TREES **Training for Renovated Energy Efficient Social housing**

Intelligent Energy -Europe programme, contract n° EIE/05/110/SI2.420021

Section 2 Tools

2.5 Energy and Community Planning

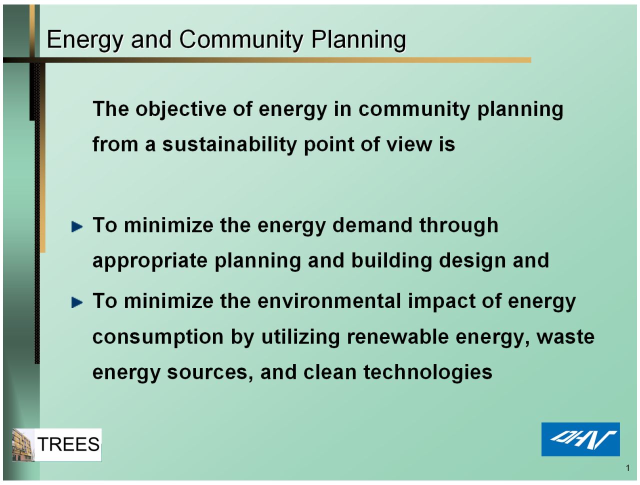
Author: Chiel Boonstra, Loes Joosten (DHV)
Reviewer: Arne Nesje (SINTEF)

Partners

Armines/Ecole Nationale Superieure des Mines de Paris – CEP, France
Budapest University of Technology and Economics (BUTE), Hungary
EnerMa, Sweden
DHV, The Netherlands
SINTEF, Norway
University of Kassel, Center for Environmental Systems Research (CESR), Germany

Index

1. Objective community planning

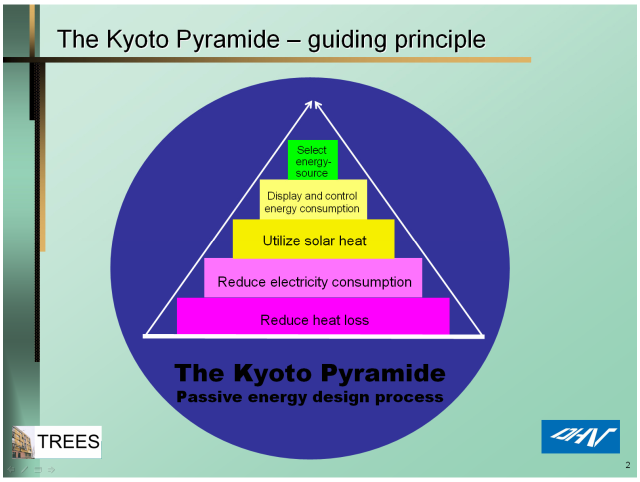


[Powerpoint slide 1]

The objective of community planning from a sustainable point of view is:

- to minimize the energy demand through appropriate planning and building design
- to minimize the environmental impact of energy consumption by utilizing renewable energy sources, and clean technologies

2. Strategy



[Powerpoint slide 2]

The Kyoto Pyramid is a strategy that has been developed for the design of low energy buildings, by (Dokka and Rødsjø, 2005). It is based on the Trias Energetica method described by Lysen (1996). The steps of the pyramid show the design strategy. In an integrated design strategy, you start at the bottom of the pyramid, applying the strategies and technologies as follows:

Reduce Demand

Optimize building form and zoning, apply super insulated and air tight conventional envelope constructions, apply efficient heat recovery of ventilation air during heating season, apply

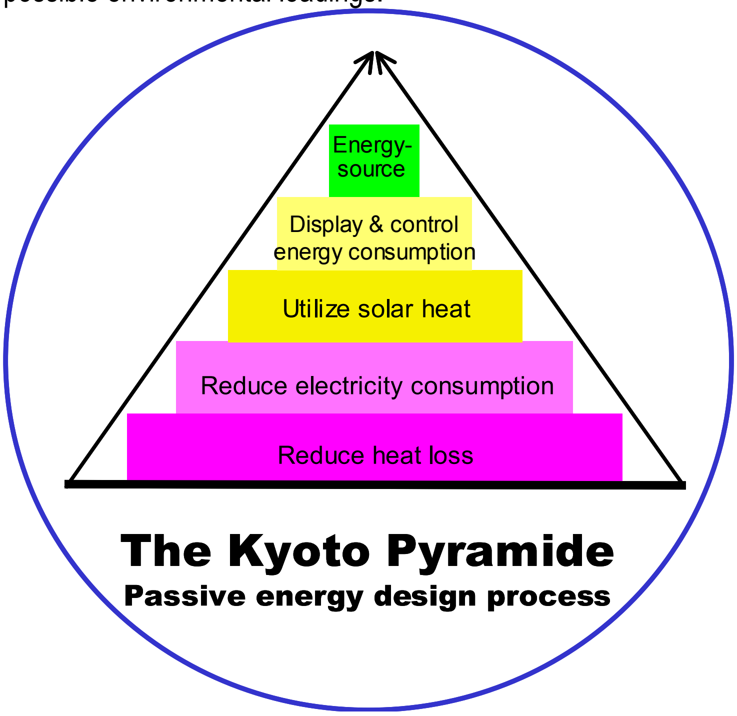
energy efficient electric lighting and equipment, ensure low pressure drops in ventilation air paths, etc.
Apply Responsive Building Elements if appropriate including advanced façades with optimum window orientation, exploitation of daylight, proper use of thermal mass, redistribution of heat within the building, dynamic insulation, etc.

Efficient use of fossil fuels
If any auxiliary energy is needed, use the least polluting fossil fuels in an efficient way, e.g. heat pumps, high-efficient gas fired boilers, gas fired CHPunits, etc.

Display and control energy consumption
Provide intelligent control of system including demand control of heating, ventilation, lighting and equipment.

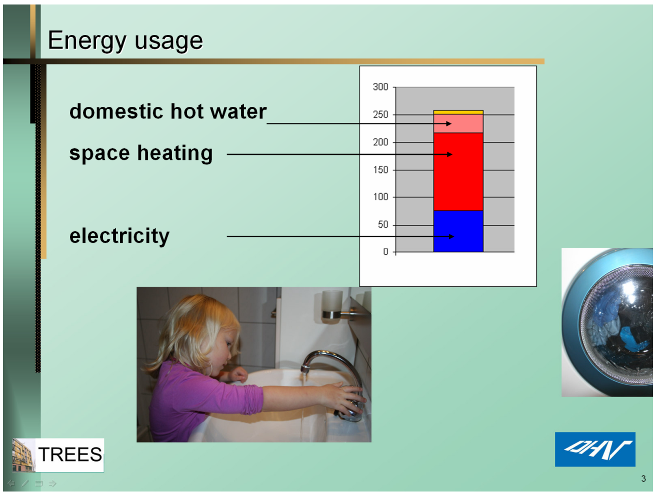
Utilize renewable energy sources
Provide optimal use of passive solar heating, daylight, natural ventilation, night cooling, earth coupling. Apply solar collectors, solar cells, geothermal energy, ground water storage, biomass, etc.

The main benefit of the method is that it stresses the importance of reducing the energy load before adding systems for energy supply. This promotes robust solutions with the lowest possible environmental loadings.



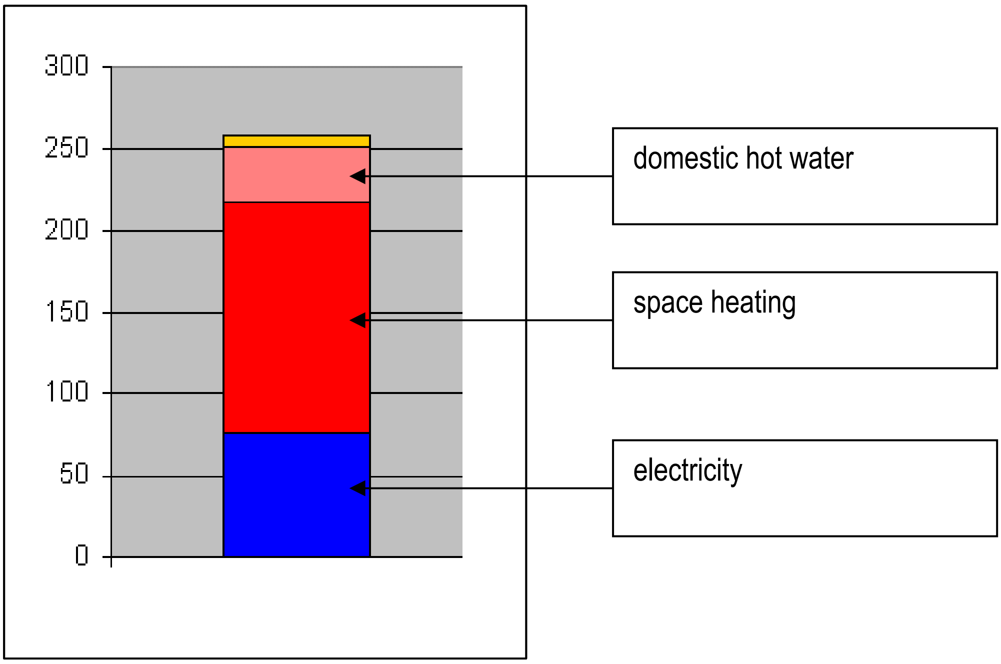
The Kyoto Pyramid, Source:(Dokka and Rødsjø, 2005

3. Energy usage



[Powerpoint slide 3]

In a household most energy is used for space heating, followed by electrical appliances and domestic hot water. In this section demand reduction for those 3 topics will be discussed.



Energy uses in a typical household proportionally

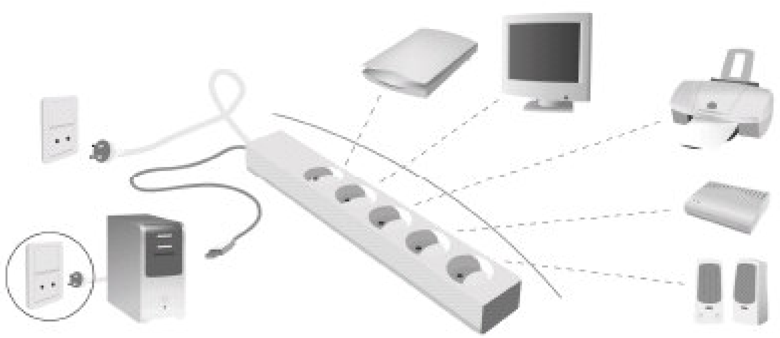
3.1 Space heating

Demand reduction for space heating can be achieved by:

- Optimizing the building form and zoning
- Applying super insulated and airtight conventional envelope constructions
- Applying efficient heat recovery of ventilation air during heating season

3.2 Electricity

Household electricity uses increase year by year. Households use more and more electrical appliances like wash dryers, fridges, air conditioning. By achieving a clothing dryer space integrated in the building, the electrical use can be reduced.
Achieving thermal comfort in summer can avoid the use of airconditioning units. Thermal comfort can be achieved by thermal mass, solar shading and thermal insulation.
Household appliances can have a high standby energy use. A standby-killer connection saves electricity during the standby mode of equipment.



Standy killer connection for house hold appliances

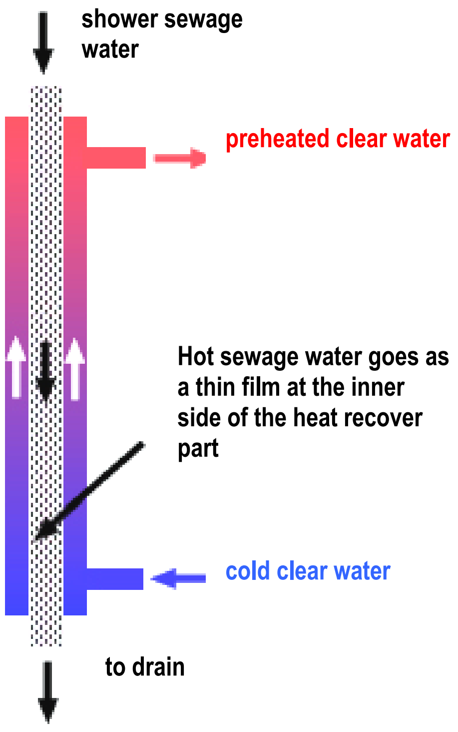
3.3 Domestic hot water

Demand reduction for domestic hot water can be achieved by several techniques:

- Short pipes
- Heat recovery for shower sewage
- Energy saving shower head

Heat recovery for shower sewage
The so called 'shower pipe' uses coiled piping around shower drain pipe. It transfers heat to incoming cold shower water. The drain water falls with gravity and creates a film against the inner wall of the pipe. The film allows for more heat exchanged than if water were pumped through the pipe.

The heat recovery efficiency ranges from 40 to 70%.



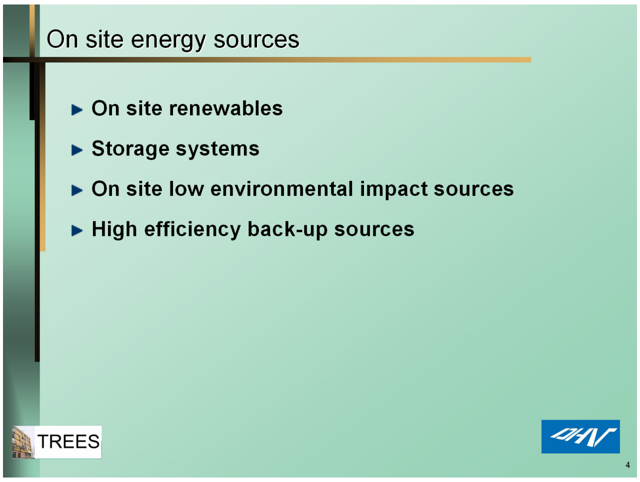
Heat recovery for shower sewage(source: Bries)

Energy saving shower head

These shower heads have a built in flow restrictor which will maintain a steady output of 8 litres per minute, compared to 14-20 litres per minute for conventional showers, while maintaining the feel of a forceful and vigorous shower. 70% of water used in a shower is hot, therefore by reducing the water you use you equally reduce the energy required to re-heat it.

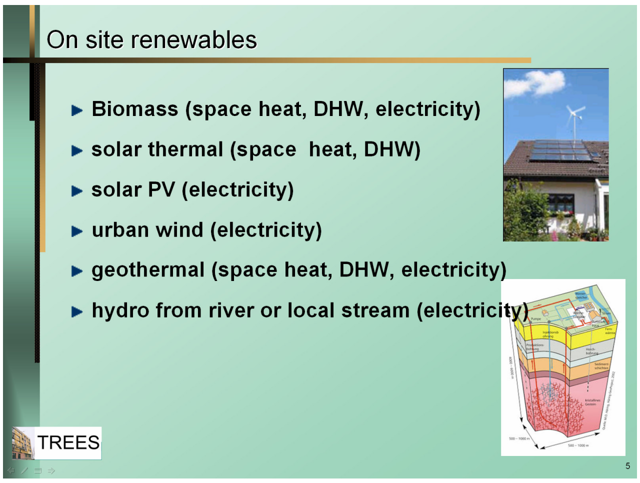
Energy saving shower head

4. On site energy sources



[Powerpoint slide 4]

4.1 On site renewables

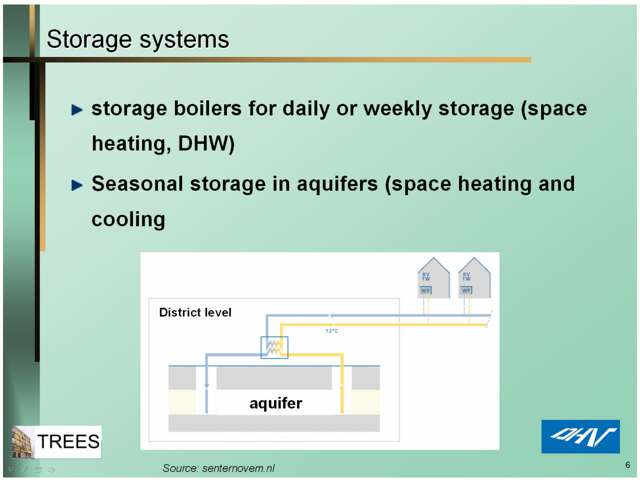


[Powerpoint slide 5]

On-site renewable energy is energy produced from "fuels" that have a stable, predictable supply, such as solar and wind. While solar and wind may be the most common renewable energy sources today, there are several others that are beginning to gain recognition in the market: biomass, ground source, and hydrogen, to name a few. With mounting research showing the negative effects of global warming, and with supply and price of oil affecting the cost of energy, there are dramatic reasons to seek out clean, renewable energy alternatives. But renewable energy is much more than a doomsday avoidance measure, it is a wise long-term investment for both the building owner and the community.

On site renewables with wind energy and photo voltaic solar energy

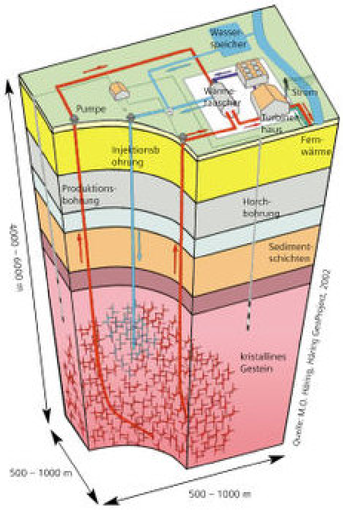
4.2 Storage systems



[Powerpoint slide 6]

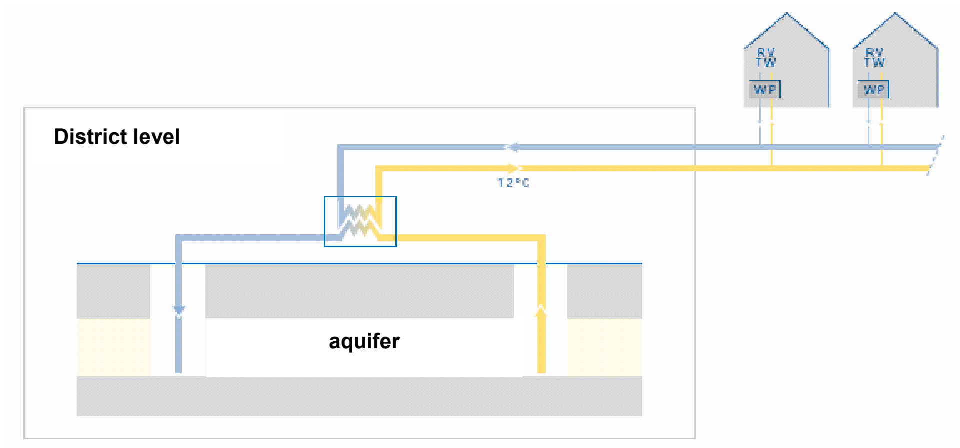
Heat and cold storage

In summer periods there is a surplus of heat that can be used for heating in winter periods, and so there is the other way around. By storing heat or cold it's possible to use the energy in others periods. A suitable battery for this storage is the ground.



Heat and cold storage in ground

The part in the ground suitable for energy storage is groundwater, which is stored in sand layers. By releasing warm water in the summer in the ground, the warm water can be used in the winter for example to heat the building. On the other hand, cold water that is stored in the ground during the winterperiod can be used to cool the building in summer.



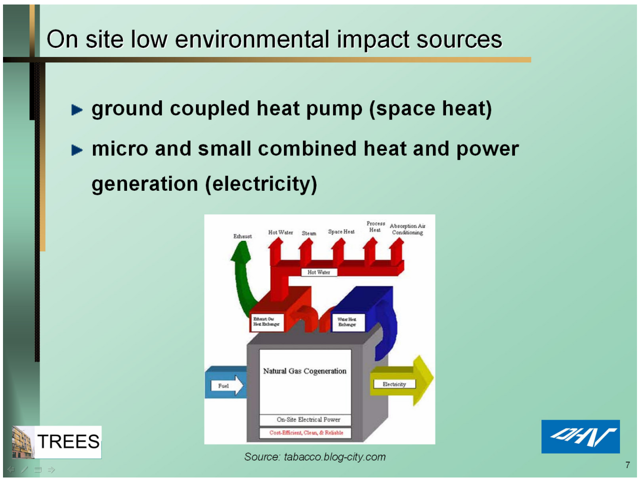
Heat and cold source in ground for heating and cooling

For the storage of heat and cold 2 'sources' have to be drilled, 1 source for heat, 1 source for cold. To cool the building in summer, cold will be extracted from the cold source, for example to cool the ventilation supply air. As soon as the cold out of the water has been used, the water warms up. The warm water goes to the warm water source. Thanks to development of heat pumps the water of this heat source can be used in winter periods for heating the building. A heat pump can heat relatively low temperatures to warm water for heating. The used water that has been cooled down goes back to the cold source.

Storage boilers for domestic hot water of heating

Another type of storage system are storage boilers for domestic hot water, for daily or weekly storage. Boilers with a storage tank (hot water cylinder) are better capable of coping with the demands of multiple use and can deliver water at a high temperature and at a high flow rate too.

4.3 On site low environmental impact sources



[Powerpoint slide 7]

Micro and small combined heat and power generation (electricity)
Combined heat and power (CHP) technologies produce both electricity and steam from a single fuel at a facility located near the consumer. These efficient systems recover heat that normally would be wasted in an electricity generator, and save the fuel that would otherwise be used to produce heat or steam in a separate unit.

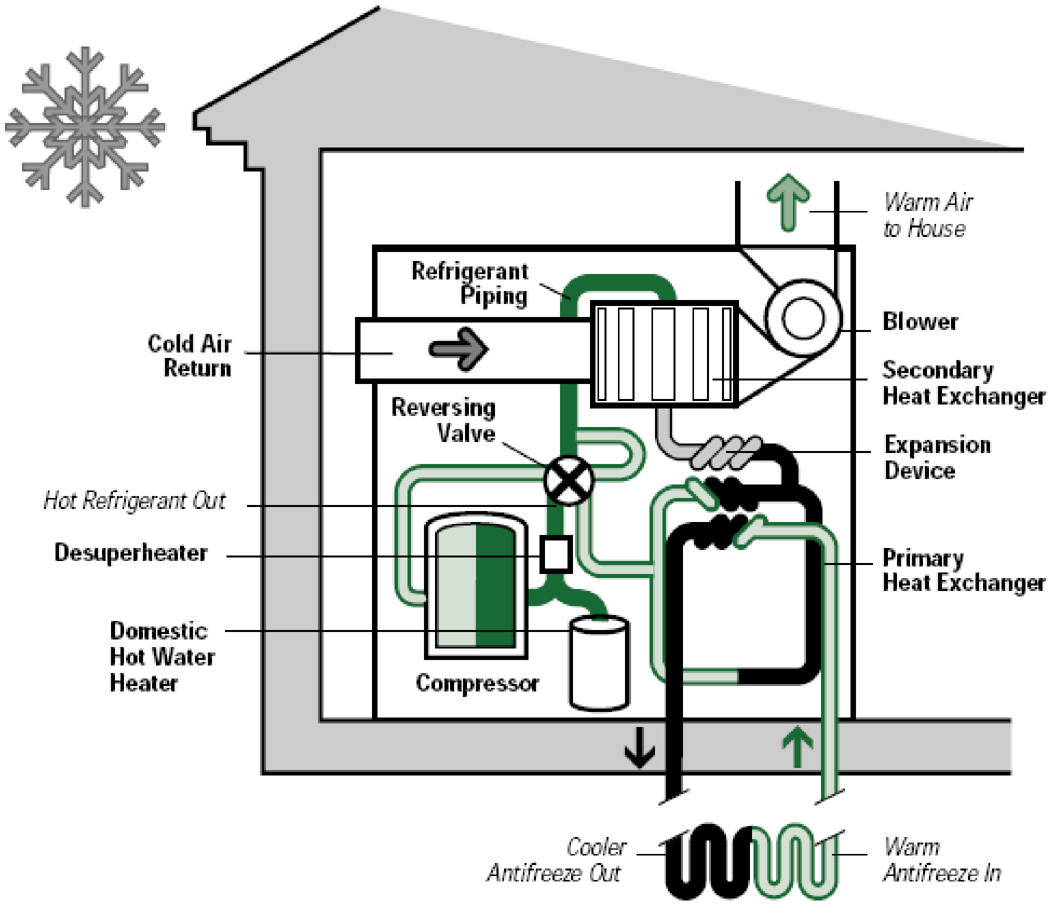
Micro-CHP systems' chief difference from their larger-scale kin is in the operating parameter-driven operation. In many cases industrial CHP systems primarily generate electricity and heat is a useful by-product. Contrarily, micro-CHP systems, which operate in homes or small commercial buildings, are driven by heat-demand, delivering electricity as the byproduct. Because of this operating model and because of the fluctuating electrical demand of the structures they would tend to operate-in, homes and small commercial buildings, micro-CHP systems will often generate more electricity than is instantly being demanded.

Ground coupled heat pump (space heat)
Ground source heat pumps provide a new and clean way of heating buildings. They make use of renewable energy stored in the ground, providing one of the most energy-efficient ways of heating buildings. They are suitable for a wide variety of building types and are particularly appropriate for low environmental impact projects. They do not require hot rocks (geothermal energy) and can be installed in most situations, using a borehole or shallow trenches or, less commonly, by extracting heat from a pond or lake. Heat collecting pipes in a closed loop, containing water (with a little antifreeze) are used to extract this stored energy, which can then be used to provide space heating and domestic hot water. In some applications, the pump can be reversed in summer to provide an element of cooling, but these systems are not currently eligible.

The only energy used by Ground Source Heat Pump systems is electricity to power the pumps. Typically, a Ground Source Heat Pump will deliver three or four times as much thermal energy (heat) as is used in electrical energy to drive the system. For a particularly environmental solution, green electricity can be purchased.

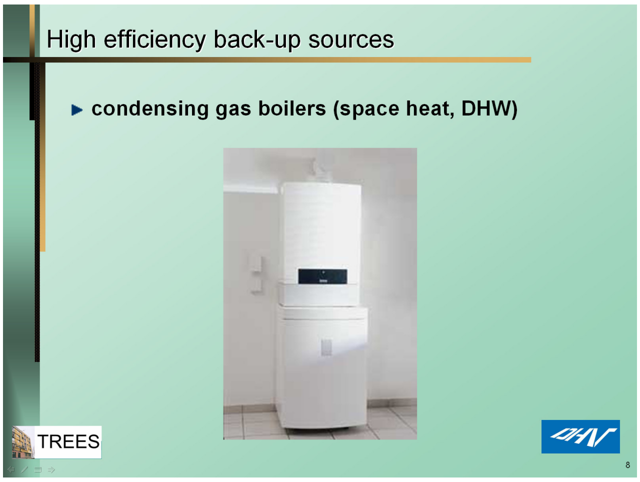
Ground Source Heat Pump systems have been widely used in other parts of the world, including North America and Europe, for many years. Typically they cost more to install than conventional systems; however, they have very low maintenance costs and can be expected to provide reliable and environmentally friendly heating for in excess of 20 years.

Ground Source Heat Pumps work best with heating systems which are optimised to run at a lower water temperature than is commonly used in conventionally and radiator systems. As such, they make an ideal partner for underfloor heating systems.



Ground source heatpump (source: Natural Resources Canada)

4.4 High efficiency back-up sources



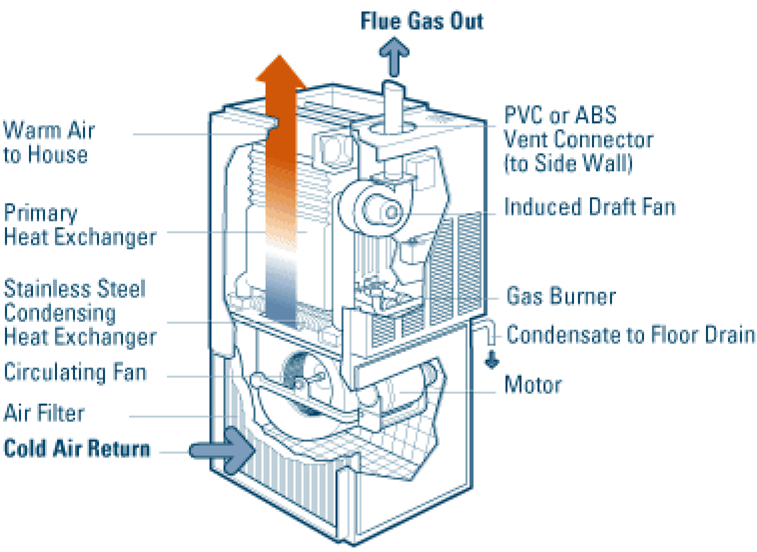
[Powerpoint slide 8]

As a backup system for space heating and domestic hot water can be achieved by condensing gas boilers (space heat, DHW). Condensing boilers claim that up to 95% efficiency of fuel conversion can be achieved in normal domestic use, compared to 70%-80% with a conventional design.

Background

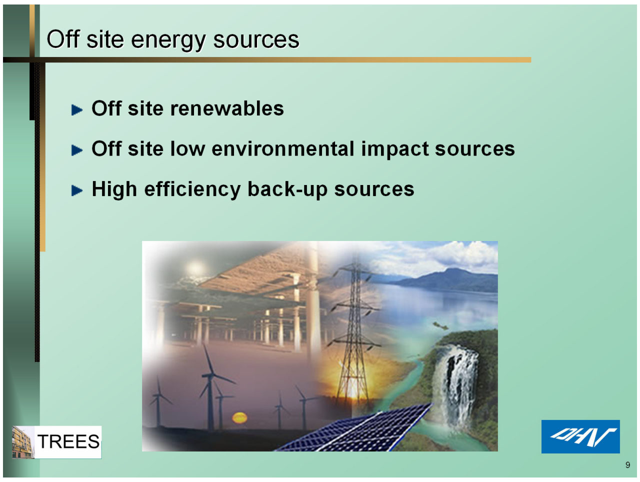
A condensing boiler is a high efficiency modern boiler that incorporates an extra heat exchanger so that the hot exhaust gases lose much of their energy to pre-heat the water in the boiler system. When working at peak efficiency, the water vapour produced in the combustion process condenses back into liquid form releasing the latent heat of vaporisation. A side effect is that this water, known as condensate, which is usually acidic, has to be piped away to a drain or soakaway.

The photo (below) shows a cutaway combination condensing boiler. It is mounted on a wall and the exhaust gases will rise through the plastic flue in the top left corner. Hot water is provided by a small storage tank on the right: the tank (which is covered by insulating foam) has been cut open to show the tightly wound quick refresh coil inside it. At the bottom of the photo are a number of pipes going into the boiler. One carries the gas for the burner and there are two (in and out) for the central heating system. The plastic pipe on the right carries the condensed water vapour produced by burning the gas. This water contains dissolved oxides of sulphur and nitrogen, making it slightly acidic.



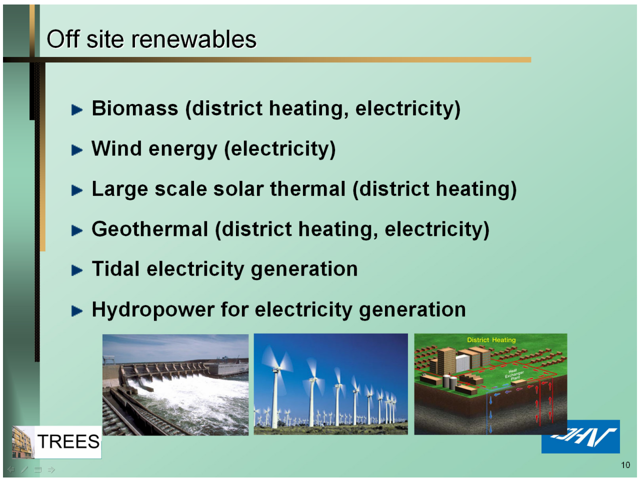
Principle condensing gas boiler (source: Natural Resources Canada)

5. Off site energy sources



[Powerpoint slide 9]

5.1 Off site renewables



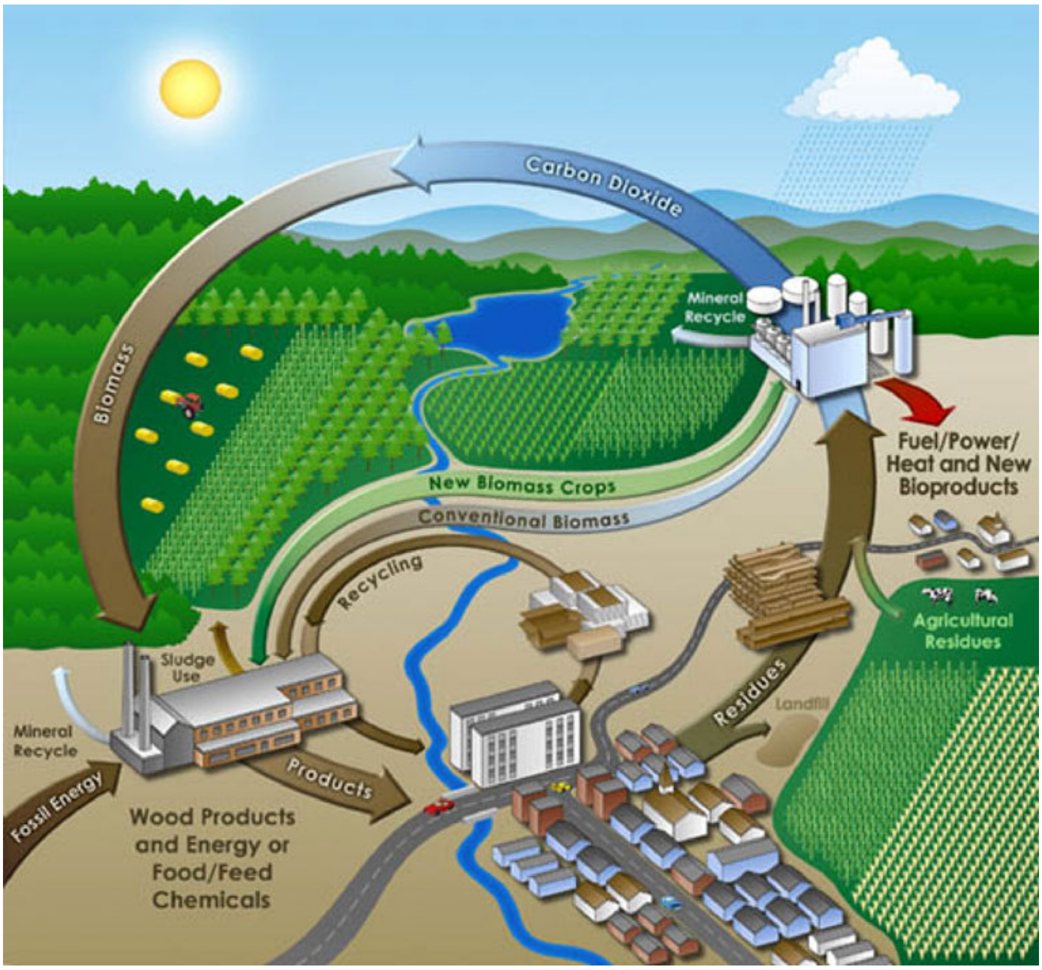
[Powerpoint slide 10]

Off site renewables help to improve the overall performance of the energy grid. Renewable energy refers to electricity or heat generated from renewable resources that are replenished – the sun, wind, water, biomass, and geothermal (the earth's heat). Renewable energy technologies include photovoltaics (also called PV or solar electric), wind turbines, small hydroelectric dams (large hydroelectric dams are not deifned as renewable because of the environmental impact of those facilities), biomass and biogas, and geothermal.

Biomass

Biomass is a renewable energy resource derived from the carbonaceous waste of various human and natural activities. It is derived from numerous sources, including the by-products from the timber industry, agricultural crops, raw material from the forest, major parts of household waste and wood.

Biomass does not add carbon dioxide to the atmosphere as it absorbs the same amount of carbon in growing as it releases when consumed as a fuel. Its advantage is that it can be used to generate electricity with the same equipment or power plants that are now burning fossil fuels. Biomass is an important source of energy and the most important fuel worldwide after coal, oil and natural gas.



Types of biomass (source: MACD)

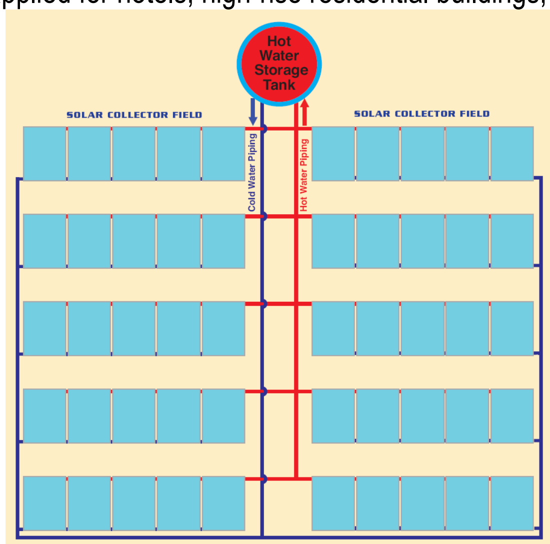
Wind energy
Winds are created by uneven heating of the atmosphere by the sun, irregularities of the Earth's surface, and the rotation of the Earth. As a result, winds are strongly influenced and modified by local terrain, bodies of water, weather patterns, vegetative cover, and other factors. The wind flow, or motion of energy when harvested by wind turbines, can be used to generate electricity. Wind-based electricity generating capacity has increased markedly since 1970, although it remains a small faction of total electric capacity.

Windenergy (source: Olino)

Large scale solar thermal

Solar thermal energy is a technology for harnessing solar power for practical applications from solar heating to electrical power generation. Solar thermal collectors, such as solar hot water panels, are commonly used to generate solar hot water for domestic and light industrial applications. Solar thermal energy is used in architecture and building design to control heating and ventilation in both active solar and passive solar designs.

Large scale solar thermal energy can be applied for hotels, high-rise residential buildings, etc.



Thermal solar collectors (Source http://www.maharishisolar.com)

Geothermal

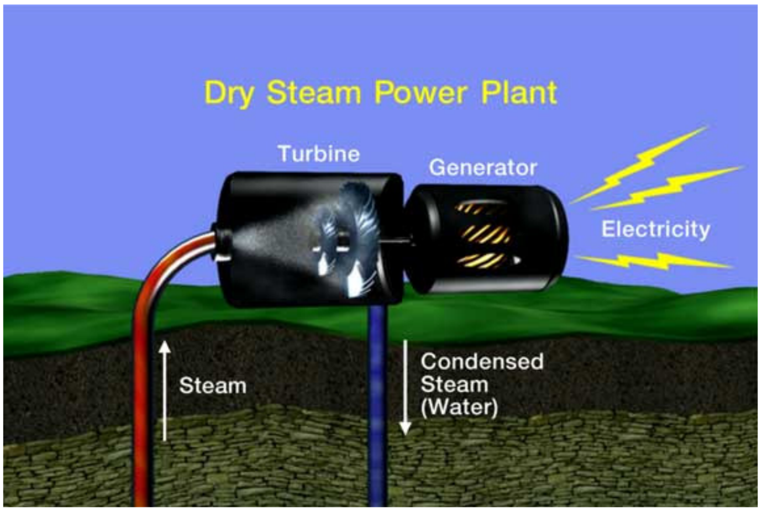
Geothermal energy is defined as heat from the Earth. It is a clean, renewable resource that provides energy in the United States and around the world. It is considered a renewable resource because the heat emanating from the interior of the Earth is essentially limitless. The heat continuously flowing from the Earth's interior is estimated to be equivalent to 42 million megawatts of power. The interior of the Earth is expected to remain extremely hot for billions of year to come, ensuring an inexhaustible flow of heat.

Geothermal energy can be used for electricity production, for direct use purposes, and for home heating efficiency (through geothermal heat pumps).

To develop electricity from geothermal resources, wells are drilled into the natural hot water or steam, known as a geothermal reservoir. The reservoir collects many meters below the groundwater table. Wells bring the geothermal liquid to the surface, where it is converted at a power plant into electricity (see below for more information about the different types of geothermal electricity production).

Direct use applications utilize geothermal heat without first converting it to electricity, such as for space heating and cooling, food preparation, industrial processes, etc. People have been taking advantage of direct use applications for centuries, with documentation of early uses tracing back to ancient Roman times.

Geothermal heat pumps are devices that take advantage of the relatively constant temperature of the Earth's interior, using it as a source and sink of heat for both heating and cooling. When cooling, heat is extracted from the space and dissipated into the Earth; when heating, heat is extracted from the Earth and pumped into the space. Geothermal heat pumps can be used anywhere on Earth, and are considered by the EPA to be one of the most efficient heating and cooling systems available.



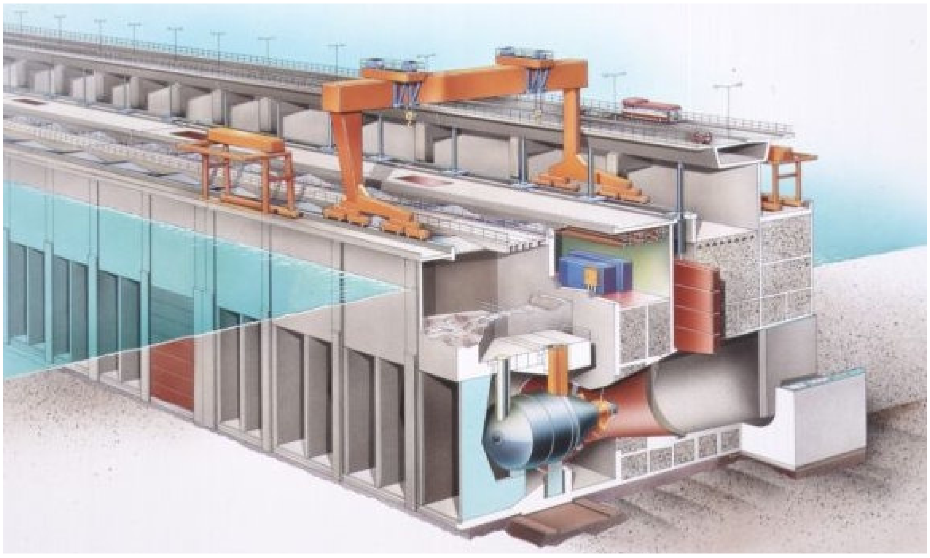
Dry steam power plant (Source: Geo Energy Association)

Tidal electricity

Tidal electricity is a form of hydropower that exploits the rise and fall in sea levels due to the tides, or the movement of water caused by the tidal flow. Because the tidal forces are caused by interaction between the gravity of the Earth, Moon and Sun, tidal power is essentially inexhaustible and classified as a renewable energy source.

Although not yet widely used, tidal power has great potential for future electricity generation and is more predictable than wind energy and solar power. In Europe, tide mills have been used for nearly a thousand years, mainly for grinding grains.

Tidal power can be classified into two types. Tidal stream systems make use of the kinetic energy from the moving water currents to power turbines, in a similar way to underwater wind turbines. This method is gaining in popularity because of the lower ecological impact compared to the second type of system, the barrage. Barrages make use of the potential energy from the difference in height (or head) between high and low tides, and their use is better established.



Artist's impression of the Severn Barrage and road link proposed in 1989. The scheme would have generated 6% of the UK's electricity supply. (Source: wikipedia)

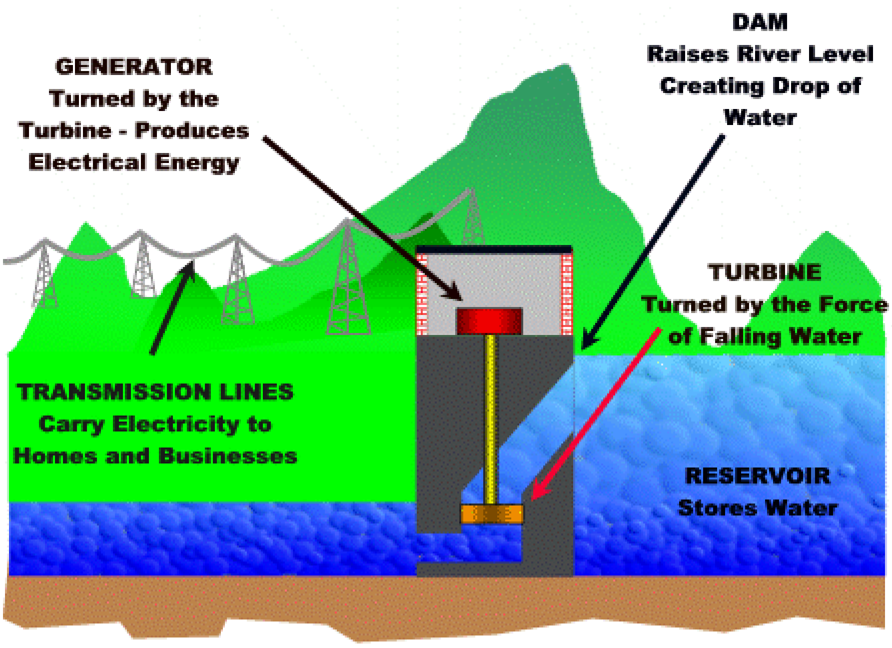
Hydropower for electricity generation
Hydropower converts the natural flow of water into electricity to light our homes and power our industries. The energy is produced by the fall of water turning the blades of a turbine. The turbine is connected to a generator that converts the energy into electricity.

The amount of electricity a hydropower installation can produce depends on the quantity of water passing through a turbine (the volume of water flow) or on the height from which the water falls (the amount of head). The greater the flow and the head, the more electricity produced.

There are different types and sizes of hydropower installations, ranging from micro hydro plants that provide electricity to only a few homes to mega installations, which produces enough power to light millions of dwellings.

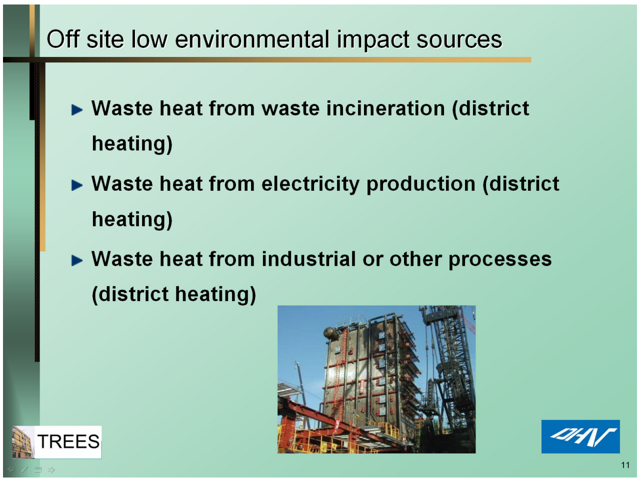
Some hydropower facilities include dams to increase the head of a waterfall or to control the flow of water, and reservoirs to store the water for future energy use (storage dam), while others produce electricity by immediately using a river's water flow (run-of-river). Some hydropower plants also use pumped storage systems, which store the water for reuse in the production of electricity during periods of high demand.

Hydropower is unique among energy sources for its operational flexibility. If there is an increased electricity demand, a hydropower plant can respond almost immediately by releasing more water. On the other hand, when the demand is low, a hydropower plant can reserve the water for future requirements. Hydropower can also supplement other forms of renewable energy such as wind or solar power.



Schematic Hydro Electro Plant (Source: Wvic.com)

5.2 Offsite low environmental impact sources



[Powerpoint slide 11]

District heating is a system for distributing heat generated in a centralized location for residential and commercial heating requirements. The heat can be obtained from a cogeneration plant. This way of heat generation is based on low environmental impact sources.

Waste heat from waste incineration (district heating)
A waste incineration plant will enhance energy recovery from the combustion process of the waste by producing both electricity for sale to the public grid and heat for district heating. This will contribute to reducing primary energy consumption and related atmospheric pollution.

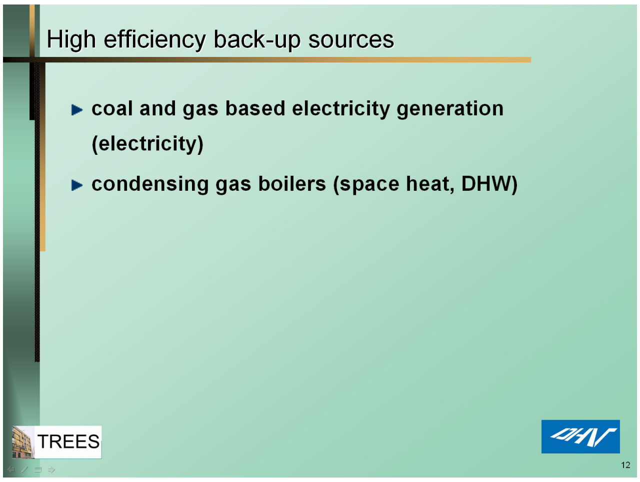
A new incineration plant will be equipped with a flue gas cleaning system designed to keep emissions below national and EU requirements, whereas the flue gas cleaning equipment of the three existing lines will be upgraded.
The CHP incineration plant can be part of a larger municipal incineration complex in which it constitutes a replacement and expansion of existing lines.

Waste Heat Recovery Boiler for Waste Incineration (Source: IMEX)

Waste heat from electricity production (district heating)
District heating is a system for distributing heat generated in a centralized location for residential and commercial heating requirements. The heat can be obtained from a cogeneration plant, like a electricity generation station. A district heating plant combined with a cogeneration plant can provide higher efficiencies.

Waste heat from industrial or other processes (district heating)
Many industrial processes generate large amounts of waste energy that simply pass out of plant stacks and into the atmosphere or are otherwise lost. Most industrial waste heat streams are liquid, gaseous, or a combination of the two and have temperatures from slightly above ambient to over 1000 ºC. Stack exhaust losses are inherent in all fuel-fired processes and increase with the exhaust temperature and the amount of excess air the exhaust contains. At stack gas temperatures greater than 500 ºC, the heat going up the stack is likely to be the single biggest loss in the process. Above 1000 ºC, stack losses will consume at least half of the total fuel input to the process. Yet, the energy that is recovered from waste heat streams could displace part or all of the energy input needs for district heating.

5.3 High efficient back-up sources

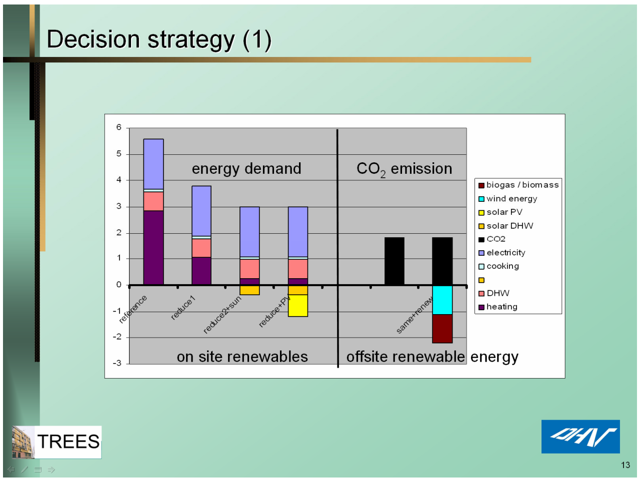


[Powerpoint slide 12]

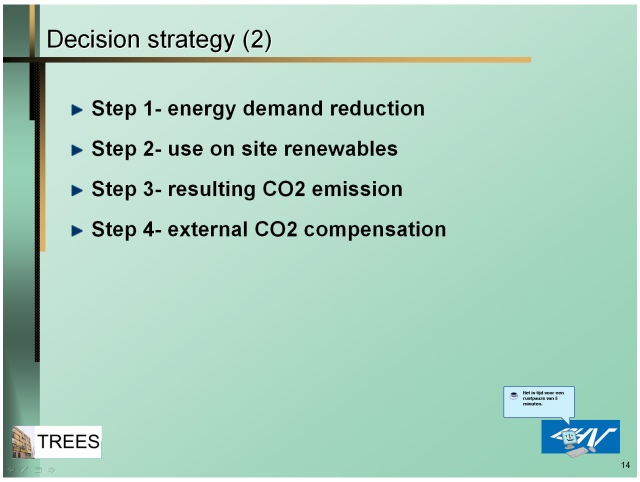
Coal and gas based electricity generation
Instead of batteries coal and gas based electricity generation can be high efficient back-up sources.

Small electricity generators are often powered by reciprocating engines burning diesel, biogas or natural gas. Diesel engines are often used for back up generation, usually at low voltages. Biogas is often combusted where it is produced, such as a landfill or wastewater treatment plant, with a reciprocating engine or a microturbine, which is a small gas turbine.

6. Decision strategy



[Powerpoint slide 13]

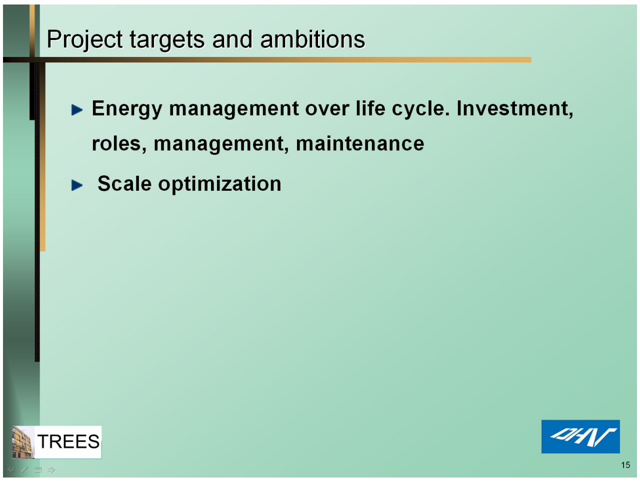


[Powerpoint slide 14]

The strategy to obtain a CO_2 emitting project is:

- Energy demand reduction (insulation)
- Use on site renewables (PV)
- Resulting CO_2 emission
- External CO_2 compensation (windenergy, biomass)

7. Project targets and ambitions

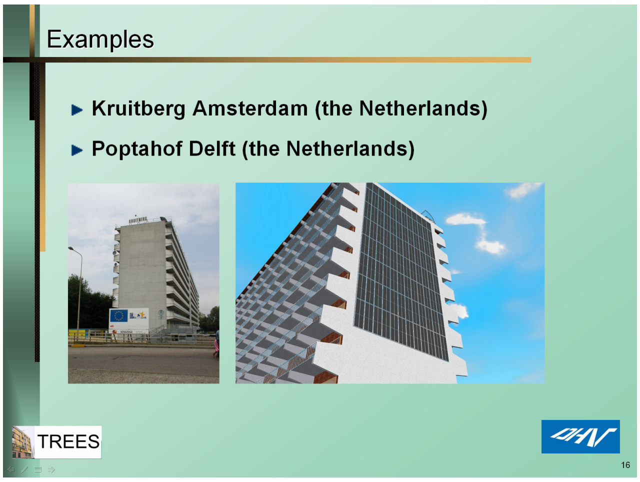


[Powerpoint slide 15]

Project targets and ambitions are to achieve:

- Scale optimization
- Energy management over life cycle; Investment, roles, management, maintenance

Examples of projects are given below:



[Powerpoint slide 16]

Kruitberg

Kruitberg is a typical large-scale high-rise building in the south-eastern part of Amsterdam built during the 1960-70's. The demonstration project includes the second phase of a large renewal operation and consists of 363 apartments out of a total of 9000, which are in need of renovation in the coming years.

Regarding the Kyoto strategy, the following measures were taken:

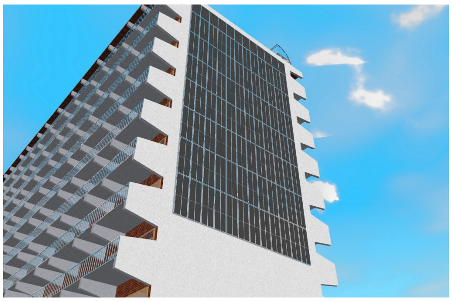
Reduced Energy Demand
– Insulation at both end facades and parapets (Rc = $3m^2K/W$)
– Insulation on the outside of staircases
– LE-glazing 1,1 W/m^2K in 80 selected apartments with relatively large transmission losses
– Air supply through pressure controlled (natural) constant volume air inlets and individual controllable constant volume outlet devices in 'wet' spaces.
– Special attention to air tightness

Renewable Energy Sources
– 33 glazed balconies
– 5 Crystalline PV in parapets
– 1 end façade got crystalline and amorphous panels with 12 kWp
– Air heat is extracted from ventilation exhaust with an electrical compression heat pump (20 kW) to preheat DHW (using 10% of the air).
– 720 m^2 thermal solar system with a performance of 1,74 GJ/m^2 primarily for DHW, and secondary for space heating.

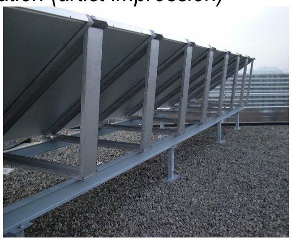
Efficient Energy Supply
– Renovating and improving the existing collective installation with CHP
– Back up with new condensing boilers on the rooftop
– Mid term temperature distribution system (70°C-40 °C) replaced former level of (90°C-70 °C)
– Main distributing system was also taken from ground floor to the roof and well insulated.
– Individual metering of heat supply and the use of cold and hot DW

Various
– Metering and reduction of tap flows from 20 litres per minute to a conventional 8 litres.

INNOVATIVE MEASURES ILLUSTRATED

End facades before and after renovation (artist impression)

Start of construction 720 m2 collector (left) and framework (right)

Heat exchanger on roof

Heat pump

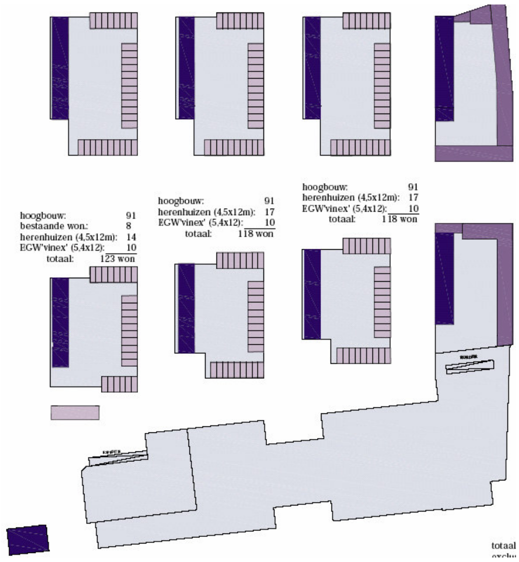
Poptahof

Part of sustainable development is the creation of homes with high energy performance levels. There are various possibilities for this. The national standard for Energy Performance on Location is easily achieved by a renewable energy supply and rational use of energy. Residents not only save in comparison to gas fuelled central heating but also contribute, as citizens, to cleaner air and a healthy climate in their own living environment.

Connection to district heating

Poptahof is presently provided with a district heating system, heated by a central gas fuelled boiler house. For the application of sustainable energy, the system will be renewed and fed with residual heat. In addition one apartment block will be equipped with a PV system.

The Poptahof energy workgroup has investigated the inceptive process of residual heat being channeled through the district heating system. The main pipeline for district heating feeds the area by separate roots to each of the 8 construction fields. Existing high apartment buildings are substantially refurbished, show a rational use of energy and will be supplied by renewable sustainable heat. This also applies to the planned high-rise apartment buildings that replace the current low and medium rise apartment buildings.



Poptahof lay-out