TramStore21 Report

Building sustainable and efficient tram depots for cities in the 21st century

Solar Thermal Systems

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Contacts – TramStore21 partners

This is a list of experts on this issue, within five TramStore21 partnership organisations. You may contact each person directly to get expert feedback.

Name	Organisation	Function or Department	Email	Telephone
Kathrin Hesse	Fraunhofer IML	Department of Logistics, Section of Environment	Kathrin.Hesse@ iml.fraunhofer.de	+49 231 9743 364
Joseph Dörmann	Fraunhofer IML	Department of Logistics, Section of Construction	joseph.doermann@ iml.fraunhofer.de	+49 231 9743 377
Lionel Thiébault	STIB	Energy and HQE officer, Infrastructures	thiebaultl@ stib.irisnet.be	+32 2 563 71 35
Koos Spindler	RET/ Spindler Design to Build		spindler@ designtobuild.nl	+31 651 24 94 67
Rem de Tender	RET	Beverwaard officer	remdetender@ret.nl	+31 10 447 5541
Phil Nixon	Blackpool Council	Senior Project Manager	phil.nixon@ blackpool.gov.uk	+44 1253 476072
Olivier Henry	Grand Dijon	Société d'Economie Mixte d'Aménagement de l'Agglomération Dijonnaise	ohenry@ semaad.com	+33 3 80 72 90 56
Sophie Mirlicourtois	Grand Dijon/ CSD Ingénieurs	Ingénieur d'études – Environnement et Construction	S.Mirlicourtois@ csdingenieurs.fr	+33 4 72 76 06 90

Introduction

The incidence of radiation energy on the continents by the sun amounts to upto 219,000,000 billion kWh per year. This corresponds to the 2500-fold of the present world energy demand.[1]

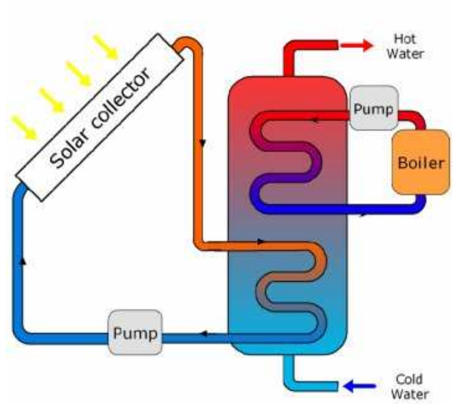

Figure 1: Solar Thermal System[2]

A solar thermal system converts sunlight into heat and consists of the following components:

- collector
- storage technology (e.g. boiler, combined storage)
- solar regulator system (e.g. temperature difference control)

The key element of solar thermal system is the solar thermal collector, which absorbs solar radiation. The purpose of the collector is to convert the sunlight very efficiently into heat. Solar heat is transmitted to a fluid, which transports the heat to the heat exchanger via pumps with a minimum of heat loss. The exchanger transfers the heat into the domestic hot water store. The distance between collector and storage tank should be as short as possible to minimise heat loss. There are two solar thermal systems:

- solar heating system to produce hot domestic water

[1] AEE- Institut für Nachhaltige Technoloien; Gottfried Purkarthofer, Technologieportrait Solarthermie
[2] http://www.crem-ltd.com/images/image011.jpg (last visited 07-03-2012)

- solar power system as supplementary heating

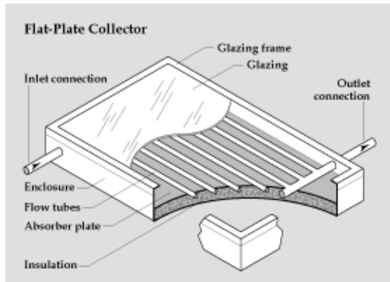

Figure 2: Flat-plate-collector[3]

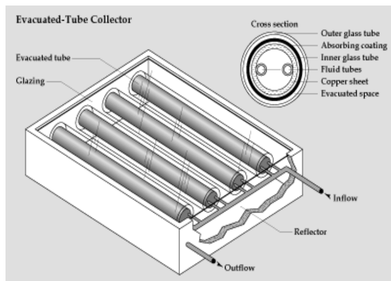

Figure 3: Evacuated-tube-collector[4]

Two main types of solar thermal collectors are available: the evacuated-tube collector and the flat-plate collector. An evacuated-tube collector is made of parallel glass tubes. Each tube contains two glass tubes: the outer glass tube and the inner glass tube. Between the two glass tubes there is a vacuum which allows small heat loss. The absorber is included in a tube. The flat-plate collector consists of an insulated (bottom and side) box with a glass or plastic cover on the top and a solar absorber located at the bottom. Almost 90% of all collectors in Germany are flat-plate collectors.

Table 1: Comparison of evacuated-tube and flat-plate collector

Evacuated-Tube Collector	Flat-Plate Collector
Very expensive	Price below evacuated-tube collector
Air is evacuated → elimination of heat loss	Air is not evacuated → heat loss
Can achieve high temperatures (77-177℃ (170-350℉)) → high efficiency	Lower temperature can be achieved (30-70℃ (86-158℉))

3 http://www.daviddarling.info/encyclopedia/F/AE_flat_plate_solar_thermal_collector.html (last visited 07-03-2012)
4 http://www.daviddarling.info/encyclopedia/E/AE_evacuated_tube_collector.html (last visited 07-03-2012)

For cloudy and freezing climates	Simple construction

About 2.1 million square meters of collector space have recently been installed in Germany (2008). The total collector area in Germany is about 11.3 million square metres (end of 2008). The total capacity amount is 7.9 giga watt in Germany (end of 2008) whereof 1.470 mega watt were the capacity of newly installed collectors in 2008. Our current research shows that projects of solar thermal energy are being realised mainly in the private sector. The activities of the commercial sector focus on potential analysis and studies in particular.

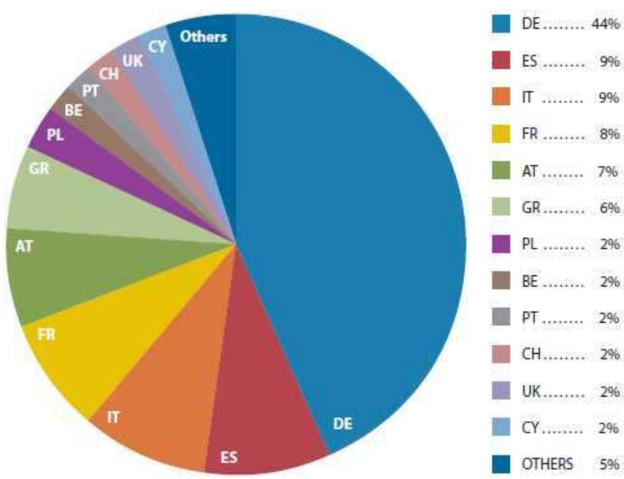

Figure 4: Share of the EU solar thermal market 2008[5]

In the light of climate change and rising gas and oil prices, the solar thermal market in the EU and Switzerland had a growth by 60% to 3.3 GW_{th} of new capacity, i.e. 4.75 million m^2 of collector area in 2008. In Germany the demand for solar thermal technology has more than doubled and has also grown strongly in smaller markets.[5]

[5] Solar Thermal Markets in Europe - Trends and Market Statistics 2008 (ESTIF), May 2009

Applications by partners

Blackpool Council

Remarks

Solar heating
The detrimental issues surrounding roof mounted photovoltaic panels also apply to the provision of solar heating installations in that the high winds containing salt spray and abrasive sand would both impair the efficiency of the units and reduce their lifespan. This would make this potential sustainable energy provider an unfavourable option at Starr Gate tram depot, as it would greatly increase the payback period for such an installation.

Grand DIJON

Description

Justification of choice for this project

The following elements of the project of Grand Dijon made it possible to retain the choice of solar collectors for the production of sanitary warm water:

- the need for sanitary warm water is constant throughout the year
- available surface allows the installation of solar panels, directed and inclined in a optimal way
- reduction of fossil energy consumption by solar energy utilisation

Presentation of installation

The production of sanitary warm water for the workshop buildings is guaranteed by solar collectors installed on the roof coupled to the gas generator with a suction cup. The main features of the thermal solar installation are as follows:

- entire surface installed: 9,2 square metres
- number of collectors: 4
- collector type: Vitosol 200F by VIESSMANN (or a technical equivalent)
- orientation: south
- inclination: 35°
- solar tank: 500l, type VITOCELL 100-V CVA by VIESSMANN
- auxiliary tank: 230l tank with gas and a horizontal suction cup
- TURBO type SANIGAZ 230-18 by Atlantic-Guillot

The simulations of solar production of sanitary warm water allowed the design of this installation and provided the following results:

- cover rate of needs: 50%
- annual productivity: 533 kWh/square metre
- 150 kg to 250 kg equivalent CO_2 avoided by the collector per square metre and year

Operation and guarantees

A SGR, “Solar Guarantee of Results”, is being carried out. SGR results in a collaboration of technical operators of the project: the manufacturer of solar collectors, the fitter and owner assisted by their technical engineers. They jointly guarantee a minimum level of annual supply of thermal kWh of solar origin for 3 to 5 years. During this period, the real production of the installation must be at least 90% of the calculated production. If this agreement is not respected, a compensatory allowance has to be paid to the customer.

The solar installation is equipped with a device that allows remote monitoring which makes the counting of monthly solar energy possible. This possibility of constantly supervising the performance of the installation was an obligation. The solar installation is thus provided with a tele-controller connected to the phone network, which immediately informs the person in charge of operation failures or faulty devices during the installation.

Maintenance

The maintenance happens periodically (two visits per year) and continuously helps to extend the life span of the equipment.

Figure 5: Installation of solar collectors

Key figures

The following check-ups need to be done when examining the equipment:

SOLAR COLLECTORS

- general visual monitoring of the collectors (broken windows, deterioration of joints or insulation) and cleaning
- control purging of the collectors
- controlling the temperature of each battery exit of the collectors

- checking the position of the balancing valves

TECHNICAL PREMISE:

- pressure of the primary education circuit to complement antifreeze
- operation of the relief valve of primary education circuit
- statements about the temperature of the exchanger and (X) balloon (S)
- measure of differential pressure of primary education circulator
- operation of the valves
- operation of the sanitary valves
- functional check of the volumeters
- absence of escapes and abnormal noises
- inversion of the engines of double circulators of primary and secondary education
- measure of the flow of primary education circuit
- control of vent cocks, surge tank and anodes

Experiences

In “low energy consumption” buildings the production of sanitary water has become a major source of energy consumption. In fact, the efforts made to reduce the heating energy have to be extended to other energy items, like the production of warm sanitary water.

The use of renewable energy for warm sanitary water production is necessary to reduce the environmental impact of the building. Hence, Grand Dijon decided for the most developed system using renewable energy in France: solar thermic.

This intention to reduce the energy consumption of warm sanitary water must be combined with a reduction of need. So before considering which system might be appropriate, it is essential to first reduce the need for warm water.

The following water-thrifty installations help to reach this target:

- pressure reducer: limiting alimentation pressure of the taps to 3 bar
- economic shower heads: a classic shower head consumes 20 l/min whilst an economic one consumes between 6.5 to 9 l/min (it explodes water drops and optimises the power of the shower head)
- shower regulator: the flow regulator can reduce the consumption of water up to 8 l/min
- mixing taps with time delay: limiting water flow to user's needs
- tap-nozzle: limiting flow from 15 – 20 l/min to 5 - 8 l/min

Advantages and disadvantages

ADVANTAGES:

- use of renewable energy
- no polluting emission
- an annual equivalent of 150 kg to 250 kg CO2 avoided per square metre by the collector
- the auxiliary energy source can be changed easily, depending on energetic availability.

DISADVANTAGES:

Maintenance cost
In this case the size of the installation was particularly difficult because it was complicated to evaluate the real need of warm water. We had to consider a hypothetical use of the showers in order to estimate the need. But the real use can be different and the installation less efficient than expected.

RET

Description

It is currently being examined whether the installation of a solar water heater is profitable for saving energy on the hot water consumption at Beverwaard depot. The hot water at the depot is in particular used for showers and washbasins in the locker rooms. This means a small system is sufficient.

Principle of the solar energy system

Most solar thermal energy systems consist of a solar collector, a control unit with a pump and a storage tank for the hot water. The water runs through the collectors in a circuit that is connected to a heat exchanger (spiral) in the storage tank by ducts. The water in the collector panels runs in copper tubing into the panel and is heated by the sun. When this water is getting warmer than the water of the storage tank, the control unit activates the pump, which pumps it through the heat exchanger. In this way, the domestic water in the boiler is being heated (up to a maximum of 85 ℃). The cooled circuit water is pumped to the collector and the process begins again. If the solar thermal heat is insufficient, an additional heat exchanger within the boiler can be used to heat more water.

Above, a typical solar water heater system is being defined, the method of supplementary heating may differ.

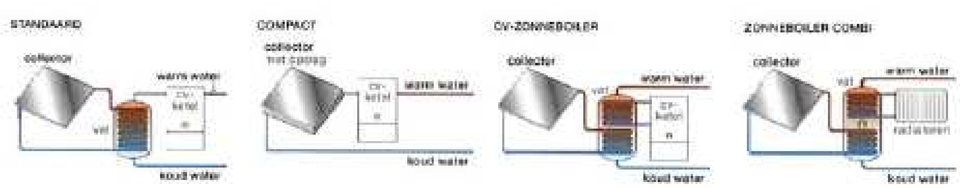

Figure 6: Ways of connecting the solar thermal installation

The suggested version for the Beverwaard depot is the “cv- zonneboiler” as shown in figure 7.

Key figures

Hot water for showers – Chosen system
The technical bureau Massier BV is responsible for all technical building installations at Beverwaard depot. To produce hot water they decided to install a sun energy system by ZEN Renewals.

The installation consists of:

- a sun boiler SDB 300 T, 300 liter for hot tap water
- integral drain back spiral and a spiral for reheating, connecting piping, a pump and an electronic control unit
- a flat plate sun thermal collector S4200, 2 pieces each 4,12 square metres
- piping between collectors and sun boiler

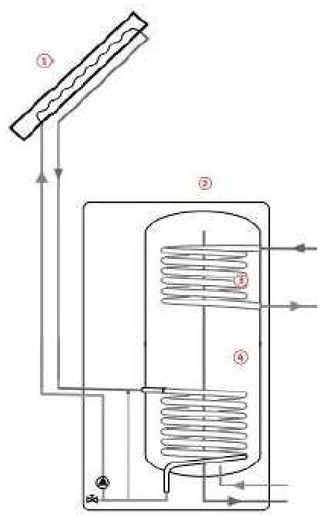

Figure 7: Section drawing of a boiler (1. Sun collector, 2. Drain back container, 3. Built-in after heating spiral, 4. Boiler 300 l)

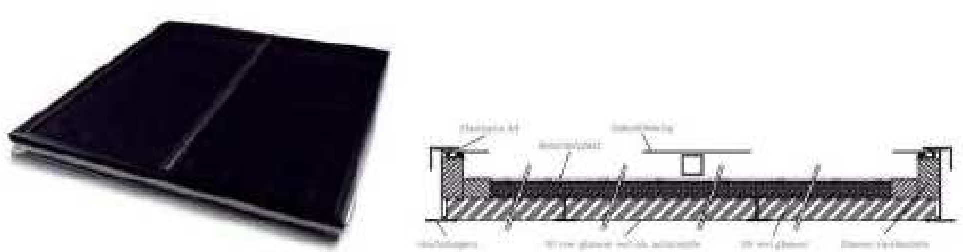

Figure 8: Section drawing of a collector

This installation is based on using water for 8 showers:

- A total use of 1.8 m3/h of mixed water with a temperature of 38℃ (defined by the operation basis and the qVn-method)
- The boiler barrel of 300 liter is equipped by a second spiral, which is connected to the heating device which is currently being used.
- On the roof above the office area, two collectors with a dimension of 1,8x2,6m will be placed near the boiler

The system is equipped with a recoil system, the so-called Drain-Back system. The Drain-Back system protects the system against overheating of the boiler and freezing of the collector. The closed Drain-Back system raises durability, safety and reliability.

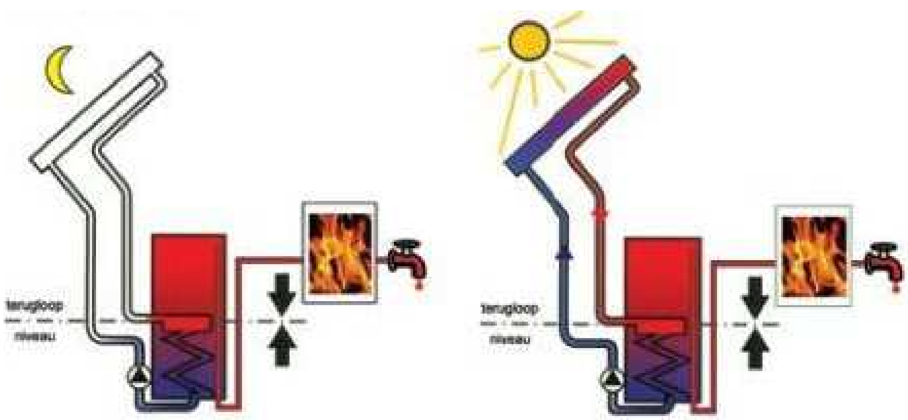

Figure 9: Principle of drain-back system

The maintenance costs of the closed Drain-Back system are low and it does not contain chemicals like anti freeze or anti corrosion additional. Any corrosion is prevented as there is no oxygen within the closed system. The lifespan of this system is about 25 - 30 years.

Less CO_2 emissions according to supplier

The supplier estimated the expected savings of CO_2 emissions. The table below shows the results of the decrease compared to electrical heating systems and gas heating systems. The calculated values are based on the consumption of an average family. The installation at Beverwaard has a collector area of 8.24 square metres of effective surface so CO_2 savings will be higher.

Table 2: Overview of CO_2 savings in electricity and natural gas according to system size

System Size (m^2)	CO_2 Savings Electricity		CO_2 Savings Natural gas	
	(kg/year)	(kg/25 year)	(kg/year)	(kg/25 year)
1.38	344	8,600	136	3,400
2.75	720	18,000	284	7,100
4.12	1,095	27,375	433	10,825

Advantages and disadvantages

These systems have been tested extensively and are thoroughly developed. They can be installed in a simple, cost effective manner so they are the logical choice for any consumer in this field as there are no known disadvantages.

STIB

Remarks

As there are several showers within the building, hot water is essential. The investment will result in a reduction of 30% to 50% of energy consumption for water heating. A solar boiler produces hot water by using solar energy. The system requires thermal solar collectors to be installed on the roof and works on sloping as well as on flat roofs. The best location for these collectors is a position towards south at an inclination angle of 45°.

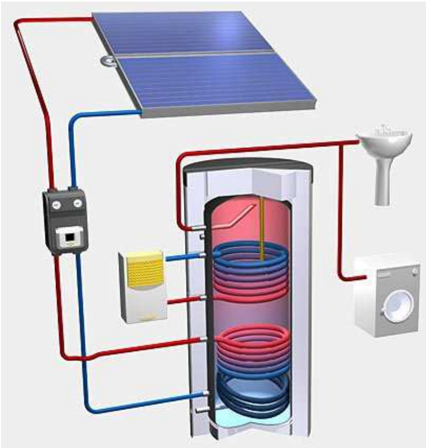

Figure 10: Image of solar boiler installation

Other degrees of inclination and set-ups are possible but they are not as effective in terms of energy yield. Solar collectors contain liquid that is heated by sunlight, which diffuses its heat to the water inside the solar boiler.

In summer the boiler heats water to a temperature, which meets the required comfortable temperature. In winter additional heating (gas or biomass) is required. A detailed study will demonstrate the economic optimum between investment costs and reduced energy costs. Orientation, position and degree of coverage are important parameters for this study. At this stage STIB has not yet received the planning permission for the construction of Marconi depot and studies have not yet been commissioned or initiated.

External applications

Southern African Solar Thermal Training and Demonstration Initiative [6]

The overall target of this regional South African project is to contribute to the switch from fossil fuel based energy supply to a sustainable energy supply system based on renewable energies. Moreover, the project goal is to:

- create new jobs at small and medium enterprises
- initiating and/or strengthening the political support mechanisms for solar thermal systems

The project focuses on three target groups [7]:

Training institutions like universities and other training centres

- preparing a comprehensive solar thermal market report for each participating country
- monitoring and analysing different solar thermal systems of sizes
- training of key groups for production, installation and implementation by the training institutions

Small and medium enterprises (companies working in the field of solar water heaters)

- support in optimising solar thermal systems by individual consulting
- component testing
- installation of 50 demonstration systems at social institutions

Policy and administration

- developing political and financial support mechanisms for renewable energies in general and particularly solar thermal systems

[6] Global Solar Thermal Energy Council http://solarthermalworld.org/node/823 (last visited 07-03-2112)
[7] Renewable Energy and Energy Efficiency Institute (REEEI) http://www.reeei.org.na/ (last visited 07-03-2112)

Key Points & Recommendations

Solar power is amongst the fastest-growing renewable energy sources. For many countries solar power means an eco-friendly alternative with regards to environmental impacts of electricity production based on fossil fuels or hydroelectric plants.

Similar to the installation of photovoltaic systems, the architect should consider an installation of solar thermal technologies on the building of the depot. Compared to Photovoltaic, this system is not as expensive and the depot is able to use renewable energies easily.