

Appropriate Heating Systems for Sustainable Solar Housing

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1. Requirements for sustainable housing

In future the main indicators for a building are the demand for *non-renewable energy carriers* and its *CO₂-emissions*. The “*Building of Tomorrow*” may be characterized by a high insulated building envelope with “passive building” standard and a low-temperature heating system with heat recovery. The remaining heat demand (below 15 kWh/(m², a)) has to be covered by *appropriate auxiliary heating system*.

Sustainable housing requires both sustainable building construction and sustainable heating systems. Therefore, the heat demand for space heating and hot water preparation have to be minimized, with a high share of renewable energy sources.

The utilization of solar energy in buildings is an important task to achieve the goals for *sustainable buildings*. The use of solar energy includes direct and indirect solar irradiation. Indirect solar energy sources like ambient heat and biomass products are possibilities to overcome the mismatch between solar irradiation and heat demand and therefore are interesting “long-term stores for solar energy” as well as auxiliary energy sources for solar housing. Today, solar systems for hot water preparation in detached, row and apartment housing have priority.

The implementation of a seasonal thermal storage in buildings with a high-insulating standard is technically possible, but it has to be considered also under economical and environmentally aspects. Experience shows that economical-technology solutions with middle-term stores in combination with renewable energy technologies, which are reliable and easy to handle, are of more importance, at least for near-term applications and commercialisation. Proved technologies are solar combined heating systems with heat pumps, bioenergy technologies and heat recovery systems. Sufficient experience and operational data already exist to achieve the goals for solar advanced (sustainable) buildings and to ensure professionally designed as well as cost-effective solutions with an optimum of performance.

2. Renewable energy sources for heating systems

Renewable energy sources include the *direct* and *indirect* use of the sustainable “solar energy” in buildings. Firstly, the direct use of solar energy is possible with “*passive*” elements (outdoor windows) and systems (winter garden, solar space, loggia, atria etc.), including thermal heat storage for absorbed solar irradiation in the building itself. With improved building materials (glass, air-collectors and/or transparent insulation) at suitable

locations a contribution to space heating can be made, which, under the meteorological conditions in cold and temperate climates, can amount - in combination with an energy-conscious use - to up to 30% of the total heating demand for space heating of a standard building; Figure 1 and Figure 2. At present the passive use of solar energy presents itself mainly for residential premises and is being more and more used in dwellings with air heating systems. In commercially used buildings solar energy has at present primarily the role of day lighting and thus the role of reducing energy for lighting: *day lighting systems*. Secondly, solar energy with its diurnal and seasonal fluctuation can be stored in *short-term, middle term* and *long-term* thermal storage, mainly in form of water tanks. For space heating purposes with a high solar share - above 80% - the integration of long-term (seasonal) storage is necessary because of the high difference between solar energy supply and heating demand during the heating season. For this type of storage economical questions are still open. In the meantime *middle-term storage* for the pre-heating season (October to December and March to May) are in operation. In spring time the heat produced by solar collectors can be transferred directly to low-temperature heating systems. Solar-assisted heating systems with an increased collector area compared to simple hot water systems have influenced the market penetration of solar thermal systems in many countries in a positive way: in Austria about 20% of solar systems installed since 1999 are used in combination with heating systems.

The indirect use of solar energy in form of *ambient heat* - utilized with the heat pump technology (Figure 3 and Figure 4) - as well as in form of locally available *bioenergy* carriers allows the use of solar energy to a high percentage also in periods when solar irradiation is not available.

Favourites for auxiliary heating solar combined heating systems are:

- heat recovery
- heat pump technologies
- advanced bioenergy technologies.

Heat recovery systems will cover the main part of the heat demand of passive housing. Nevertheless, about 15 kWh/(m², a) has to be shared by auxiliary heating; Figure 5a and b. In low-energy housing without heat recovery about 40 kWh/(m², a) have to be covered by a “conventional” heating system. New developments combine the renewable energy sources heat recovery, solar thermal, solar electric and bioenergy; Figure 6 and Figure 7.

The combination of heat recovery with renewable energy sources will reduce the requirements for passive housing: high building insulation (U-value $\leq 0,1$ W/(m², K)), high insulated windows (U-value for glass and frame $\leq 0,7$ W/(m², K)). Also natural air conditioning would be possible.

The operating comfort of biomass boilers could be improved by features of full automatic operation and a similar comfort as oil or gas fired boilers: *woodchips*- and pellets-boilers; Figure 8. Within series production of small biomass heating systems, especially pellets-boiler cost-effective products are offered on the market nowadays. Pellets offer the possibility to use wood as a fuel without any reduction of convenience in comparison to heating oil or natural gas. Pellets are transported in a tank lorry and pumped dust-free into a storage. From there, they are fed to automatically working pellet furnaces. Today, pellets boilers are fully developed in a number of options and environment-friendly in every respect. Heating with pellets is economical at the current (December 2002) price level of heating oil and natural gas.

New on the market is a storage-integrated pellets-burner. This compact system supports both high efficient use of pellets and cost-effective installation; Figure 9a and b.

3. Primary energy demand and CO₂-emissions of heating systems

Both primary energy demand and environmentally relevant CO₂-emissions of heating systems are indicators for the quality of housing.

The *space heat demand* for different advanced heating systems in detached housing is shown for cold, temperate and mild climates in Figure 10. Based on the annual efficiency of the heating systems – Figure 11 – the *fuel/electricity demand* for the heating systems are calculated in Figure 12. With the *primary energy factor* in Figure 13 the *primary energy demand* for the heating systems is shown in Figure 14. Figure 15 shows the *specific CO₂-emissions of fuels and electricity* and Figure 16 the *specific CO₂-emissions* of the different heating systems.

More information:

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Energieeffiziente Haustechniksysteme GmbH, Drexel und Weiss, Kennelbacherstraße 36, A-6900 Bregenz

www.solarfocus.at

Kalkgruber Solar- und Umwelttechnik GmbH, WerkstraÙ 1, A-4551 St. Ulrich/Steyr

ENERGY BALANCE OF A DETACHED HOUSE

Factor 4+ Standard, AUSTRIA

Heat losses
17,590 kWh/year

Heat gains
8,156 kWh/a



Ventilation
6752 kWh/Jahr 38%

Transmission
10838 kWh/Jahr 62%



Internal gain
2880 kWh/Jahr 35%

Solar gain
5276 kWh/Jahr 65%

Heat energy demand: 9,434 kWh/a (49 kWh/(m², a))
Share of solar gain: 30 %/year

Fig. 1: Heat losses and heat gains in housing



Fig. 2: Solar use in housing

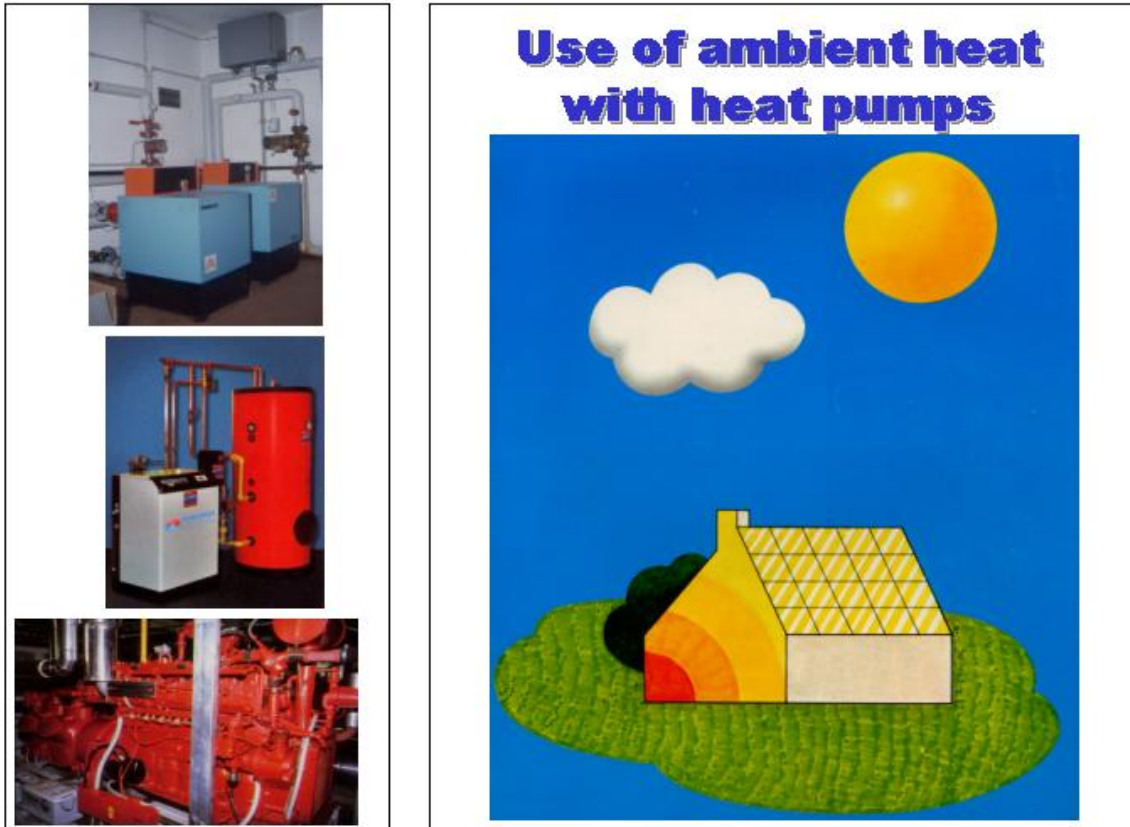


Fig. 3: Heat pump technology

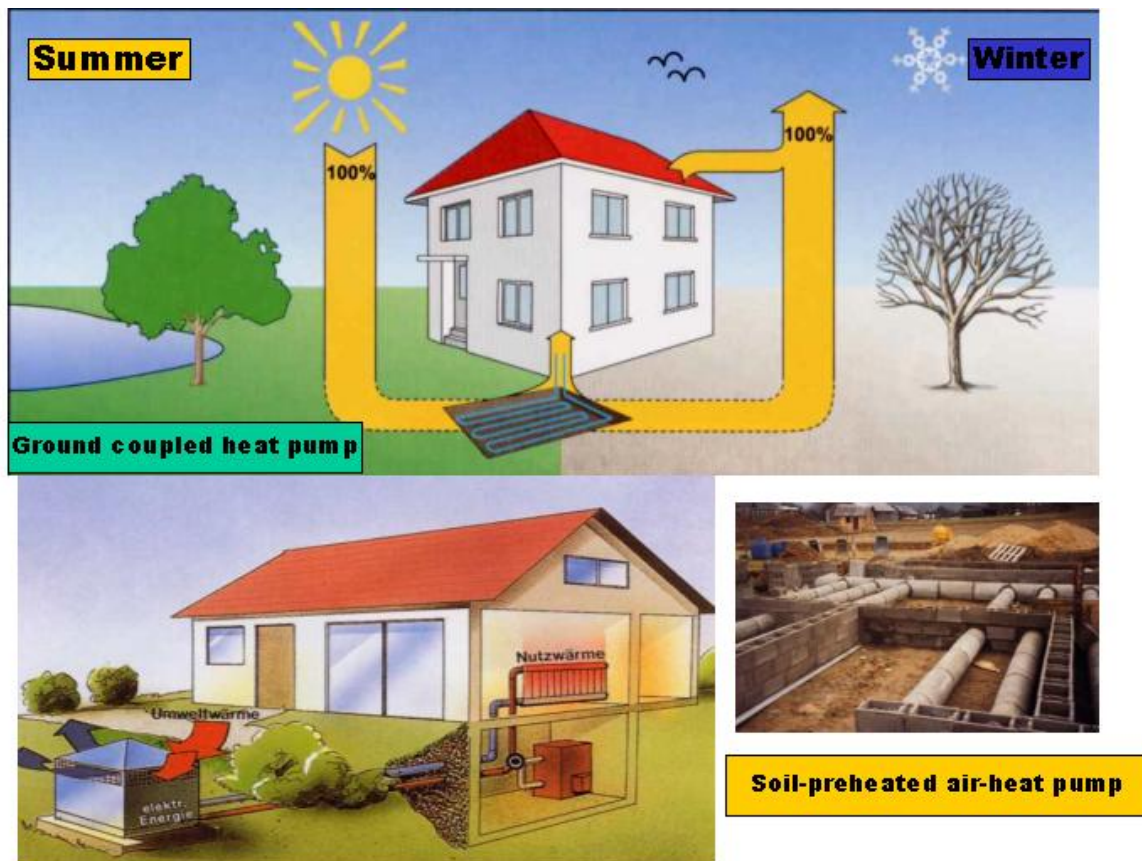


Fig. 4: Ground coupled heat pump technologies

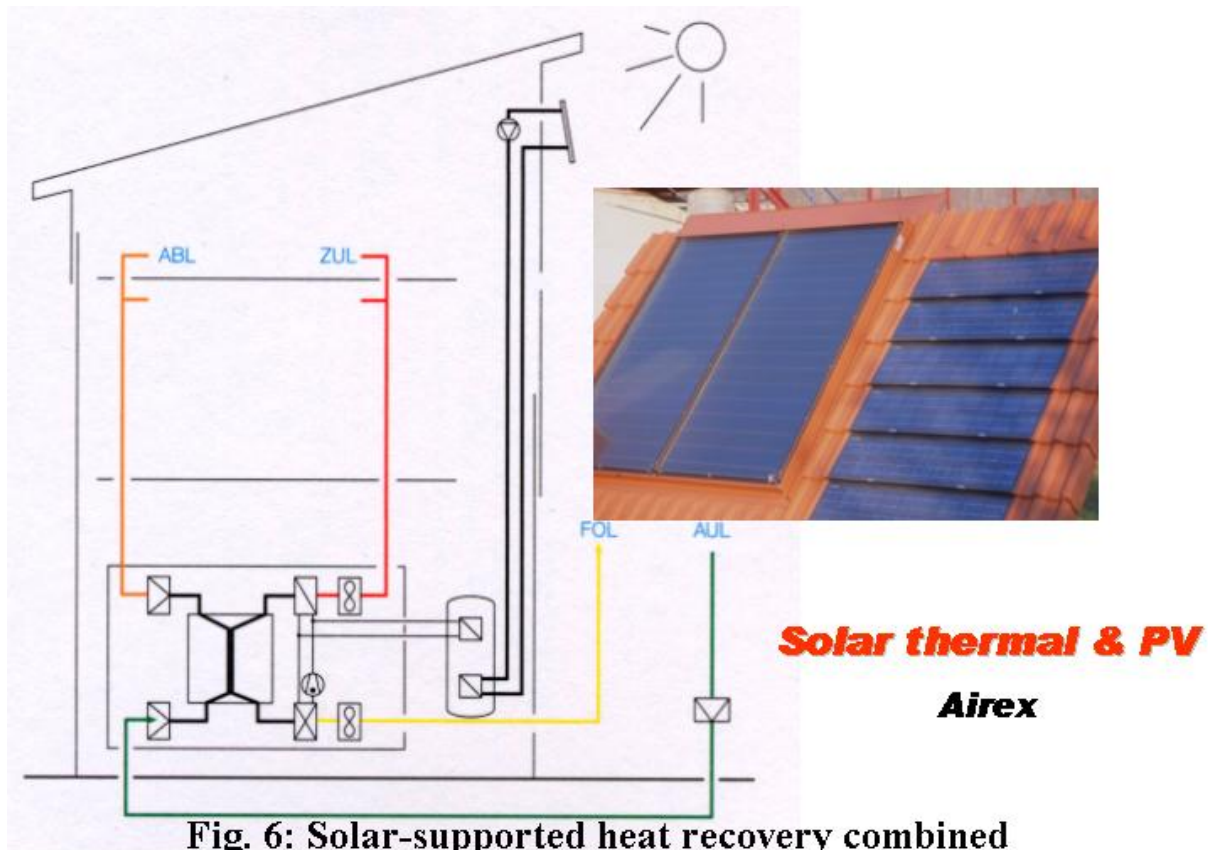


Fig. 6: Solar-supported heat recovery combined with air-heat pump

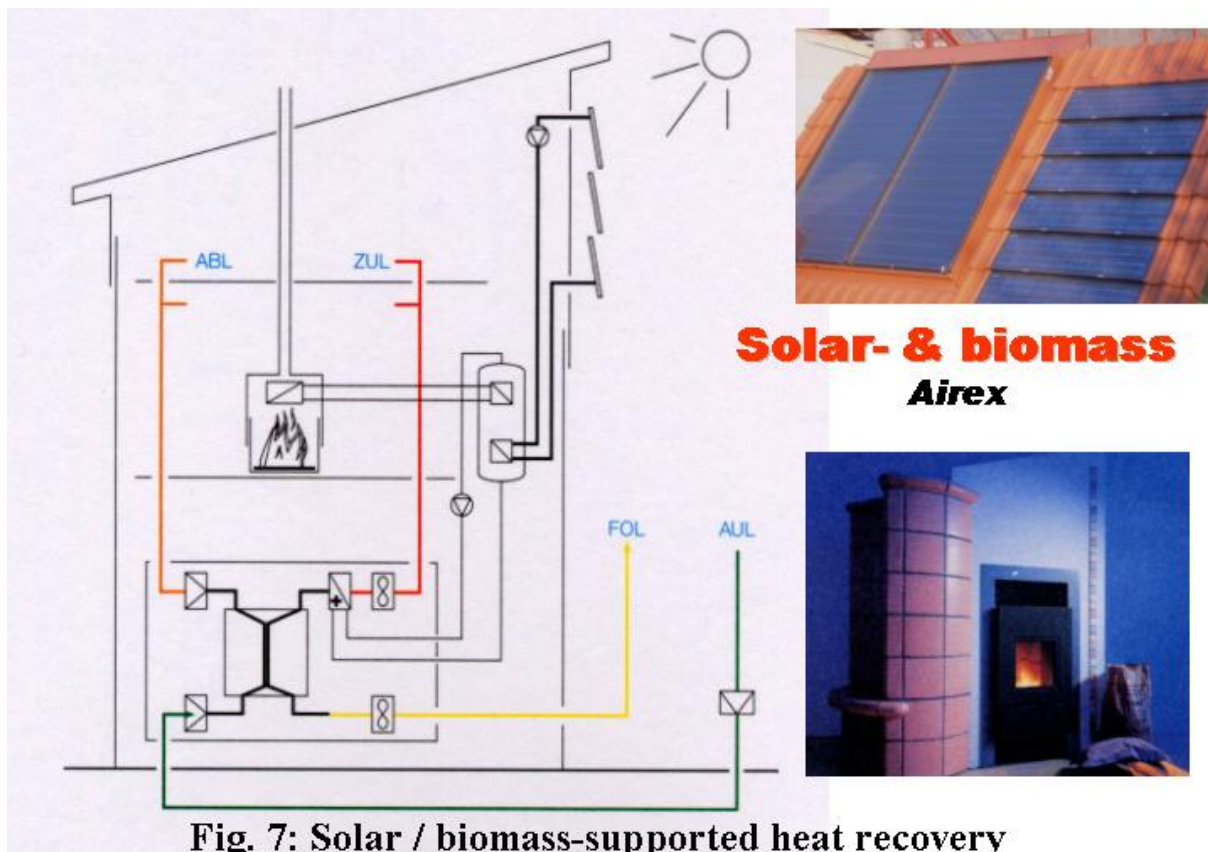


Fig. 7: Solar / biomass-supported heat recovery combined with air-heat pump



Fig. 8: Biomass heating for housing: pellets boilers



**Combined
Solar-Pellets Storage
Pellet^{plus}**

SOLARFOCUS, Austria

**Load:
3,9 kW – 14 kW**

**Storage volume:
800 litre + 60 litre**

Fig. 9a: Combined solar-pellets heating unit

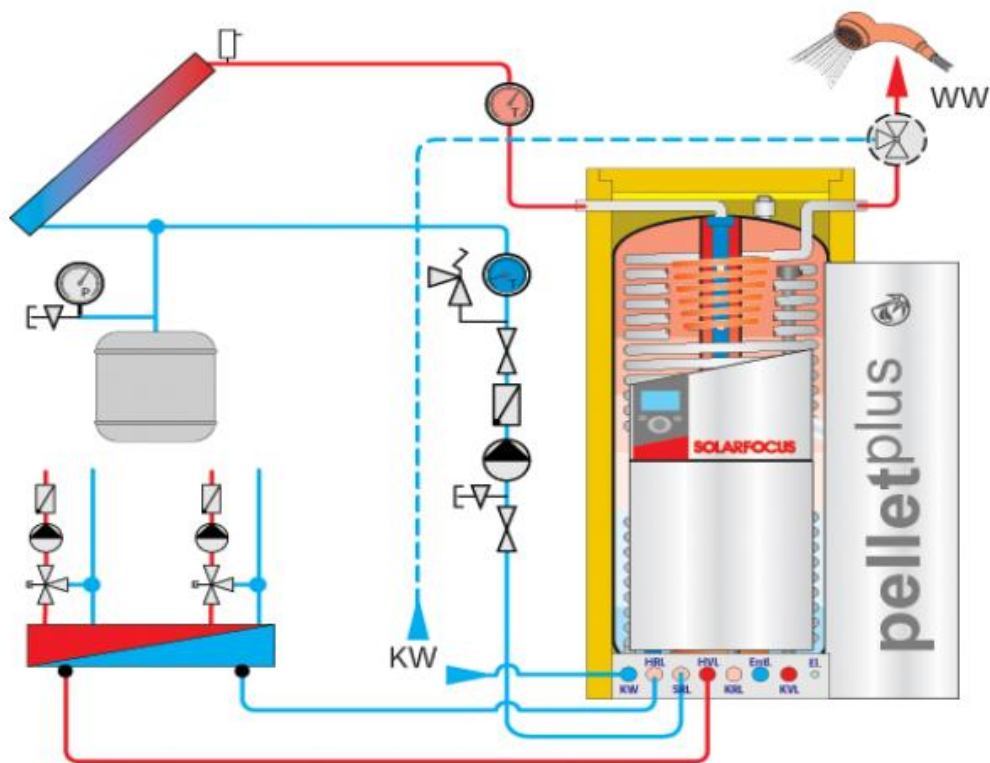
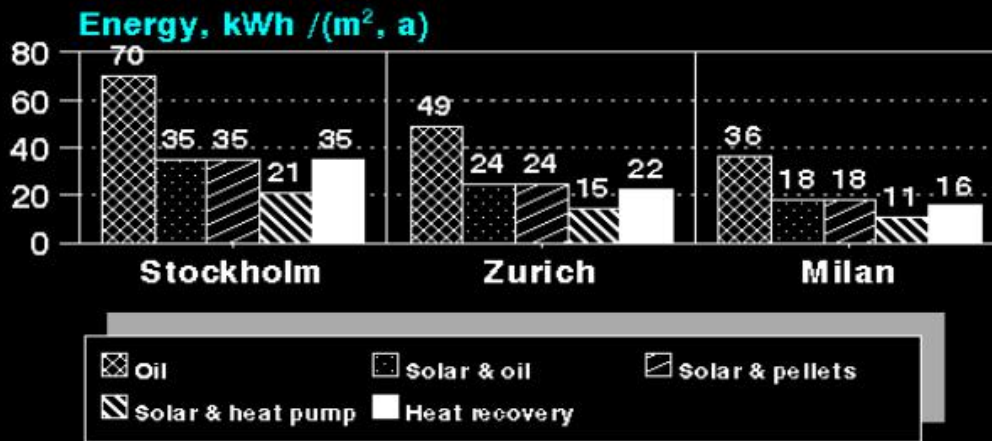


Fig. 9b: Combined solar-pellets heating system

SOLARFOCUS, Austria

HEAT DEMAND

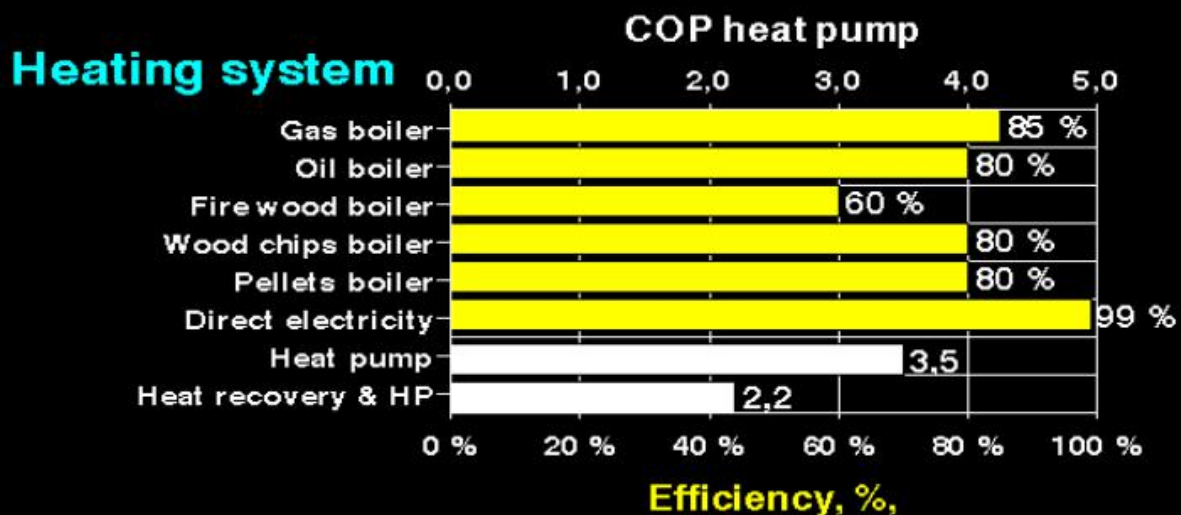
Reference detached house: Factor 4-Standard Cold, temperate and mild climates



Solar supported heating system (50% annual solar share)
Solar supported heat pump system (70% annual solar/ambient share)
Heat recovery (EN 832)

Fig. 10: Heat demand for different advanced heating systems

ANNUAL SYSTEM EFFICIENCY OF HEATING SYSTEMS

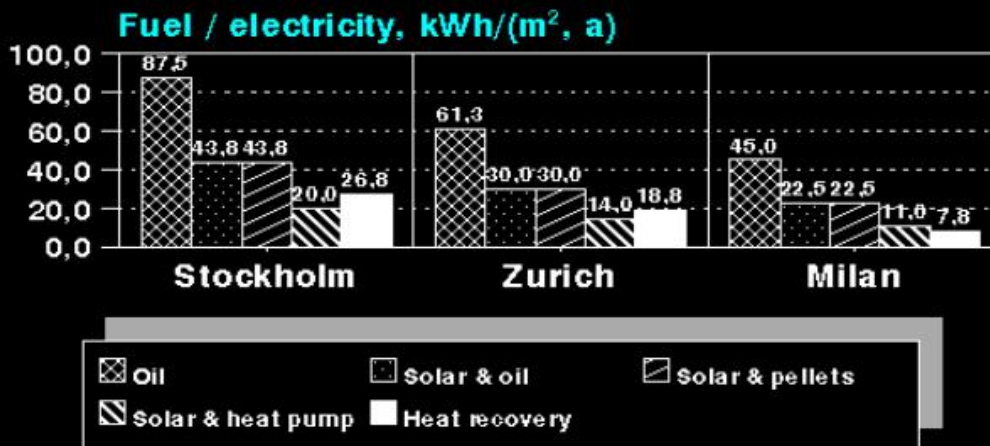


Average data from demonstration-projects
in Austria (2002)

Fig. 11: System efficiency of different advanced heating systems

FUEL / ELECTRICITY DEMAND

Reference detached house: Factor 4-Standard Cold, temperate and mild climates



Solar supported heating system (50% annual solar share)
Solar supported heat pump system (70% annual solar/ambient share)
Heat recovery (EN 832)

Fig. 12: Fuel/electricity demand for different advanced heating systems

PRIMARY ENERGY FACTORS FOR FUELS AND ELECTRICITY

EU-Standards

Fuel / Electricity

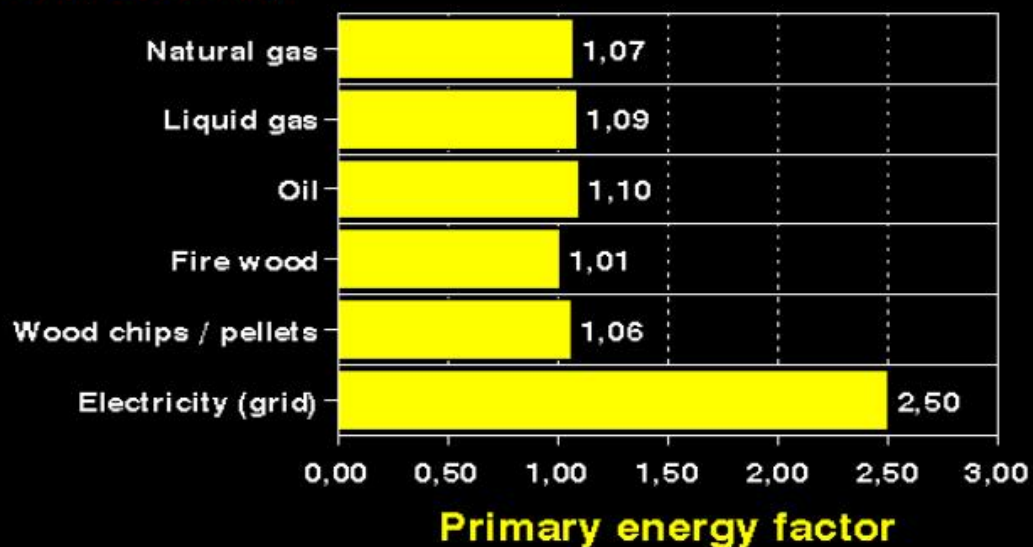


Fig. 13: Primary energy factor for fuels and electricity

PRIMARY ENERGY DEMAND

Reference detached house: Factor 4-Standard Cold, temperate and mild climates

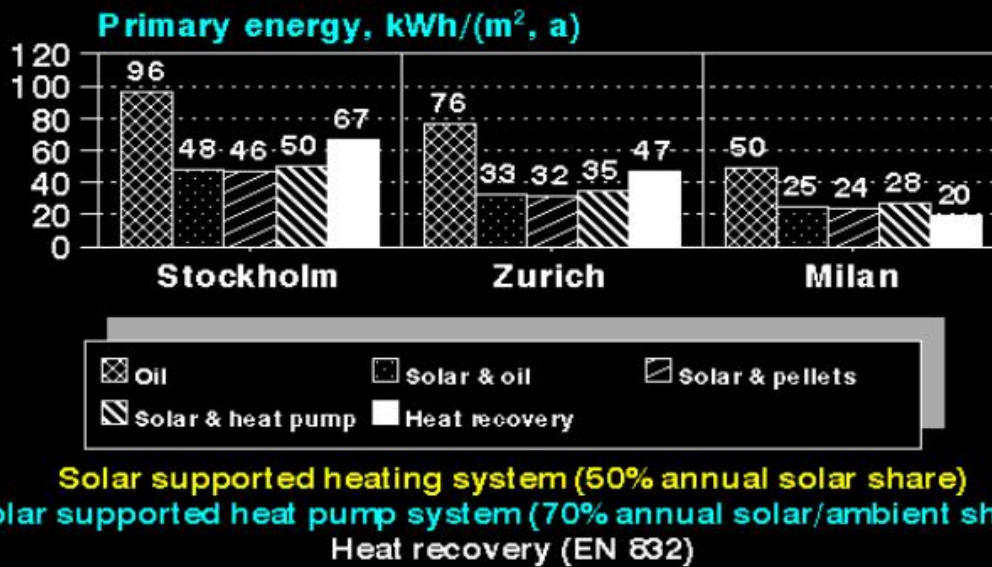


Fig. 14: Primary energy demand for different advanced heating systems

CO₂-EMISSIONS OF FUELS AND ELECTRICITY

EU-Standards

Fuel / Electricity

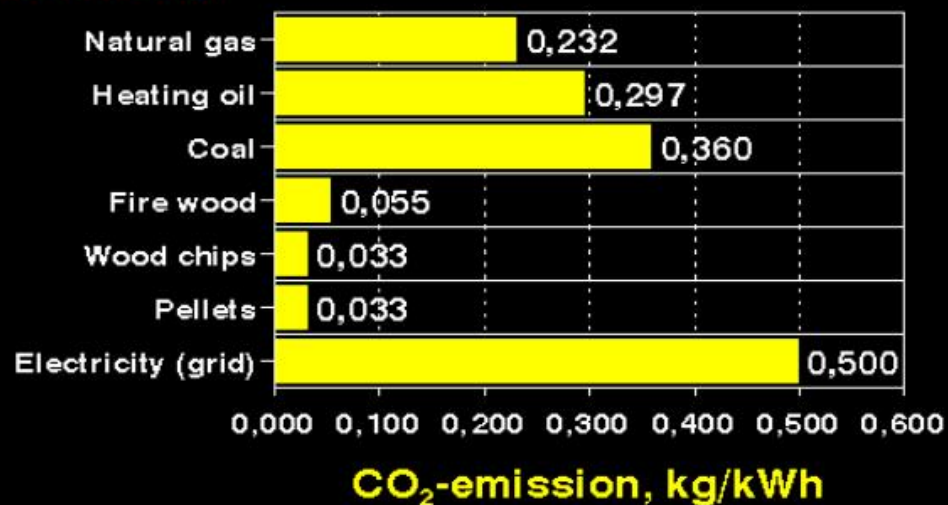
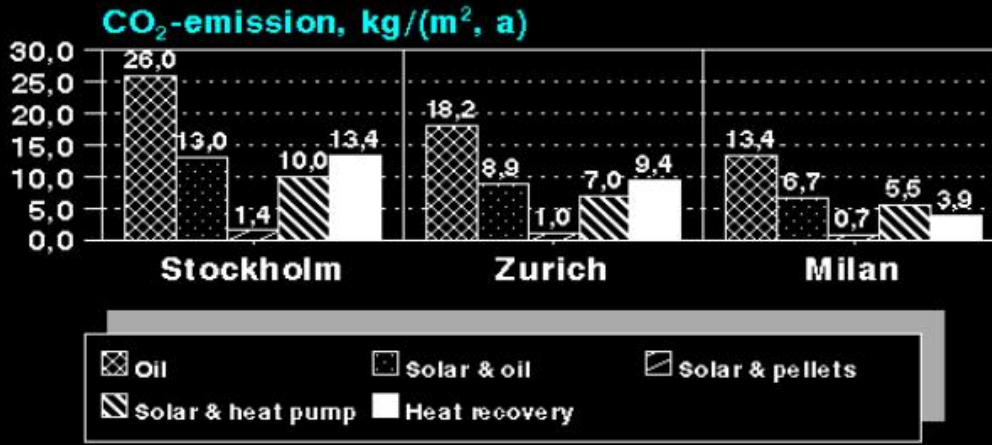


Fig. 15: CO₂-emissions of fuels and electricity

CO₂-EMISSION

Reference detached house: Factor 4-Standard Cold, temperate and mild climates



Solar supported heating system (50% annual solar share)
Solar supported heat pump system (70% annual solar/ambient share)
 Heat recovery (EN 832)

Fig. 16: CO₂-emissions of different advanced heating systems