2009

Tesco Trip to Dunakeszi

Report

Course: Energetics
Faculty: Kandó Kálman
University: Budapest Tech. / BMF
Teacher: Prof. Kádár Péter

Handed over by:

Jan Schray und Janek Böhm
Erasmus 2009 / 2010
Erasmus ID code: D Essling03

26.01.2010

Table of Contents

Foreword

Within the framework of our term abroad we took part at the energetic class. One of our contents of this lesson was a trip to the Tesco in Dunakeszi. But it is not a usual supermarket because there are a lot of renewable energies installed. Tesco has unveiled wide ranging plans to cut carbon emissions and encourage its customers to buy green. In an interview with Sir Terry Leahy, Tesco chief executive said: “Tesco planned to halve the price of energy-efficient light bulbs and offer more energy-efficient products in its cheaper Value range of goods.” “The group also plans to cut emissions from existing stores worldwide by at least 50% by 2020, and would seek to restrict air transport to less than 1% of the firm's products”, he added.
Tesco produced two million tons of carbon dioxide a year and a third of that was produced by mass refrigeration. That’s the reason why they built up a Tesco with a lot of green systems and devices. On the following pages we want to present the most important of these green systems.

Budapest, January 2010

Janek Böhm, Jan Schray

Tesco Dunakeszi (www.tesco.hu) Google Maps

Air Conditioning

About 1.3 % of the primary energy requirement is used for the production of the cold air for the air conditioning of buildings. This is quite less energy consumption and of course is here a very big potential to safe energy.
So it is important to think about, how it is possible to safe energy and to become more environment-friendly.
The most air conditioning systems are based on the vapor-compression refrigeration. Refrigeration may be defined as lowering the temperature of an enclosed space by removing heat from that space and transferring it elsewhere. A device that performs this function may also be called a heat pump.

How the vapor-compression refrigeration works:

The vapor-compression refrigeration cycle has four components: evaporator, compressor, condenser, and expansion valve. The most common used refrigeration cycle is the vapor-compression refrigeration cycle. In an ideal vapor-compression refrigeration cycle, the refrigerant enters the compressor as a slightly superheated vapor at a low pressure. It then leaves the compressor and enters the condenser as a vapor at some elevated pressure, where the refrigerant is condensed as heat is transferred to cooling water or to the surroundings. The refrigerant then leaves the condenser as a high-pressure liquid. The pressure of the liquid is decreased as it flows through the expansion valve, and as a result, some of the liquid flashes into cold vapor. The remaining liquid, now at a low pressure and temperature, is vaporized in the evaporator as heat is transferred from the refrigerated space. This vapor then reenters the compressor.[1]

The refrigerant enters the compressor Vapor-compression refrigeration cycles specifically have two additional advantages. First, they exploit the large thermal energy required to change a liquid to a vapor so we can remove lots of heat out of our air-conditioned space. Second, the isothermal nature of the vaporization allows extraction of heat without raising the temperature of the working fluid to the temperature of whatever is being cooled. This is a benefit because the closer the working fluid temperature approaches that of the surroundings, the lower the rate of heat transfer. The isothermal process allows the fastest rate of heat transfer. The cycle operates at two pressures, Phigh and Plow, and the statepoints are determined by the cooling requirements and the properties of the working

[1] Comp.: - www.coolingdevice.net

fluid. Most coolants are designed so that they have relatively high vapor pressures at typical application temperatures to avoid the need to maintain a significant vacuum in the refrigeration cycle. The ideal vapor-compression cycle consists of four processes.[2]

Ideal Vapor-Compression Refrigeration Cycle

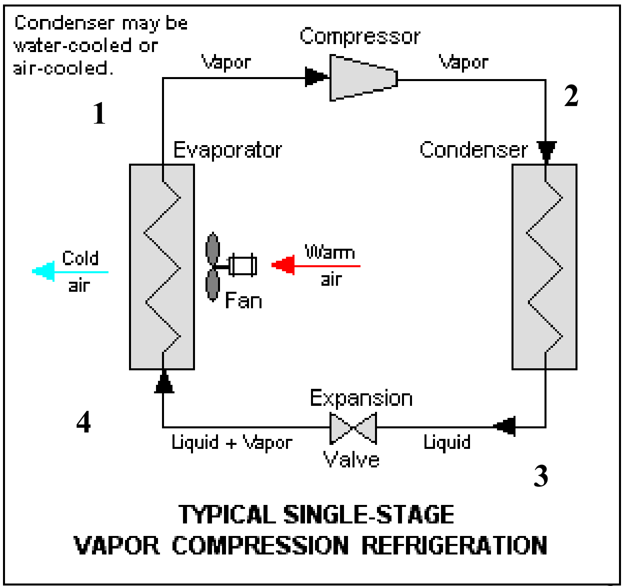
Process Description

1-2 Isentropic compression

2-3 Constant pressure heat rejection in the condenser

3-4 Throttling in an expansion valve

4-1 Constant pressure heat addition in the evaporator



Pic.[3]

Why Carbon Dioxide Refrigerant (CO_2)

Innovation in air conditioning technologies continues, with much recent emphasis placed on energy efficiency, and on improving indoor air quality. Reducing climate change impact is an important area of innovation, because in addition to greenhouse gas emissions associated with energy use,

[2] Comp.: - www.coolingdevice.net

[3] Comp.: - www.absoluteastronomy.com/Topics/Vapor-compression_refrigeration

CFCs, HCFCs and HFCs are, themselves, potent greenhouse gases when leaked to the atmosphere. For example, R-22 (also known as HCFC-22) has a global warming potential about 1,800 times higher than CO_2.[4]

Although carbon dioxide is known as a major greenhouse gas, but it is because the low Global Warming Potential (GWP = 1) a very promising alternative to fluorocarbons. Also a big advantage of CO_2 as a refrigerant is, it is non-toxic and non-flammable.

When carbon dioxide is used as a refrigerant, it must operate at high pressure and this made it difficult to commercialize in compact appliances. Today more efficient and compact appliances have been developed by using a two-stage compression method.[5] So is the vapor-compression refrigeration cycle more difficult than the cycle on the page before but the scheme is the same.

On the basis of the following chart it is easy to understand how good the carbon dioxide is in contrast to man-made refrigerant.

Natural and man-made Refrigerant

	Ozone Depletion Potential, ODP	Global Warming Potential, GWP
Ammonia (NH_3)	0	0
Carbon Dioxide (CO_2)	0	1
Hydrocarbon (C_3H_8, C_4H_{10})	0	3
Water (H_2O)	0	0
Chlorofluorocarbon (CFC)	1	4.680-10.720
Hydrochlorofluorocarbons (HCFC)	0,02-0,06	76-12.100
Hexafluoroethane (R-116)	0	5.820-12.010
1,1,1,2-Tetrafluoroethane (R-134a)	0	122-14.310

In the early days of refrigeration the two refrigerants in common use were ammonia and carbon dioxide. Both were problematic - ammonia is toxic and carbon dioxide requires extremely high pressures (from around 30 to 200 atmospheres!) to operate in a refrigeration cycle, and since it operates on a transcritical cycle the compressor outlet temperature is extremely high (around 160°C). When Freon 12 was discovered it totally took over as the refrigerant of choice. But the Freon 12 is very bad for the ozone layer and in the case of a leak of the refrigeration cycle the Freon helps to deplete the ozone layer.

[4] Comp.: - www.en.wikipedia.org/wiki/Air_conditioing
[5] Comp.: - www.env.go.jp/earth/ozone/non-cfc/pamph_products/ntrl-refrig_en_6.pdf

So the Freon 12 has been essentially replaced by chlorine free R134a (tetraflouro-ethane) - not as stable as Freon 12, however it does not have ozone depletion characteristics.[6]

But it's easy to see on the basis of the chart, the R-134a is very worse than CO_2 because the GWP. The new hot topic is a return to carbon dioxide as a refrigerant (R-744). The previous two major problems of high pressure and high compressor temperature are found in fact to be advantageous. The very high cycle pressure results in a high fluid density throughout the cycle, allowing miniaturization of the systems for the same heat pumping power requirements.[7]

Condenser of the rooftop

[6] Comp.: - www.ent.ohiou.edu/~thermo/Applied/Chapt.7_11/Chapter9.html
[7] Comp.: - www.ent.ohiou.edu/~thermo/Applied/Chapt.7_11/Chapter9.htm

Heat pump technology

General information - The technology

Heat pump systems offers us one of the most energy-efficient way to provide heating and cooling in many applications, as they can use renewable heat sources in our surroundings. In Situations which we consider as cold, air, ground and water contain useful heat that's continuously replenished by the sun. By using some more money, a heat pump can raise the temperature of this temperature of this heat energy to the level needed. So can heat pumps also use waste heat sources, such from the industry, cooling equipment or ventilation air extracted from buildings. A normal heat pump will just need 100kwh of power to turn 200kwh of environmental or waste heat into 300kwh of useful heat.[8]

Heat flows naturally from a higher to a lower temperature. Heat pumps, however, are able to force the heat flow in the other direction.[9] They can be also used for cooling. Then the heat the heat is transferred from the application that is cooled to the surroundings at a higher temperature.

"Because heat pumps consume less primary energy than conventional heating systems, they are important technology for reducing gas emissions that harm the environment, such as carbon dioxide, sulphur dioxide and nitrogen oxides. However, the overall environmental impact of electric heat pumps depends very much on how the electricity is produced."[10]

The two main heat pump types

Almost all heat pumps are either based on a vapour compression, or on an absorption cycle.

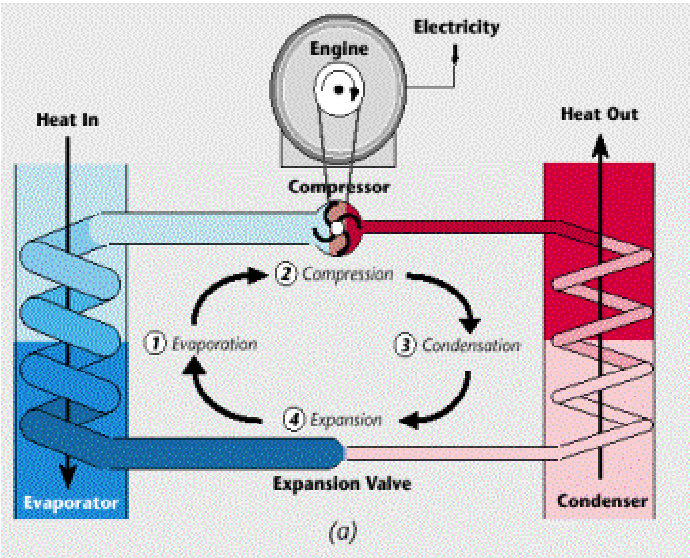
Vapour compression

"The majority of heat pumps work on the principle of the vapour compression cycle. The main components are the compressor, the expansion valve and two heat exchangers which are the evaporator and the condenser. The components are connected to form a closed circuit, as shown in the picture under the text. A volatile liquid, known as the working fluid or refrigerant, circulates through the four components.

In the evaporator the temperature of the liquid working fluid is kept lower than the temperature of the heat source, causing heat to flow from the heat source to the liquid, and the working fluid

8 Comp. - http://www.behvac.com/heatpumpcheck.htm
9 Comp. - http://www.heatpumpcentre.org/About_heat_pumps/HP_technology.asp
10 Comp.- http://www.heatpumpcentre.org/About_heat_pumps/HP_technology.asp

evaporates. Vapour from the evaporator is compressed to higher pressure and temperature.
The hot vapour then enters the condenser, where it condense and gives off useful heat.
Finally, the high-pressure working fluid is returned to its original state and once again enters the evaporator. The compressor is usually driven by an electric motor and sometimes by a combustion engine. " [11]



Vapour compression cycle Pic.[12]

Efficiency

“When comparing the performance of heat pumps, it is best to avoid the word "efficiency" which has a very specific thermodynamic definition. The term coefficient of performance (COP) is used to describe the ratio of useful heat movement to work input. Most vapor-compression heat pumps utilize electrically powered motors for their work input. However, in most vehicle applications, shaft work, via their internal combustion engines provide the needed work.
When used for heating a building on a mild day, a typical air-source heat pump has a COP of 3 to 4, whereas a typical electric resistance heater has a COP of 1.0. That is, one joule of electrical energy will cause a resistance heater to produce one joule of useful heat, while under ideal conditions, one joule of electrical energy can cause a heat pump to move much more than one joule of heat from a cooler place to a warmer place.

[11] Comp.- http://www.heatpumpcentre.org/About_heat_pumps/HP_technology.asp
[12] Comp.- http://www.heatpumpcentre.org/About_heat_pumps/HP_technology.asp

Ground source heat pumps, which are also referred to as geothermal heat pumps, typically have higher efficiencies than air-source heat pumps. This is because they draw heat from the ground or groundwater which is at a relatively constant temperature all year round below a depth of about eight feet (2.5 m).
This means that the temperature differential is lower, leading to higher efficiency. Ground-source heat pumps typically have COPs of 3.5-4.0 at the beginning of the heating season, with lower COPs as heat is drawn from the ground. The tradeoff for this improved performance is that a ground-source heat pump is more expensive to install due to the need for the digging of wells or trenches in which to place the pipes that carry the heat exchange fluid. When compared versus each other, groundwater heat pumps are generally more efficient than heat pumps using heat from the soil.” [13]

Pipes which go in to the ground

[13] http://en.wikipedia.org/wiki/Heat_pump

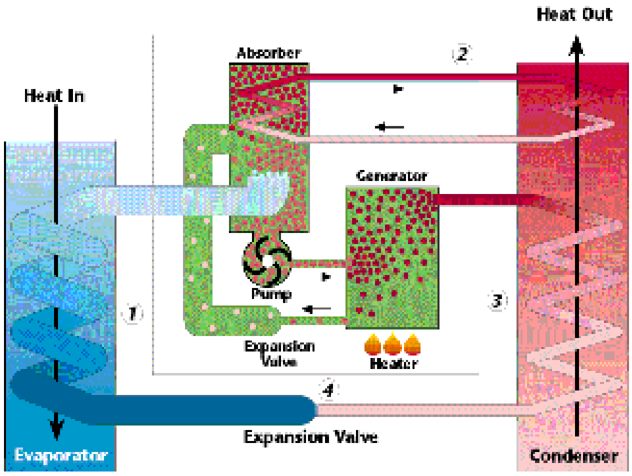
Heat pump

Absorption heat pumps

Now I want to say something about Absorption heat pumps: Absorption heat pumps are thermally driven, which means that heat rather than mechanical energy is supplied to drive the cycle. Absorption heat pumps for space conditioning are often gas-fired, while industrial installations are usually driven by high-pressure steam or waste heat.
Residential absorption heat pumps use an ammonia-water absorption cycle to provide heating and cooling. As in a standard heat pump, the refrigerant (in this case, ammonia) is condensed in one coil to release its heat; its pressure is then reduced and the refrigerant is evaporated to absorb heat. If the system absorbs heat from the interior of your home, it provides cooling; if it releases heat to the interior of your home, it provides heating.[14]
The difference in absorption heat pumps is that the evaporated ammonia is not pumped up in pressure in a compressor, but is instead absorbed into water. A relatively low-power pump can then pump the solution up to a higher pressure. The problem then is removing the ammonia from the water, and that's where the heat source comes in. The heat essentially boils the ammonia out of the water, starting the cycle again.[15]

[14] Comp. - http://www.heatpumpcentre.org/About_heat_pumps/HP_technology.asp
[15] Comp. - http://www.daviddarling.info/encyclopedia/A/AE_absorption_heat_pump.html

You can see that in the picture under:



Absorption Cycle Pic.[16]

Adsorption-type refrigeration system

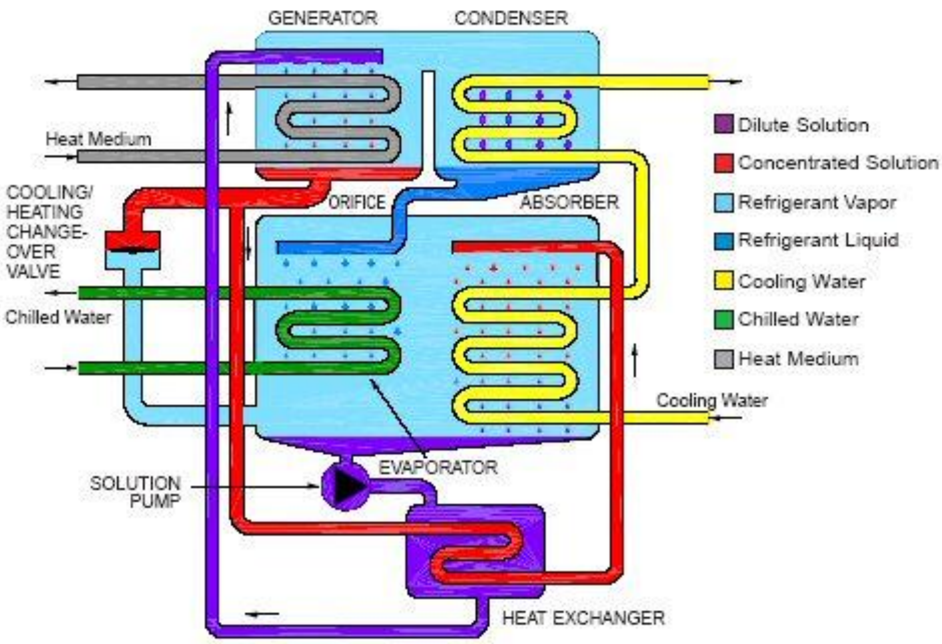
Water fired SINGLE-EFFECT chillers or chiller-heaters have cooling capacities of 10, 20 and 30 tons of refrigeration and produce chilled water for cooling or hot water for heating in comfort air conditioning applications. The absorption cycle is energized by a heat medium (hot water) at 70°C to 95°C from an industrial process, cogeneration system, solar energy or other heat source and the condenser is water cooled through a cooling tower.[17]

Absorption Principle

The Tesco absorption chiller or chiller-heater uses a solution of lithium bromide and water, under a vacuum, as the working fluid. Water is the refrigerant and lithium Bromide, a nontoxic salt, is the absorbent. Refrigerant, liberated by heat from the solution, produces a refrigerating effect in the evaporator when cooling water is circulated through the condenser and absorber.[18]

[16] Comp. - http://www.heatpumpcentre.org/About_heat_pumps/HP_technology.asp
[17] Comp. - http://www.yazakienergy.com/waterfired.htm
[18] Comp. - http://www.yazakienergy.com/waterfired.htm

Cooling Cycle



Pic.[19]

Generator

When the heat medium inlet temperature exceeds 68°C, the solution pump forces dilute lithium bromide solution into the generator. The solution boils vigorously under a vacuum and droplets of concentrated solution are carried with refrigerant vapor to the primary separator. After separation, refrigerant vapor flows to the condenser and concentrated solution is precooled in the heat exchanger before flowing to the absorber.[20]

Condenser

In the condenser, refrigerant vapor is condensed on the surface of the cooling coil and latent heat, removed by the cooling water, is rejected to a cooling tower. Refrigerant liquid accumulates in the condenser and then passes through an orifice into the evaporator.[21]

[19] Comp. - http://www.heatpumpcentre.org/About_heat_pumps/HP_technology.asp
[20] Comp. - http://www.yazakienergy.com/waterfired.htm
[21] Comp. - http://www.yazakienergy.com/waterfired.htm

Evaporator

In the evaporator, the refrigerant liquid is exposed to a substantially deeper vacuum than in the condenser due to the influence of the absorber. As refrigerant liquid flows over the surface of the evaporator coil it boils and removes heat, equivalent to the latent heat of the refrigerant, from the chilled water circuit. The recirculating chilled water is cooled to 44.6oF and the refrigerant vapor is attracted to the absorber.[22]

Absorber

A deep vacuum in the absorber is maintained by the affinity of the concentrated solution from the generator with the refrigerant vapor formed in the evaporator. The refrigerant vapor is absorbed by the concentrated lithium bromide solution flowing across the surface of the absorber coil. Heat of condensation and dilution are removed by the cooling water and rejected to a cooling tower. The resulting dilute solution is preheated in a heat exchanger before returning to the generator where the cycle is repeated.[23]

Water fired SINGLE-EFFECT chillers or chiller-heaters

[22] Comp. - http://www.yazakienergy.com/waterfired.htm
[23] Comp. - http://www.yazakienergy.com/waterfired.htm

“Absorption coolers and heat pumps usually only make sense in homes without an electricity source, but they have an added advantage in that they can make use of any heat source. Because of this, they can make use of solar energy, geothermal hot water, or other heat sources. They are also amenable to zoned systems, in which different parts of the house are kept at different temperatures. The efficiency of air-source absorption coolers and heat pumps is indicated by their coefficient of performance (COP). COP is the ratio of either heat removed (for cooling) or heat provided (for heating) in Btu per Btu of energy input.”[24] You have to look that the heating efficiency is greater than 1.2 COP and a cooling efficiency is greater than 0.7 COP .

[24] Comp.: - http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12680

Solar Thermal Energy

Solar thermal energy is a technology to utilize solar energy for thermal energy (heat). Solar thermal collectors are defined by the USA Energy Information Administration as low-, medium-, or high-temperature collectors. Low temperature collectors are flat plates usually used to heat swimming pools. Medium-temperature collectors are also usually flat plates but are used for creating hot water for residential and commercial use. High temperature collectors concentrate sunlight using mirrors or lenses and are generally used for electric power production. Solar thermal energy is different from photovoltaics, which convert solar energy directly into electricity. While only 600 megawatts of solar thermal power is up and running worldwide in October 2009 according to Dr David Mills of Ausra, another 400 megawatts is under construction and there are 14,000 megawatts of the more serious concentrating solar thermal (CST) projects being developed.[25]

Different Types of Systems

There are a number of different solar thermal designs, but all are based on the same simple principle. Each has its advantages and disadvantages, and each is suitable for a specific application.

Passive and active

The different of a passive or active system is if the system uses pumps to circulate the water through the the system or only the thermodynamics.

Passive:

The simplest systems are passive solar water heaters, also called batch or breadbox collectors, they are most common in regions that do not experience extensive periods of below freezing temperatures. The water in these solar collectors circulates without the aid of pumps or controls.[26]

Active:

Active solar water heaters use pumps to circulate water or an antifreeze solution through heat-absorbing solar thermal collectors.[27]

---

[25] Comp.: - www.en.wikipedia.org/wiki/Solar_thermal_energy

[26] Comp.: - www.southface.org/solar-roadmap/solar_how-to/solar-how_solar_works.htm

[27] Comp.: - www.southface.org/solar-roadmap/solar_how-to/solar-how_solar_works.htm

Direct and indirect

Also a important different between the systems are if the system direct or indirect. In a direct system, the water that is pumped through the solar collector is the same that used by building occupants to wash their clothes or bathe.

In an indirect system, an antifreeze solution is pumped through the solar heat collector. This warm solution is then used to heat the water used by building occupants. In this case, water is indirectly heated.[28]

Direct system

A direct system, also known as "open loop," is a little simpler. There is no antifreeze solution; the water heated directly by the sun is the same water used by building occupants. A thermometer and controller sense when the solar collector is warm and ready to heat water. The controller starts a pump that moves cold water into the solar collector, where it is heated. The solar heated water is then stored in a conventional hot water tank. It is typical, especially during high use or periods of little sun for the water to be kept warm through supplemental gas or electricity. The problem on this system is, it is susceptible to freezing because there are no additional safeguards like antifreeze.[29]

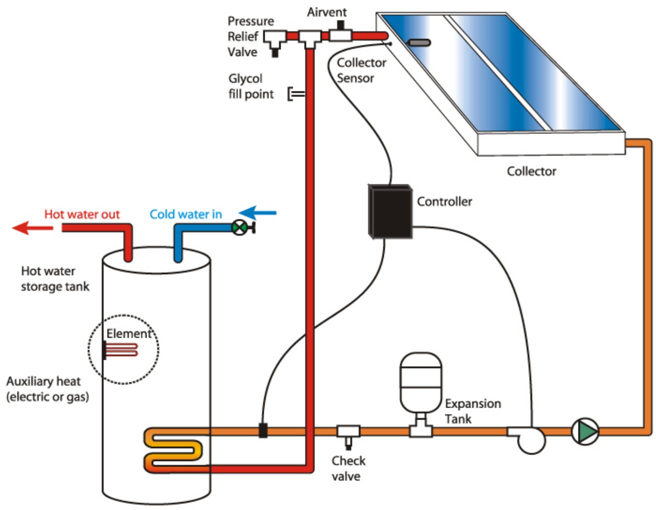
Indirect system

In an indirect system, also known as "closed loop," a simple pump moves the antifreeze solution through a loop into the solar collector, through the collector's pipes, and out of the solar collector. Then, the sun-warmed antifreeze solution flows into a heat-transfer unit where it warms the cool water heading into a conventional hot water tank.

---

[28] Comp.: - www.southface.org/solar-roadmap/solar_how-to/solar-how_solar_works.htm
[29] Comp.: - www.southface.org/solar-roadmap/solar_how-to/solar-how_solar_works.htm

Closed Loop, Freeze-Protection System



Pic.[30]

The antifreeze solution then returns to the pump and again flows into the solar collector without ever mixing with the building's water. Indirect systems are encouraged in climates with extended periods of below-freezing temperatures.[31]

How to collect the sun

Also a different between the solar thermal systems is the type of collectors. These collectors are responsible for gather and store the sun's energy. Flat plate collectors are the simplest and most common type.

More advanced systems like evacuated tube collectors and parabolic trough collectors can heat water or other fluids to much higher temperatures appropriate for industrial needs.

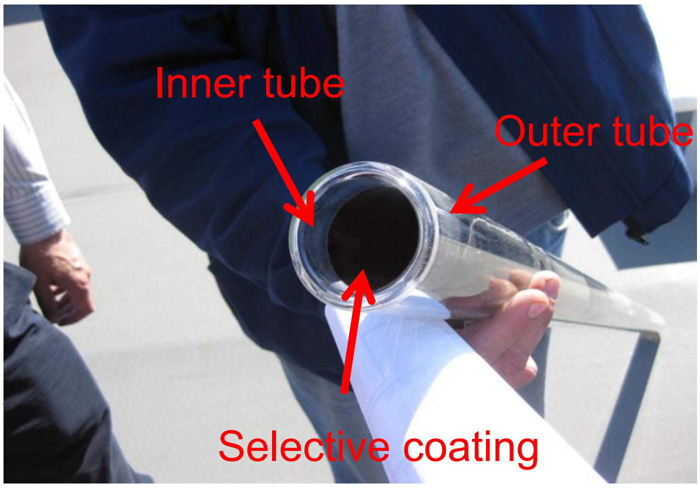
In the case of the Tesco the evacuated tube collectors are used.

[30] Comp.: - www.southface.org/solar-roadmap/solar_how-to/solar-how_solar_works.htm

Evacuated tube collectors

Evacuated tubes are the absorber of the solar water heater. They absorb solar energy converting it into heat for use in water heating. There are several types of evacuated tubes in use in the solar industry. Apricus collectors use the most common "twin-glass tube". This type of tube is chosen for its operational safety, performance and low manufacturing cost.

Each evacuated tube consists of two glass tubes made from extremely strong borosilicate glass. The outer tube is transparent allowing light rays to pass through with minimal reflection. The inner tube is coated with a special selective coating (Al-N/Al) which features excellent solar radiation absorption and minimal reflection properties.



The top of the two tubes are fused together and the air contained in the space between the two layers of glass is pumped out while exposing the tube to high temperatures. This "evacuation" of the gasses forms a vacuum, which is an important factor in the performance of the evacuated tubes.

A vacuum is an excellent insulator. Here in the case of the evacuated tube collectors we use the same principle than in a glass lined thermos flask. This is important because once the evacuated tube absorbs the radiation from the sun and converts it to heat. It is very important to not lose the heat. The vacuum helps to achieve this. The insulation properties are so good that while the inside of the tube may be 150 °C, the outer tube is cold to touch. This means that evacuated tube water heaters can perform well even in cold weather when flat plate collectors perform poorly due to heat loss (during high Delta-T conditions).[32]

[32] Comp.: - Apricus Solar Co.,Ltd 2008

Cooling with Solar Head

The new technical solutions make it possible to cool buildings with the power of the sun. The summer sun, which heats up buildings, also delivers the energy to cool them. The thermal use of solar energy offers itself: Days that have the greatest need for cooling are also the very same days that offer the maximum possible solar energy gain.

These systems works by adsorption refrigeration machines. Solar energy can easily be used in the form of vacuum tube or flat plate collectors. The refrigerating machine is composed of two adsorbers, one an evaporator and the other a condenser. An adsorber chamber takes up the water vapor, which is transformed into the gas phase under low pressure and low temperatures (about 9°C) within the evaporator. Granulated silicate gel, well known as an environmentally friendly drying agent, then accumulates it (adsorbs the water vapor). In the other sorption chamber the water vapor is set free again (the chamber is regenerated or "charged") by the hot water from the solar collector (about 85°C). The pressure increases and at the temperature of the surroundings (30°C) the water vapor can be transformed once again into a fluid within a cooling tower (condensed). Through a butterfly valve the water is led back into the evaporator and the cycle begins from the beginning. Both the condensed water (low temperature) and the sorption heat (high temperature) are discharged.[33]

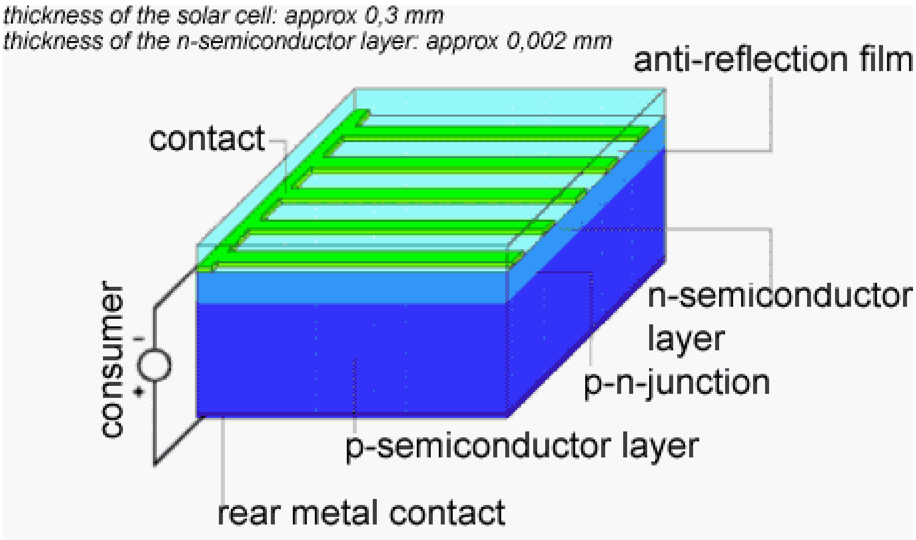
Evacuated tube collectors

[33] Comp. - www.solarserver.de/solarmagazin/artikeljuni2002-e.html

Photovoltaic's

Solar photovoltaic's are arrays of cells containing a material that converts solar radiation into direct current electricity. Solar cells are composed of various semi conducting materials. Semiconductors are materials, which become electrically conductive when supplied with light or heat, but which operate as insulators at low temperatures.[34]

"Over 95% of all the solar cells produced worldwide are composed of the semiconductor material Silicon (Si). As the second most abundant element in earth's crust, silicon has the advantage, of being available in sufficient quantities and additionally processing the material does not burden the environment. To produce a solar cell, the semiconductor is contaminated or "doped". Doping is the intentional introduction of chemical elements, with which one can obtain a surplus of either positive charge carriers which is called p-conducting semiconductor layer or negative charge carriers which is called n-conducting semiconductor layer from the semiconductor material. If two differently contaminated semiconductor layers are combined, then a so-called p-n junction results on the boundary of the layers."[35]



Model of a crystalline solar cell Pic.[36]

"Light, including sunlight, is sometimes described as particles called "photons." As sunlight strikes a photovoltaic cell, photons move into the cell.

When a photon strikes an electron, it dislodges it, leaving an empty "hole". The loose electron

[34] Comp. - http://en.wikipedia.org/wiki/Photovoltaics
[35] Comp. - http://www.solarserver.de/wissen/photovoltaik-e.html
[36] Comp. - http://www.solarserver.de/wissen/photovoltaik-e.html

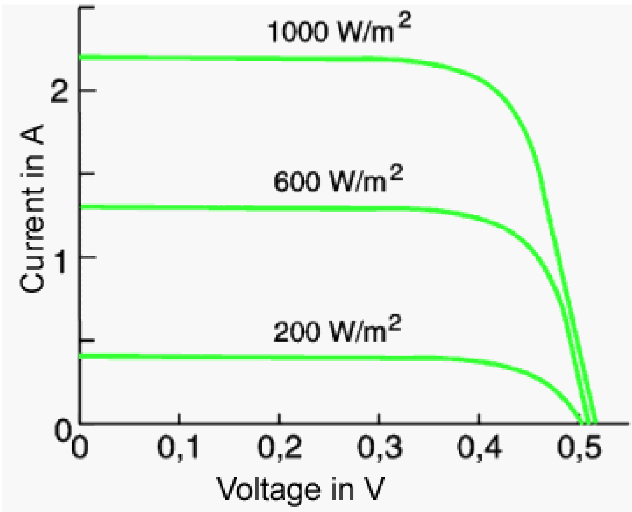
moves toward the top layer of the cell. As photons continue to enter the cell, electrons continue to be dislodged and move upwards."[37]

"At this junction, an interior electric field is built up which leads to the separation of the charge carriers that are released by light. Through metal contacts, an electric charge can be tapped."[38] If an electrical path exists, meaning a consumer is connected, outside the cell between the top grid and the backplane of the cell, a flow of electrons begins. Loose electrons move out the top of the cell and into the external electrical circuit. Electrons from further back in the circuit move up to fill the empty electron holes. "The silicon cells are approximately 10cm by 10cm large. A transparent anti-reflection film protects the cell and decreases reflective loss on the cell surface."[39]

Most cells produce a voltage of about one-half volt, regardless of the surface area of the cell. However, the larger the cell, the more current it will produce. "Current and voltage are affected by the resistance of the circuit the cell is in. The amount of available light affects current production. The temperature of the cell affects its voltage. "[40]

Characteristics of a Solar Cell

"The usable voltage from solar cells depends on the semiconductor material. In silicon it amounts to approximately 0, 5 V. Terminal voltage is only weakly dependent on light radiation, while the current intensity increases with higher luminosity. A 100 cm² silicon cell, for example reaches a maximum current intensity of approximately 2A when radiated by 1000 W/m².



Current-voltage line of a Si-solar cell Pic.[41]

[37] Comp. - http://www.polarpowerinc.com/info/operation20/operation23.htm
[38] Comp. - http://www.solarserver.de/wissen/photovoltaik-e.html
[39] Comp. - http://www.solarserver.de/wissen/photovoltaik-e.html
[40] Comp. - http://www.polarpowerinc.com/info/operation20/operation23.htm
[41] Comp. - http://www.solarserver.de/wissen/photovoltaik-e.html

The output (product of electricity and voltage) of a solar cell is temperature dependent. Higher cell temperatures lead to lower output, and hence to lower efficiency. The level of efficiency indicates how much of the radiated quantity of light is converted into useable electrical energy."[42]

Different types of solar cells

"**Monocrystalline cells** are cut from a single crystal of silicon. They are basically a slice of crystal. This makes them very smooth in texture and you can see the thickness of the slice. Monocrystalline cells are the most efficient, but also the most expensive to produce. They are completely rigid and must be mounted in a rigid frame for protection.

Polycrystalline (or Multicrystalline) cells are made from a slice cut from a block of silicon, but whereas Monocrystalline cells are from a single crystal, these cells consist of a large number of crystals. This gives them a speckled reflective appearance but, once again you can you see the thickness of the slice. Photovoltaic solar panels made from these types of cell are slightly less efficient but also slightly cheaper than monocrystalline cells. They also need to be mounted in a rigid frame.

Finally, **amorphous cells** are manufactured by placing a thin film of amorphous (non crystalline) silicon onto a wide range of surfaces. These create the least efficient type of Photovoltaic solar panels but also the cheapest. Due to the amorphous nature of the thin layer it is flexible, and if manufactured on a flexible surface, the whole photovoltaic solar panel can be flexible. One problem with amorphous cells, however, is that their power output reduces over time, particularly during the first few months, after which time they are basically stable. The quoted output of an amorphous panel should be that produced after this period."[43]

[42] Comp. - http://www.solarserver.de/wissen/photovoltaik-e.html
[43] Comp. - http://www.articlesbase.com/diy-articles/3-types-of-photovoltaic-solar-panels-what-are-the-differences-623038.html

Efficiency of the different materials[44]

Material	Level of efficiency in % Lab	Level of efficiency in % Production
Monocrystalline Silicone	Approx. 24	14 to 17
Polycrystalline Silicone	Approx. 18	13 to 15
Armorphous Silicone	Approx. 13	5 to 7

From the Cell to the Module

"In order to make the appropriate voltages and outputs available for different applications, single solar cells are interconnected to form larger units. Cells connected in series have a higher voltage, while those connected in parallel produce more electric current. The interconnected solar cells are usually embedded in transparent Ethyl-Vinyl-Acetate, fitted with an aluminum or stainless steel frame and covered with transparent glass on the front side."[45]

Limits of Efficiency

"In addition to optimizing the production processes, work is also being done to increase the level of efficiency, in order to lower the costs of solar cells. However, different loss mechanisms are setting limits on these plans. Basically, the different semiconductor materials or combinations are suited only for specific spectral ranges. Therefore a specific portion of the radiant energy cannot be used, because the light quanta (photons) do not have enough energy to "activate" the charge carriers. On the other hand, a certain amount of surplus photon energy is transformed into heat rather than into electrical energy. In addition to that, there are optical losses, such as the shadowing of the cell surface through contact with the glass surface or reflection of incoming rays on the cell surface. Other loss mechanisms are electrical resistance losses in the semiconductor and the connecting cable. The disrupting influence of material contamination, surface effects and crystal defects, however, are also significant.
Single loss mechanisms (photons with too little energy are not absorbed, surplus photon energy is transformed into heat) cannot be further improved because of inherent physical limits imposed by the materials themselves. This leads to a theoretical maximum level of efficiency, i.e. approximately 28% for crystal silicon."[46]

[44] Comp. - http://www.solarserver.de/wissen/photovoltaik-e.html
[45] Comp. - http://www.solarserver.de/wissen/photovoltaik-e.html
[46] Comp. - http://www.solarserver.de/wissen/photovoltaik-e.html

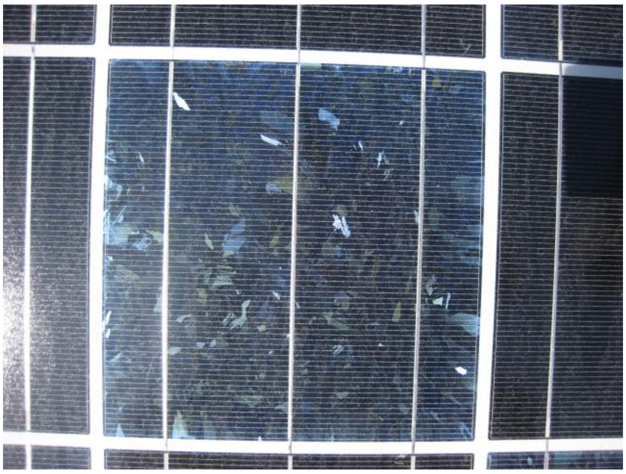
Solar inverters

A Solar inverter or PV inverter is a type of electrical inverter that is made to change the direct current (DC) electricity from a photovoltaic array into alternating current (AC) for use with home appliances and possibly a utility grid.[47]

Pictures of the photovoltaic elements of the Tesco

Sunnyboy Solar inverters

Photovoltaic arrays



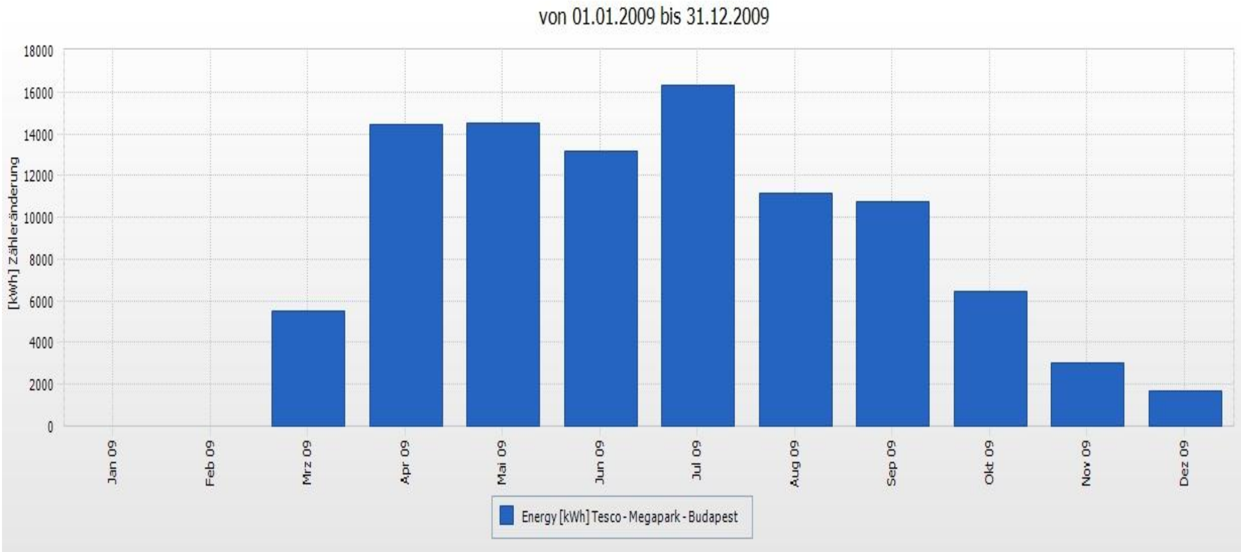
Polycrystalline Cells

Polycrystalline Cells

[47] Comp. - http://en.wikipedia.org/wiki/Solar_inverter

Real remote measurements

Here are the measurements of the photovoltaic plant of the Tesco Megapark in Budapest. The total amount of the year 2009 was around 72900 kwh.



With the revenue of 21cents per kWh the harvest was around 15300€. As a consequence you avoid 51030 kg of CO_2 with a CO_2 balance of 0,7 kg CO_2 per kwh. With this amount of saving in CO_2 it would be possible to drive around the earth 7,6 times with a usual car.

Air humidification

First I want to say something general about air humidity. "Whether we heat with gas, oil, coal, wood, or electricity, as the air heats up, the humidity or water carried in the air in our rooms in room's falls, often to a point actually drier than the Sahara Desert that means less than 10 - 15 percent. Relative humidity is the moisture expressed as percentage of the air's moisture holding capacity at any particular temperature."[48]

And human beings and most of the plants work best when the humidity in the air is between 30 and 60 percent. If the skin is exposed to very dry air, our skin and our mucous membranes, especially our respiratory systems, tend to dry out and the normal mucous gets sticky and thick. Because of this the people can more easily get infected. In the dry air many people get headache, have troubles with concentration or troubles with sleeping.

So the important task is to put water back in the air that people feel comfortable when they buy some stuff in the supermarket.

One possibility for humidifiers is the vaporizers. They put a cool mist into the air and are an excellent solution to the problem. Advantages are that they are quieter not so very expensive. They put out hot steam and will humidify single rooms. Disadvantages are the danger of burns and of furniture damage, and their limited capacity as compared to a large humidifier.

Air Himidification in supermarket

The right air humidity saves a good quality of the products, unchanging store conditions and gets out the best of employers and machines. So the air humidification is optimal for the usage in sale places and warehouses.

Air Humidification:

A very fine fog ensures the quality of the vegetables. With evaporative coldness the room temperatures falls down about 5 degrees without additional energy. And in the Tesco supermarket the water for the humidification is pumped up by a own well.

---

[48] Comp.: - http://wellness.uwsp.edu/medinfo/handouts/Humidify%20The%20Air.pdf

Use the Waste Heat of the Bakery

The bakery of the Tesco produces a lot of heat. It would be very wastefully if this heat would go away without a second exploitation.

Because of this, there are some heat exchangers on the top of the roof. All the heat exchanger are in series and the warm are is pushed through the heat exchanger by means of a fan.

The heat exchanger is cooling down the waste heat of the bakery and warming up water. So the unit recovers heat from the waste air stream that can be used for the heating of ventilation air or tap water.

The warm water that comes out of the heat exchangers goes to a warm water tank. This tank is a buffer for the warm water. If needed the water is used for heating up ventilation air or tap water. This system is a good example for not wasting energy.

The heat exchanger in series on the rooftop

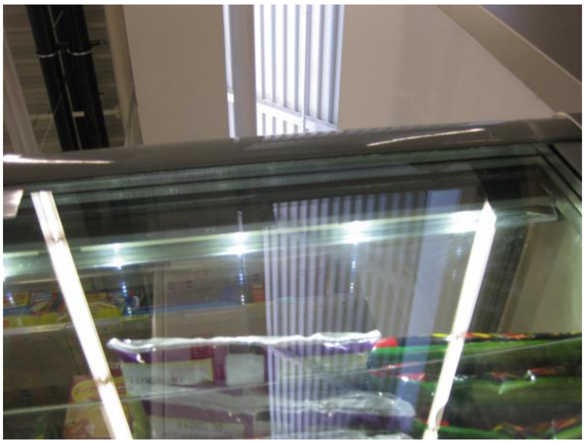
Lightening system

Neon signs

The lighting is realized with neon signs. It depends of the daylight which comes inside. If there is less illumination inside then there switch on automatically more neon signs to make it brighter.

Neon signs

Led lights in the deep freezers



LED's in deep freezer

LED's in fridges

The advantages are clear. On the one side the customer profits by a brighter and continuous illumination of the commodities, which make the goods more visible. Furthermore we have a passive lightning which avoids mirroring. On the other hand the LED reduce energy consumption up to 70% compared with fluorescent lamps and have much less service costs, because LED have a lifetime up to 6 years in that case.

Blinds

The blinds shut down automatically, when there is to much light inside and when the temperature rise up because of the solar radiation

Blinds on the roof of the building

Light domes

Light domes on the rooftop

Single Light domes

The advantages of the light domes are that they let only light inside the building without heat load. That saves energy consumption and is good for health, because we need sunlight to build vitamin D.

Conclusion

In this report we showed different kinds of possibilities how to save energy or make a building „greener“. Every single system do one's stint to reduce the demand on electric energy, gas or water. It is a quite big challenge to connect all this systems to one big system which works together and perform the task.

The Tesco in Dunakeszi is a good example how to manage this connection between all this different systems. At least in every weather situation is one system in a position to reduce the cost for energy and espouse the conventional units for heating, air-conditioning or lighting.

On balance are the renewable units only for the support and not to be in the position to supplant the conventional systems.

This could be able if the whole roof area would be used for photovoltaic panels or heat pipes. In this case the production of the green energy would be substantial higher and would be a real additional help to increase the environmental impact of such buildings.

We guess that the idea of the Tesco is not only to save energy and reduce the emission of CO_2 also one aim is of course the marketing effect. It became popular to be a green company and show the customers what the company does for the environment.

The Tesco did one big first step and now it should be follow some more.

Sources

- http://www.ixtenso.com/portal/de/product/1809
- http://www.solarstromerzeugung.de/photovoltaik-module.html
- http://www.bbc.co.uk/
- http://www.solarserver.de/wissen/photovoltaik-e.html
- http://en.wikipedia.org/wiki/Absorption_heat_pump
- http://www.gasklima.de/fileadmin/filemounts/gkl/pdf/Produkte_Yazaki/Produktprospekt_W
- FC-SC_5_bis_30.pdf
- http://www.gasklima.de/yazaki.0.html
- http://www.befeuchtungssysteme.eu/anwendungen/luftbefeuchtung/verkaufsraumbefeuchtun
- g/index.php
- http://www.foe.co.uk/resource/media_briefing/tesco_agm_2006.pdf
- http://wellness.uwsp.edu/medinfo/handouts/Humidify%20The%20Air.pdf
- http://en.wikipedia.org/wiki/Solar_cooling
- http://www.solarserver.de/solarmagazin/artikeljuni2002-e.html
- http://www.southface.org/solar/solar-roadmap/solar_how-to/solar-how_solar_works.htm
- http://www.rvmobile.com/Tech/Trouble/cooldoc.htm
- http://www.coldsystemsllc.com/co2-refrigeration.html
- http://www.focus.de/wissen/wissenschaft/klima/neue_technologien/tid-
- 13345/zukunftstechnologie-aldi-sued-kuehlt-mit-co2_aid_369657.html
- http://www.ent.ohiou.edu/~thermo/Applied/Chapt.7_11/Chapter9.html
- All photos are self-made