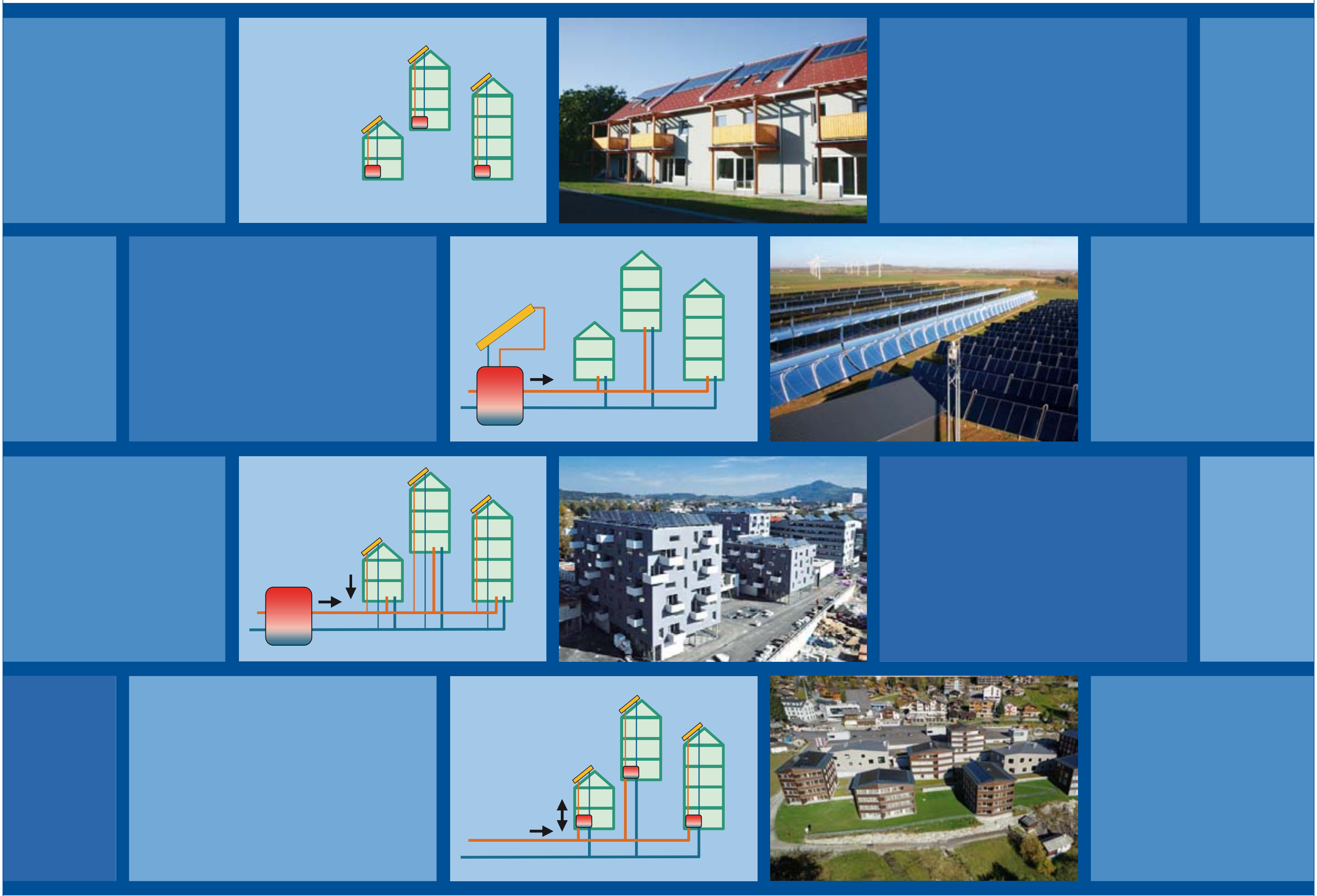
Task 52
Solar Heat and Energy Economics
in Urban Environments

SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Solar Thermal Applications



in Urban Environments

Editorial

Source: Fotohof

In the framework of **IEA SHC Task 52** the future role of solar thermal in urban energy systems is investigated.

This **leaflet** provides snapshots of seven best practice examples from Austria, Denmark, Germany, Sweden and Switzerland. The examples represent the entire range of solar thermal system configurations suitable for applications in urban environments including systems, which are hydraulically connected to a district or block heating grid, as well as systems which are directly attached to individual buildings.

A comprehensive description and analysis of the presented examples from different stakeholder perspectives is given in **Technical Report C2 - Analysis of built best practice examples and conceptual feasibility studies**.

Source: Fotohof

We hope these examples will serve as inspiration for urban actors to consider solar thermal as reliable, efficient and eco-friendly technology that meets future low-carbon-economy requirements.

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Solar district heating with seasonal

Pit heat storage in Dronninglund with the solar thermal collector field seen in the back (Source: Dronninglund Fjernvarme A.m.b.A)

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District heating has a long tradition in Denmark and is the most common heating technology in the residential sector today. For several years already, large-scale solar thermal installations attached to existing district heating grids are on the rise all over the country. These solar district heating plants typically provide 5–20% of the annual district heating demand by solar thermal. For load balancing either existing district heating storages are utilized or additional short-term (diurnal) solar energy storages are installed.

The Dronninglund system in Northern Denmark represents an evolutionary step in large-scale solar district heating, **covering around half of the annual district heating demand by solar thermal energy without increas-**

storage in the city of Dronninglund, DK

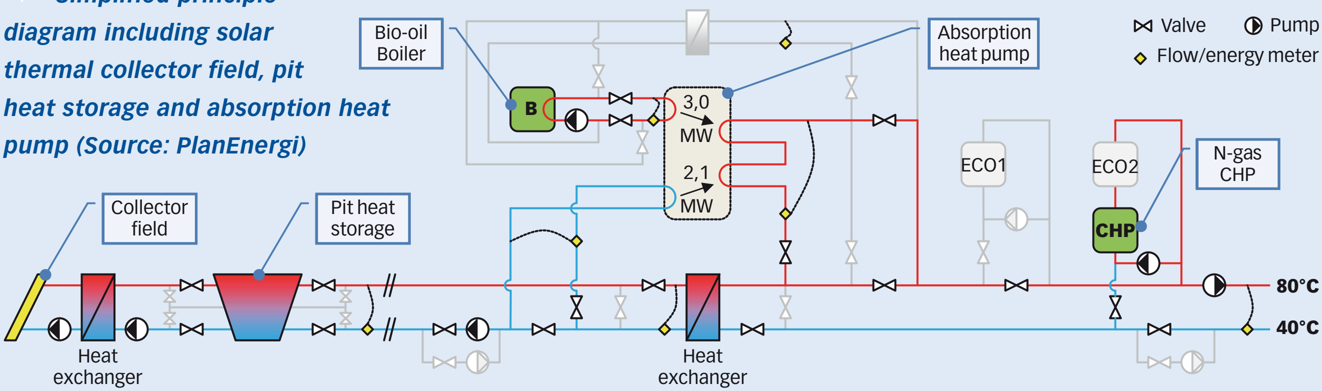
ing end-consumer cost for heat. Technically, this is achieved by combining large-scale solar thermal with seasonal pit heat storage and MW-scale heat pump with the existing district heating infrastructure.

Due to uncertain price developments of natural gas and biomass the board of Dronninglund district heating initiated "SUN- STORE 3" project in 2008 with the objective to design, optimize and implement a full-scale solar district heating plant that is able to cover around half of the heat demand. The project ended up with the inauguration of a 40,466 m² flat plate collector field hydraulically connected to a 62,000 m³ pit heat storage as well as to an absorption heat pump (2.1 $MW_{cooling}$) in 2014.

By end of 2016, the district heating utility supplied around 1,350 consumers via 46 km of district heating network. In the period 06/2015–05/2016 48% of the annual district heating output originated from solar thermal.

Aerial view on the solar district heating system of Dronninglund Fjernvarme (Source: Brønderslev Municipality)

Simplified principle diagram including solar thermal collector field, pit heat storage and absorption heat pump (Source: PlanEnergi)



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Hybrid solar district heating

Aerial view on the hybrid solar district heating system in the city of Taars, DK (Source: Aalborg CSP)

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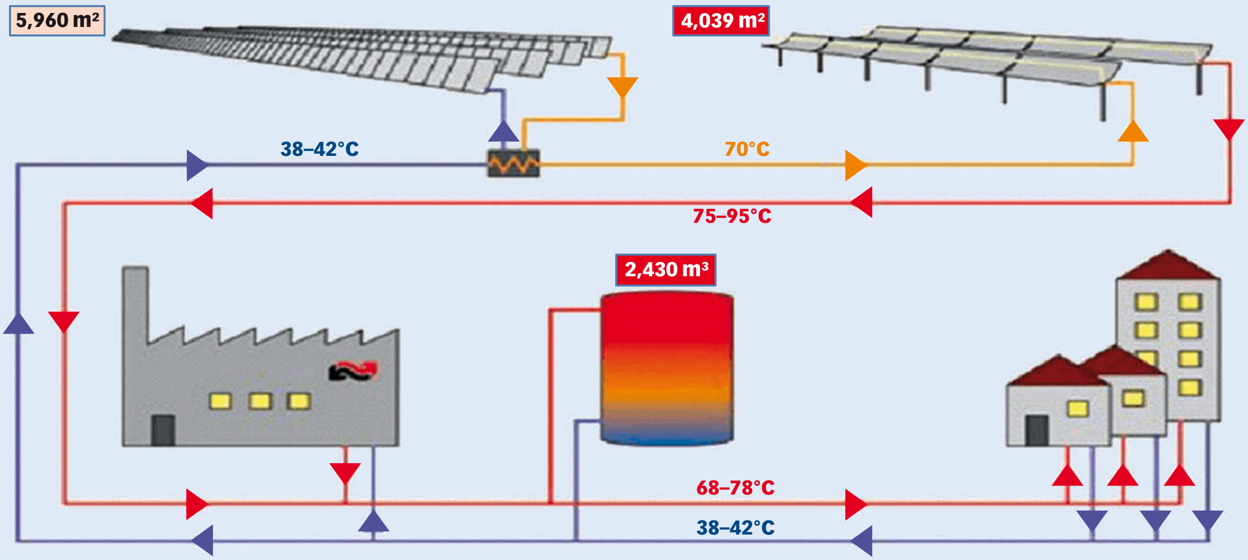
Taars district heating is situated in northern Denmark and was established in 1960 as a consumer-owned cooperative with limited liability. Since the early 1990s heat generation is based on natural gas based boilers and CHP units and is supplemented by two thermal energy storage tanks with 2,215 m^3 each. Based on economic and security of supply considerations it was decided by the board of Taars district heating in 2014 to substitute a significant share of natural gas (approximately 30%) by solar thermal.

Together with a local turnkey solar thermal system provider a novel solar district heating concept based on the combination of concentrating parabolic trough collectors and flat plate collectors was developed. The idea behind this is to first use the flat plate collectors at lower temperatures to preheat the district heating return flow and boost the temperature up to 95°C in the parabolic trough collectors afterwards. As an added value, tracking of the parabolic trough collectors enable automated stagnation management and accurate temperature control.

By the end of 2016, the district heating utility supplied around 850 consumers via the 13 km of district heating network. In the period 09/2015–08/2016 solar thermal provided a share of 26% of the entire district heating output of the utility.

Opening of the Taars solar thermal system (Source: Aalborg CSP)

Simplified principle diagram of the Taars hybrid solar district heating system (Source: Aalborg CSP)



Solar-assisted urban quarter

Aerial view on northern part of the urban quarter "Stadtwerk Lehen" (Source: AEE INTEC)

From 2011 to 2016, a new residential area with a total of 287 dwellings in nine buildings as well as a student dormitory and a kindergarten were built in the Salzburg district of Lehen, Austria. The two- to eight-storey buildings meet the lowest energy building standards and are equipped with air ventilation with heat recovery. Moreover, several new low-energy buildings for commercial use were erected and an existing 10-storey office building was renovated. Total area comprises a heated gross floor area of 48,650 m².

For heat supply, all buildings are connected to a low-temperature (65/35°C) heating grid that serves a 2-pipe building distribution network with local heat transfer stations for space heating and domestic hot water. In the period 08/2013–07/2014 total thermal energy consumption (including 10% distribution losses) amounted to 3,975 MWh. Solar fraction was 25% (989 MWh).

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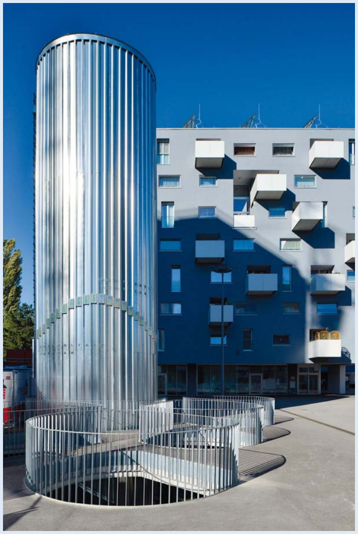
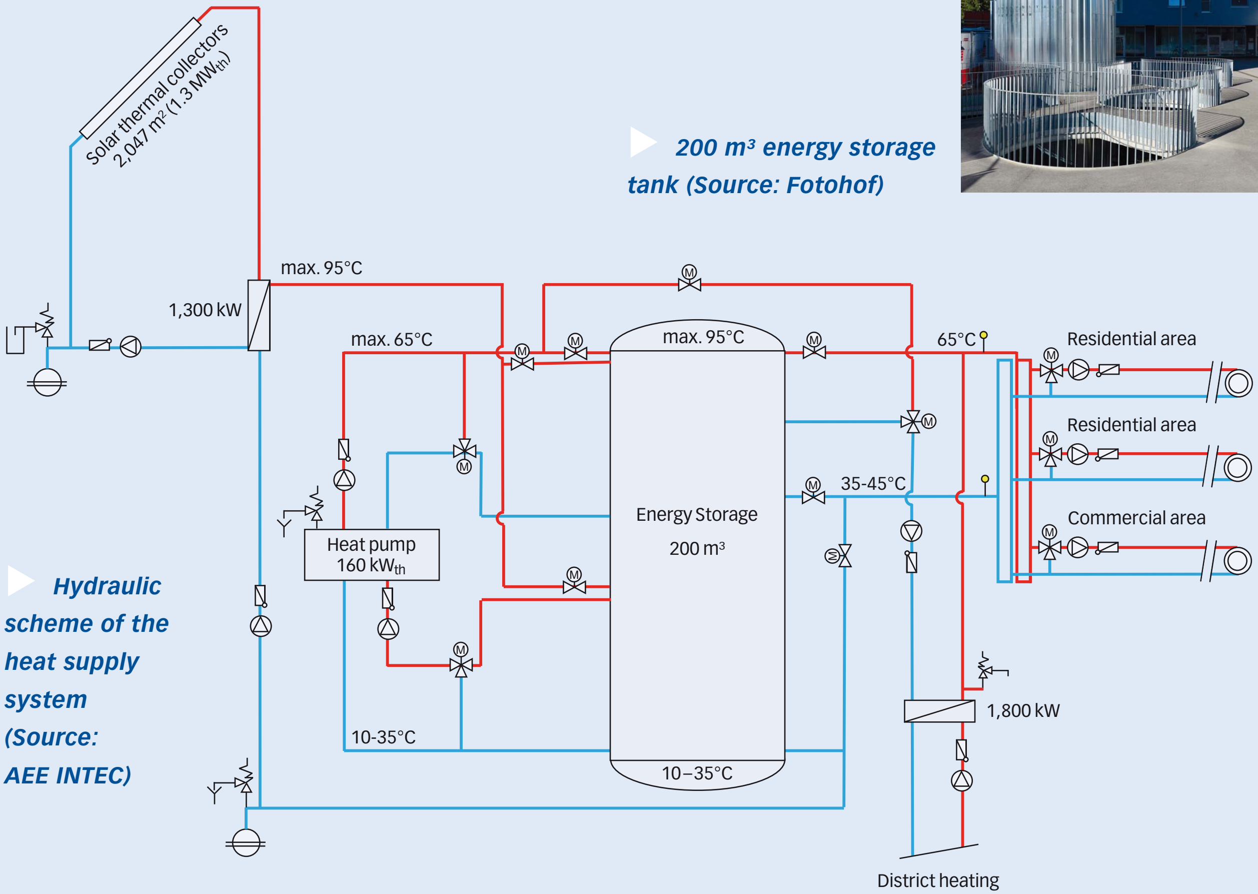
In sum, 2,048 m² flat plate collectors are split into 13 roof-mounted collector fields and feed into a 200 m³ central energy storage. Additionally, a compression heat pump is hydraulically connected to the storage utilizing the lower part as heat source while charging the upper part. District heating serves as the auxiliary heating system and backup.

Heat pump operation enables temperatures down to 10°C in the lower storage part, which **increases storage capacity and solar yields and decreases thermal losses**.

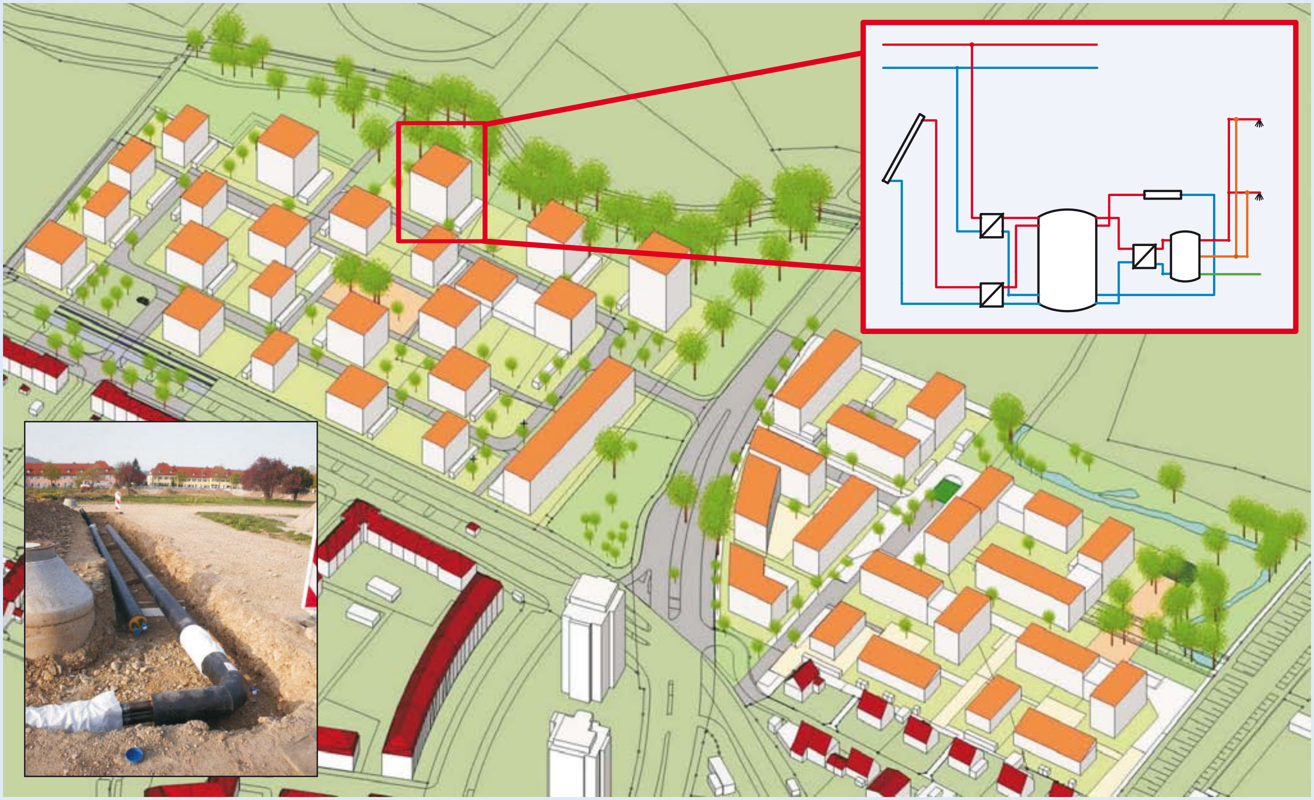


200 m³ energy storage tank (Source: Fotohof)



Hydraulic scheme of the heat supply system (Source: AEE INTEC)

Solar-assisted urban quarter



▲ ***Development area Gutleutmatten including hydraulic scheme of a bi-directional building sub-station (Source: Fraunhofer ISE, city planning office Freiburg i. Br., BadenovaWärmePlus)***

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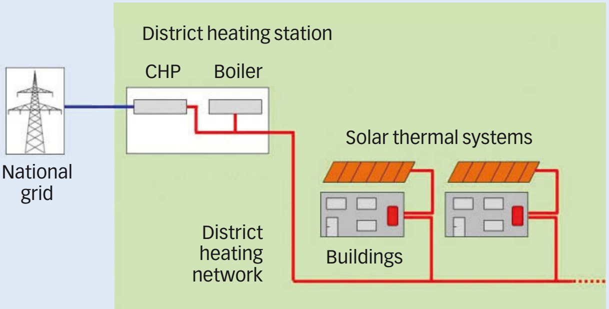
“Gutleutmatten” is a development in the German city of Freiburg where 500 households with approximately 40,000 m² heated floor area are being constructed between 2013 and 2018.

The entire building stock meets German low-energy building standard *“KfW-Effizienzhaus 55”*. Projected total building thermal energy demand sums up to 2,600 MWh/a and is supplied by natural gas fired district heating (75%) and distributed solar thermal (25%). In sum, 2,220 m² solar

"Freiburg-Gutleutmatten", DE

thermal collectors are split into 38 roof-mounted collector fields and feed thermal energy storages in the building basements (177 m³).

The hydraulic design enables bi-directional feed-in, meaning that solar thermal may charge the storage tank for direct building heat supply as well as feed back into the heating network as well. A sophisticated control scheme allows for the **exchange of (solar thermal) energy between the single building substations on demand**.



Schematic diagram on the integration of distributed solar thermal systems and storages into the district heating network (Source: Fraunhofer ISE)

View of the eastern part of the urban quarter "Gutleutmatten" (Source: Fraunhofer ISE)

View of the collector array of the largest plant in the urban quarter "Gutleutmatten" (Source: Fraunhofer ISE)

Solar-assisted residential area

Aerial view onto the "Vallda Heberg" residential area, Kungsbacka, SE (Source: Eksta Bostads AB)

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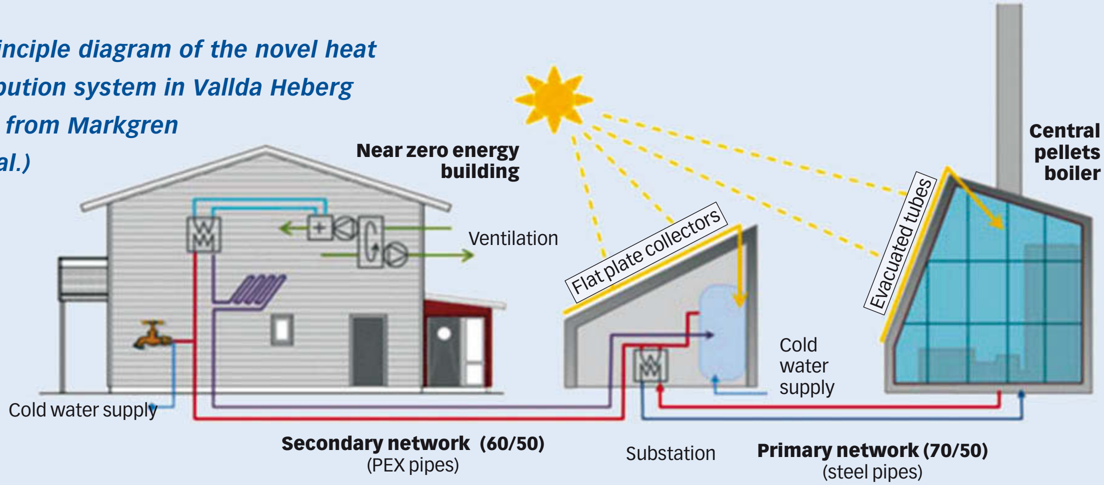
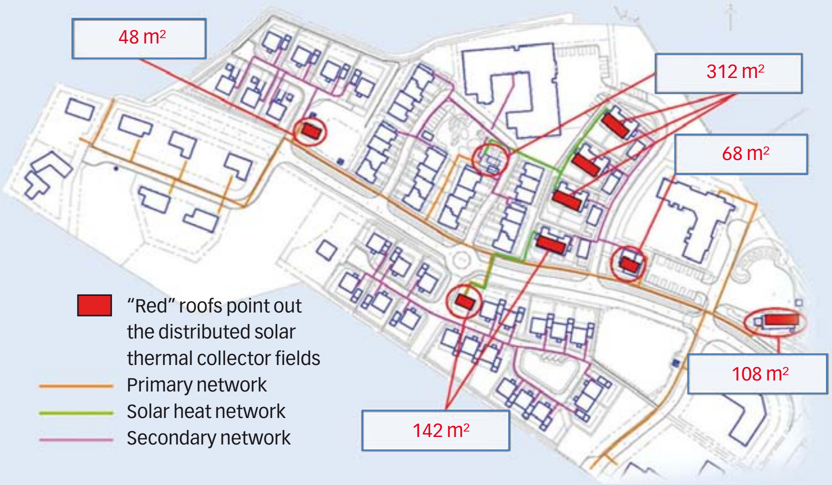
Vallda Heberg is a newly built residential area in the suburbs of Kungsbacka, Sweden. Between 2011 and 2016, 128 residential units with a total of 14,000 m² of heated floor area were built following Swedish passive house standards. Useful building thermal energy demand of approximately 620 MWh/a is designed to be met solely by renewables (60% biomass, 40% solar thermal). **Costs for the advanced heat supply system amounted to around 1% of the overall project costs**, which proved

“Vallda Heberg” in Kungsbacka, SE

Simplified principle diagram of the novel heat supply and distribution system in Vallda Heberg (Source: Adapted from Markgren Arkitektur AB et al.)



to have irrelevant impact on the residential sales market. The heat distribution system divides into a steel piping primary network (70°C/50°C) fed by a pellets boiler and evacuated tube collectors and an inexpensive secondary pipe network (60°C/50°C) made of plastic. Primary and secondary networks are hydraulically coupled in four substations that also provide space for flat plate collectors on the roof as well as for the storage tanks. Evacuated tube collectors are installed at the central boiler house with steeper inclination angles for optimized solar yields in winter and reduced overheating in summer.



Schematic showing the heat distribution network in Vallda Heberg

Solar-assisted mountain holiday

Aerial view on the "Reka Feriendorf" in Naters, Switzerland (Source: Lauber IWISA AG)

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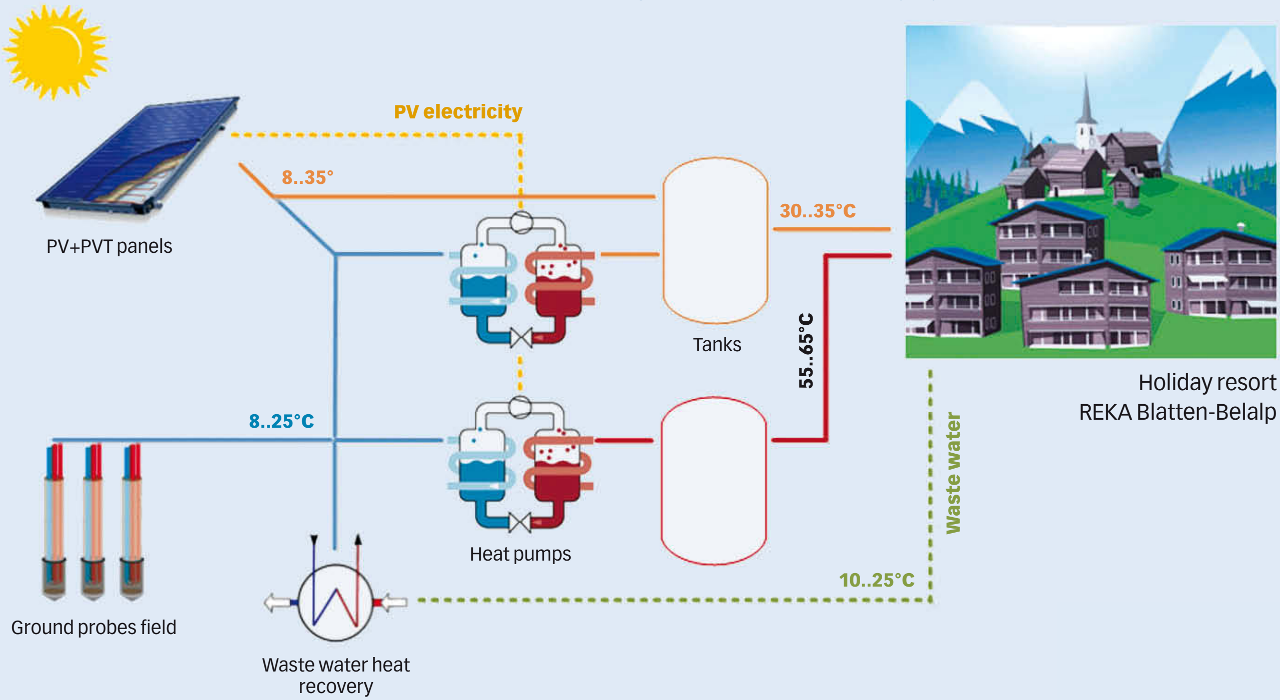
"Reka Feriendorf" is a holiday resort located 1,300 meters above sea level in Kanton Wallis, Switzerland and was inaugurated in winter 2014. The resort comprises 50 apartments, an indoor pool as well as a childcare infrastructure and offices. Total heated floor area amounts to 6,650 m^2 and thermal energy demand is 660 MWh/year. The high-quality buildings are equipped with heat pumps, PVT collectors as well as PV panels. On an annual basis, about 67% of the thermal energy and 48% of the electrical energy is provided on site.

resort "Reka Feriendorf" in Naters, CH

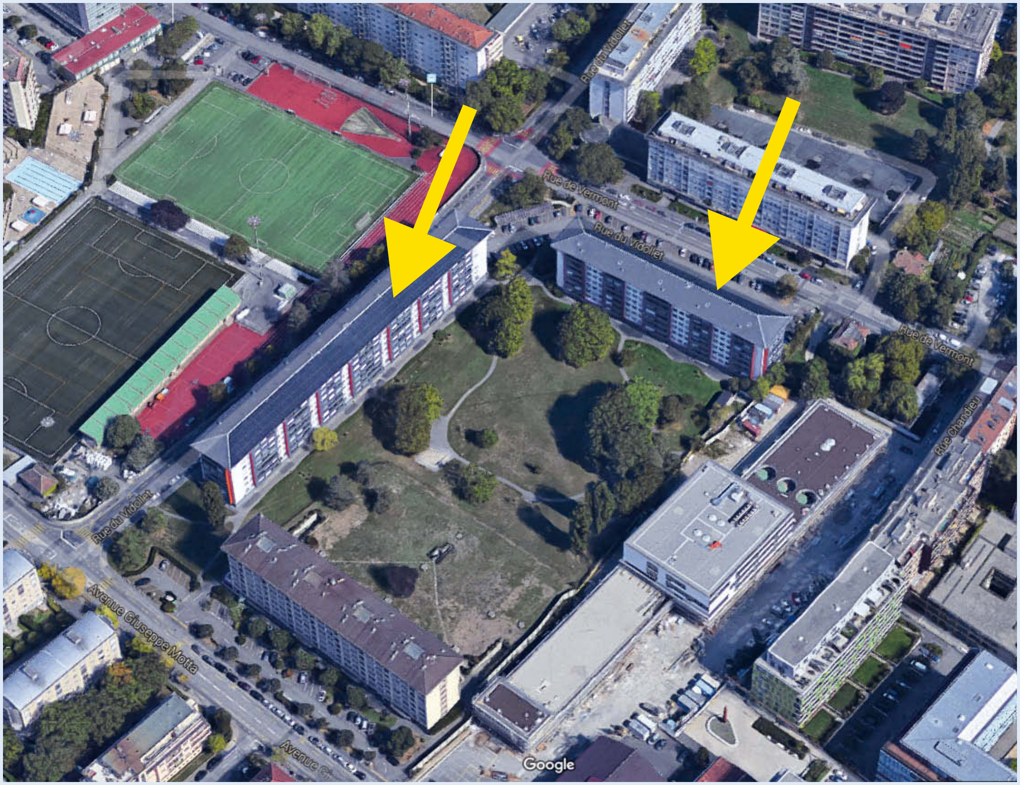
The energy supply concept consists of two separate networks. The first is a low temperature network (30–35°C) dedicated to heating. The second is a high temperature network (55–65°C) for domestic hot water. One central heat pump is installed for each network in order to produce the required temperature level. Furthermore, a seasonal borehole thermal energy storage is used in summer to store excess solar thermal generated heat. In the heating season, the storage is utilized as heat source for heat pump operation. A waste water heat recovery system is installed as additional heat source for heat pump operation.

▲ *Solar roofs at a glance (Source: Lauber IWISA AG)*

▼ *Schematic diagram of the heat supply system (Source: Reka AG 2015)*



Solar assisted apartment blocks



"La Cigal" apartment blocks after renovation in Geneva, Switzerland. Arrows indicate the solar thermal collector fields. (Source: Google Earth)

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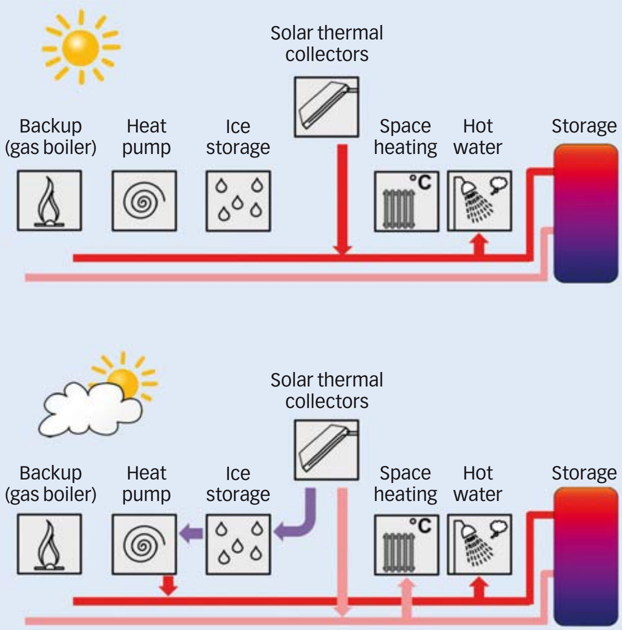
'La Cigale' is a housing cooperative established in 1952 in Geneva, Switzerland comprising 273 apartments with a heated floor area of approximately 19,000 m². Between 2013 and 2014, full renovation of the building envelope with modernization of the heating system was realized. The overall project achieved very ambitious goals: Building refurbishment decreases thermal energy demand by 70% (building complex meets low energy standards today) and moreover, **65% of the building's final thermal energy demand is covered by 1,740 m² roof-integrated un-**

“La Cigale” in Geneva, CH

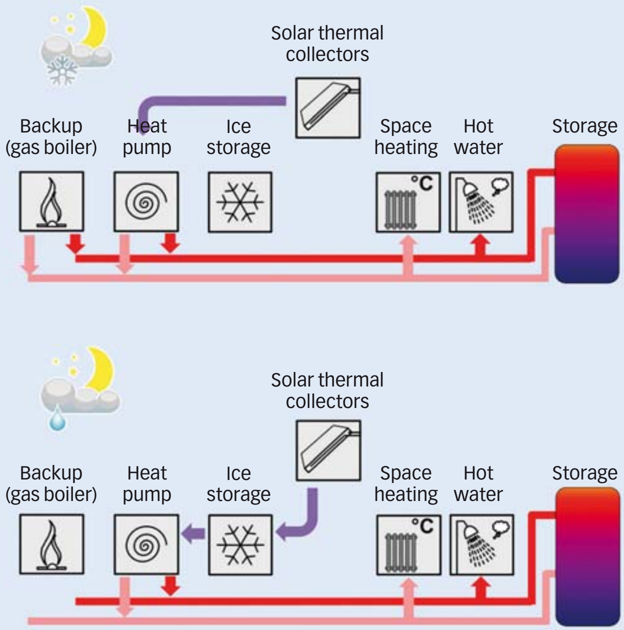
glazed water collectors. This high solar fraction is achieved by means of a heat supply concept that combines compression heat pump, latent heat storage (water/ice) and solar thermal in a very smart way.

Depending on the season of the year space heating and domestic hot water preparation is either provided by solar thermal only or a combination of solar thermal with heat pump operation including charging / discharging of the ice storage is applied. A small natural gas source provides peak and backup capacity.

Schematic diagram “La Cigal” warm season (Source: ENERGIE SOLAIRE S.A.)



Schematic diagram “La Cigal” cold season (Source: ENERGIE SOLAIRE S.A.)



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About IEA Solar Heating and Cooling Programme

The Solar Heating and Cooling Programme was founded in 1977 as one of the first multilateral technology initiatives („Implementing Agreements“) of the International Energy Agency. The member countries of the Programme collaborate on projects (referred to as "Tasks") in the field of research, development, demonstration (RD&D), and test methods for solar thermal energy and solar buildings.

IEA SHC Task 52
task52.iea-shc.org/

Task 52
Solar Heat and Energy Economics in Urban Environments

In the framework of **IEA SHC Task 52** the future role of solar thermal in urban energy systems is investigated.

Subtask A – Energy Scenarios
Leader: Aalborg University, DK

Subtask B – Methodology, Tools & Case Studies
Leader: Sorane SA, CH

Subtask C – Technology and Demonstrators
Leader: AEE INTEC, AT

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