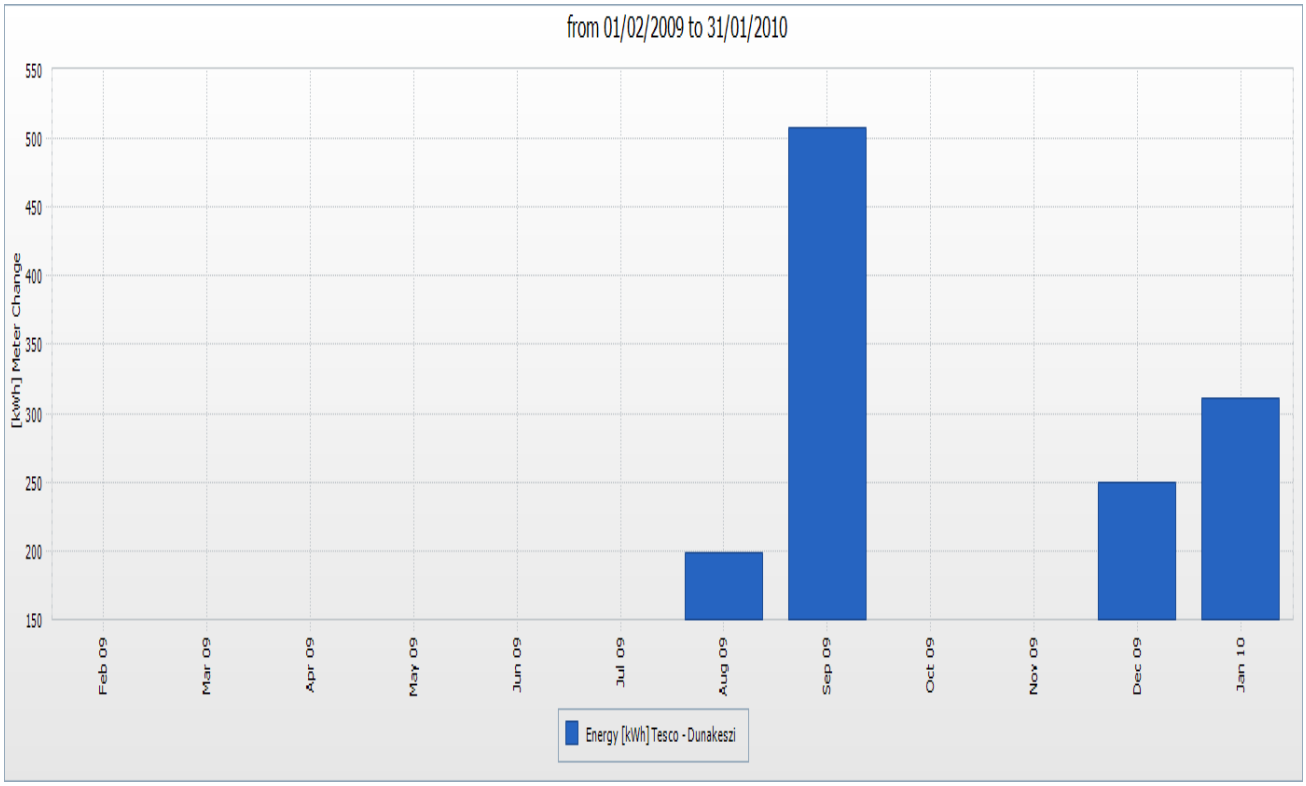


Image 28 - Annual measurement of energy, since February of 2009 until January of 2010 [9]

As we can see there are no measurements from February of 2009 until July of 2009 and from October of 2009 and November of 2009, because there were some problems and the measurements could not be done. Another thing that we can see is that the month of September of 2009 was the most productive, so we are going to analyse it better. The next image will show the daily measurements of energy in the month of September of 2009:

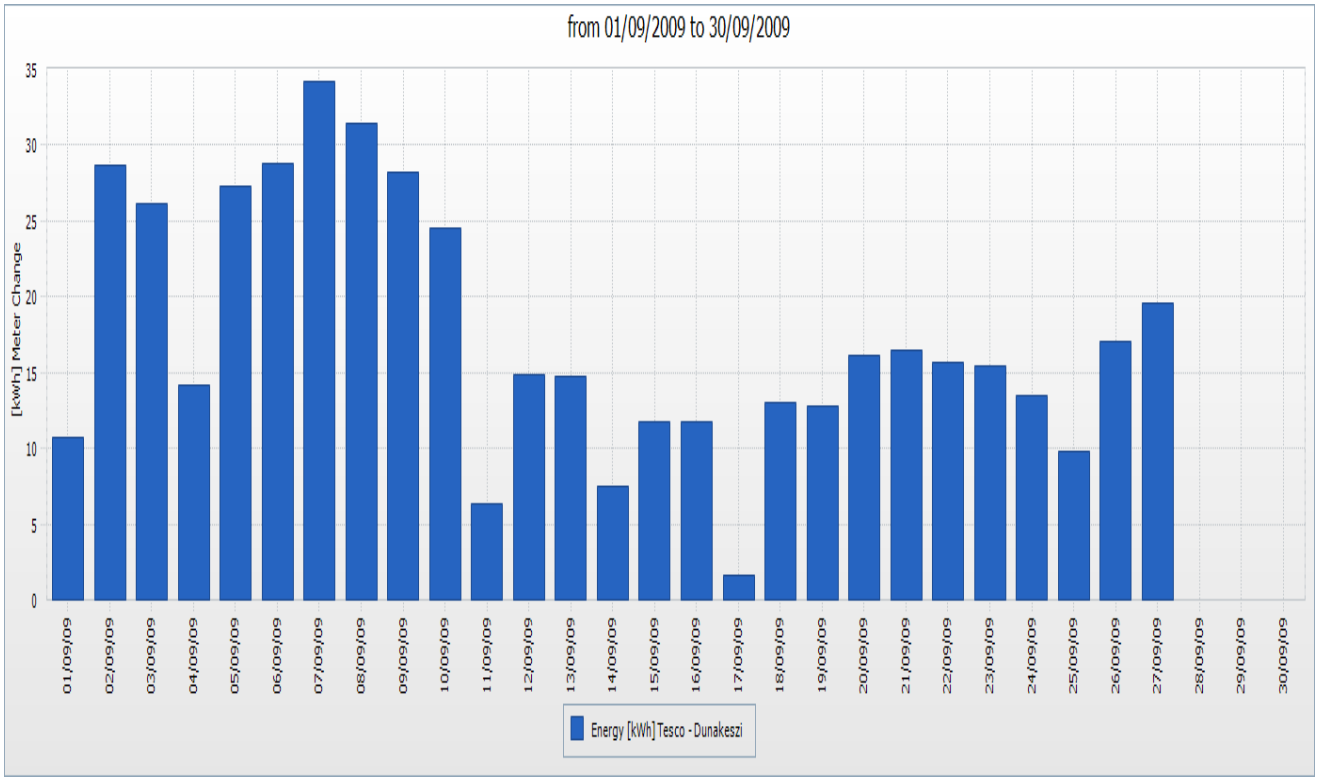


Image 29 - Daily measurements of energy in the month of September of 2009 [9]

In this image we can see that the most productive days were from 5 of September of 2009 until 9 of September of 2009 and the most productive day was the 7 of September of 2009. In the next image we are going to analyse better the most productive day of the month of September of 2009 (07/09/09):

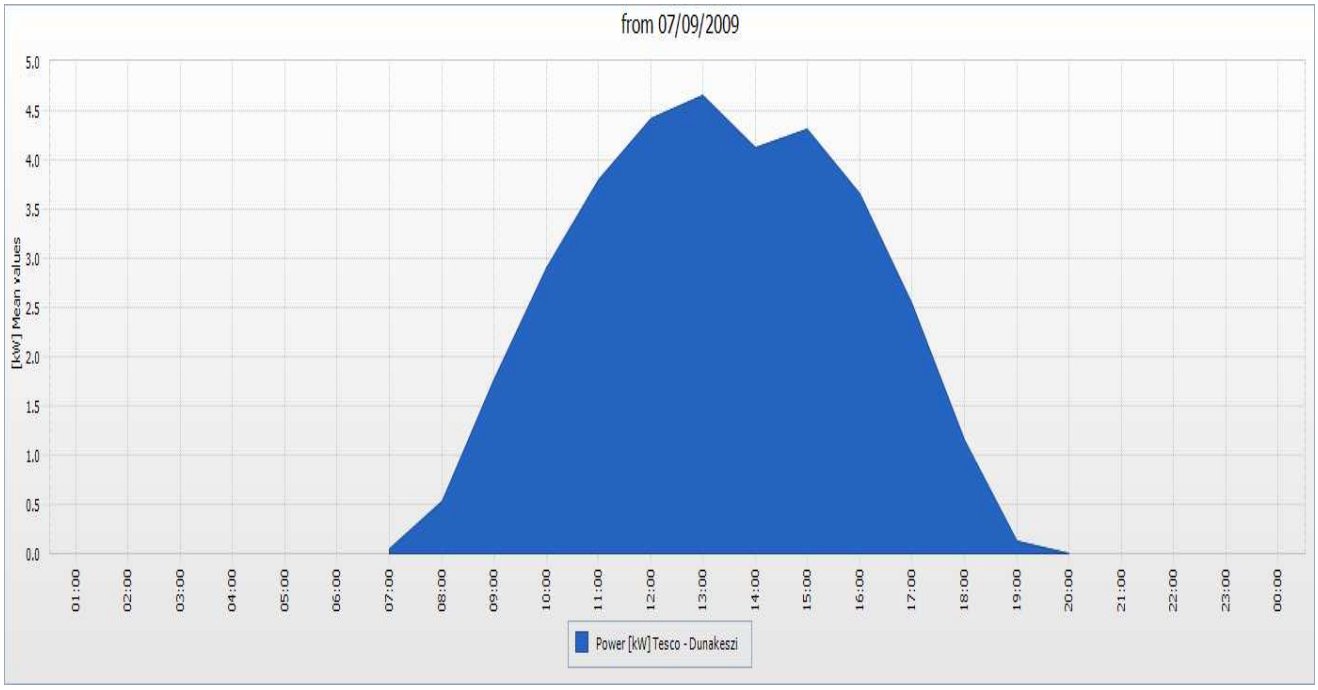


Image 30 – Measurements of Power in 7 of September of 2009 [9]

In this image we can see that this was a productive day, producing energy since 07:00h until 20:00h. And we can see that the most productive hours were from 12:00h until 14:00h.

Another interesting thing that is possible to see in the site is the values of energy, CO2 avoided and revenue in the present day, like we can see in the next image:

Image 31 – Diagram with the values of energy, CO2 avoided and revenue in the present day [9]

Conclusion

In Tesco the idea to be environmental friendly was use a concept of eco-design, building Dunakezi Tesco was a remarkable example for this big chain of super markets. The new technology and design used in all systems installed in this facility not only make them spend fifty per cent less of overall energy consumption but the efforts made by this company was to reduce the emissions of gases that cause greenhouse effect.

To reduce fifty per cent of energy consumption, all systems need to work in the maximum of power, as we know this scenario is not available all days, unfortunately. For example, the photovoltaic systems needs sun light to work, during the night they cannot work and during the day, some days the sky is not clear enough to they work in full power, the same happens with the heat collectors to warm the water but systems like air quality management, heating management and lighting management, help all facility to reduce the consumption. Innovations that are energy and environmentally friendly use are:

- Use a glass roof to cover the exhibitors of frozen products
- Thick wall and roof insulation
- Building not so high
- Allow that more sun light enter inside the building
- New and powerful insulation materials to don’t permit heat exchange with the outside
- More efficiency in light power and brightness management
- Light sensors in some areas
- Replacement of halogenated refrigerant by CO2 which is several times less polluting
- Heat recovery and reuse of the same for heating water
- Collection and reuse of rainwater, reducing water use in the network
- Connection of the photovoltaic system to the network

Use the geothermic energy is one of the solutions that help to reduce the consumption, in Tesco this source of energy is used sometimes to warm the water or to cooling that water too.

References

1) (http://www.nclabor.com/boiler/boiler_faq1.htm)
2) (http://en.wikipedia.org/wiki/Boiler)
3) **(**Images from: http://www.solartubs.com/how-do-solar-vacuum-tubes-work.html**)**
4) (http://www.esru.strath.ac.uk/EandE/Web_sites/01-02/heat_pump/background.html)
5) (Image from: http://en.wikipedia.org/wiki/Cooling_tower)
6) (http://www.solarshop-europe.net/solar-components/solarmodules/kyocera_kd210gh-2p_m_774.html)
7) (http://www.sma.de/en/products/solar-inverters/sunny-boy/sunny-boy-3000tl-4000tl-5000tl.html)
8) (http://www.solartubs.com/Solar-Heating-Basics.html)
9) (http://www.sunnyportal.com/Templates/PublicPageOverview.aspx?page=07b626b3-55f1-4bad-96a8-d13e0b7e5948&plant=e6d8d22f-8de8-4dd6-bbda-baf6993c7743&splang=en-GB)
10) (www.tru-lite.com/)
11) Pictures taken by us in the visit to Dunakezi Tesco Supermarket.
12) Schemes provided by Tesco.
13) (http://maps.google.pt/maps?ie=UTF8&ll=47.564481,19.14196&spn=0.151506,0.363579&z=12)