SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Solar Heat for Cities, Towns and Energy Communities

Introduction to solar district heating by the
IEA SHC Task 68 - Efficient Solar District Heating Systems
https://task68.iea-shc.org/

An enormous task…

… decarbonising around **6,000 district heating networks** across Europe.

… solar heat is one of the proven, available, cost-effective measures to help complete this enormous task.

In this presentation we would like to show you how **solar district heating** works and who is using it successfully already.

Graphic: IEA SHC Task 55

Lemgo, Germany: Reducing gas price risk

DANIEL STEUBE
Project and Energy Manager at
Stadtwerke Lemgo

Portrait photo (left): Guido Broer   Photo (right): Viessmann

"Our 5.2 MW solar collector field has been feeding into the city of Lemgo's heating network since April 2022. It benefits from very low operational costs over its entire life cycle and also reduces the CO_2 and gas price risk."

266 towns and cities in Europe use solar heat

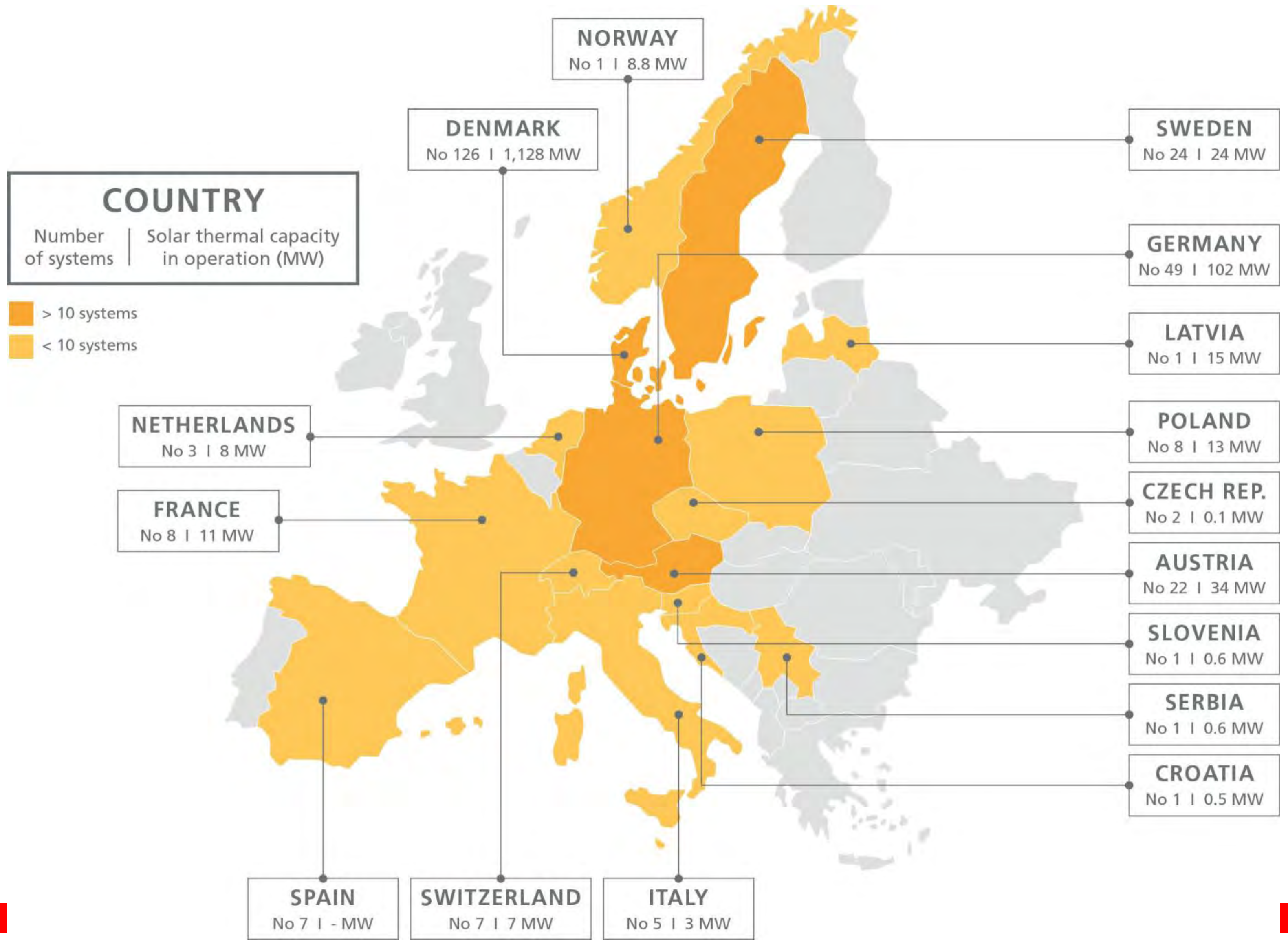


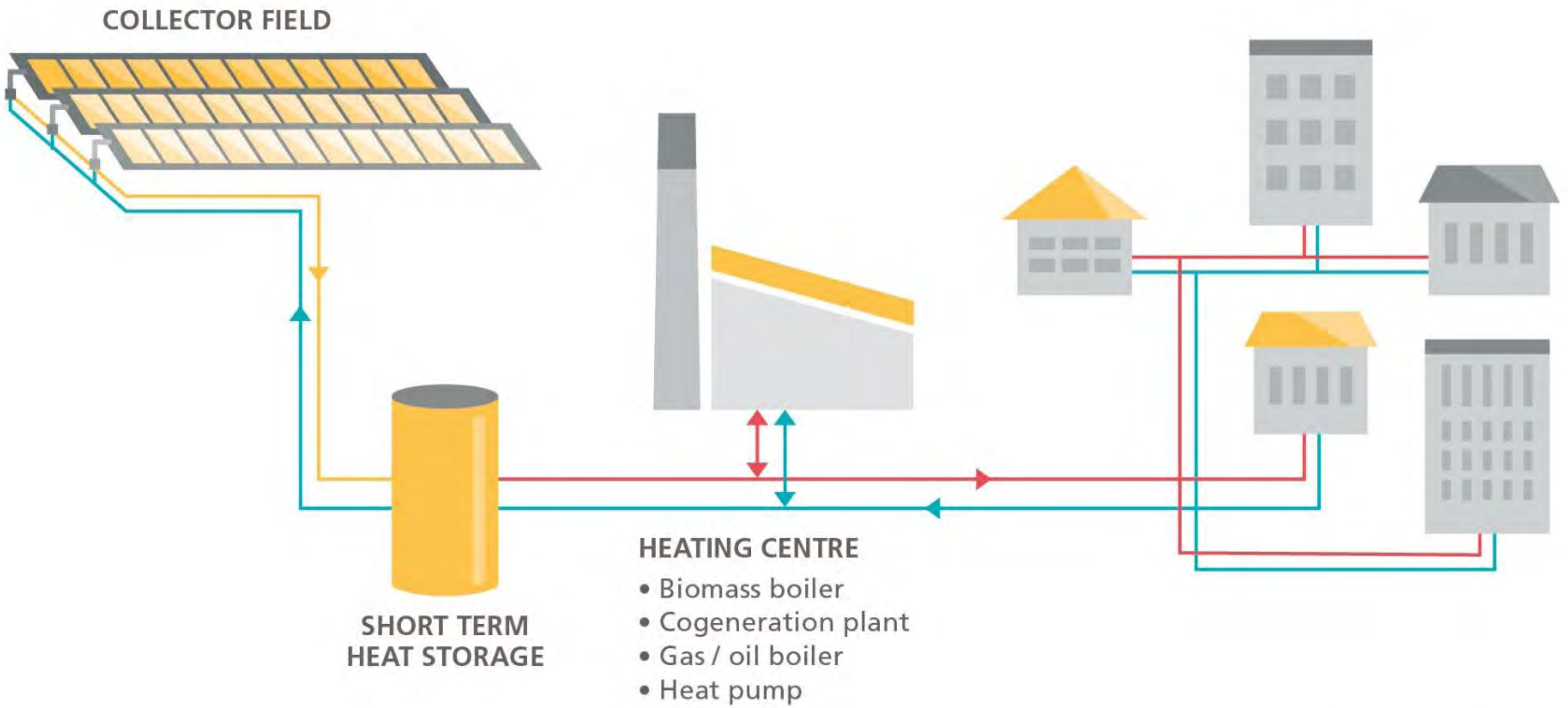
Chart: IEA SHC Task 68
Source: IEA SHC Solar Heat Worldwide Report Ed. 2023 / own research

Multi-MW solar district heating plants on the rise across Europe

- ✓ **37 MW** collector field under construction in Groningen, Netherlands. 30 years solar heat delivery contract with utility company Warmtestad.
- ✓ The municipal utility in Leipzig, Germany, placed the order for a **41 MW** collector field in April 2023
- ✓ Financing is secured for a **41 MW** collector field in Pristina, Kosovo, planned by the local utility Termokos.

Photo: Ritter Solar XL

How does solar district heating work?



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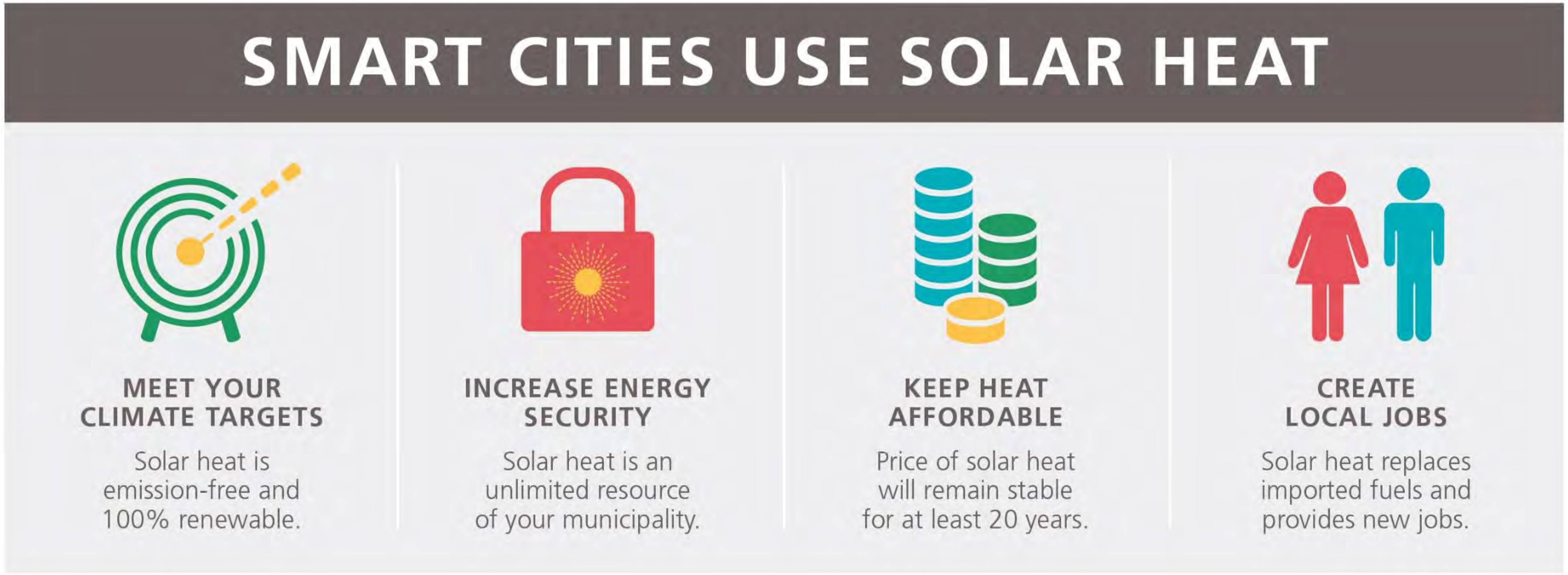
The advantages



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Mengsberg, Germany, heats with 100 % renewables

Photo: Bioenergiegenossenschaft Mengsberg

The German village of Mengsberg has built up an energy community that owns and operates a 100 % renewable district heating network with a wood chip boiler and a solar collector field.

Everyone who wants to join the energy cooperation makes a deposit of EUR 4,000 per building. In return, the transfer station is installed and the district heating pipes connected to the house.

Mengsberg's energy community owns the district heating system

141 participants

4,000 EUR
deposit per building for the transfer station and the piping to the house.

112 EUR/MWh
heat price (status November 2022). No basic price is charged.

Graphic: Task 68
Source: Bioenergiegenossenschaft Mengsberg

Mengsberg's energy community owns the district heating system

Map/Source for Table: Bioenergiegenossenschaft Mengsberg

Site	Mengsberg, Germany
Inhabitants	925
Connected households	149
Length of piping	9 km
Wood chip boiler	1.1 MW
Solar thermal field	2.1 MW
Annual solar share	17 %

Operator models for energy communities

1. Foundation of an energy cooperative as a legal entity to own and operate the heat network

+ heat prices only reflect the real costs, no trade profit margins included

- a lot of voluntary work is required by the board members

2. Energy community signs a contract with a private heat supply contractor or the public or neighbouring utility company to creates, owns and operates the heat network

+ little responsibility for the members of the energy community

+ contractor/utility has specialist knowhow about renewable heat networks

- slightly higher heat prices because of the profit margin of the heat contractor

Manual about energy communities (in German):

https://www.solare-waermenetze.de/wp-content/uploads/2022/06/2020_Infoblatt-Solare-Waermenetze-Nr.7-Energiedoerfer-mit-erneuerb.-Waermeversorg.-Modelle-fuer-erfolgreichen-Betrieb-von-Waermenetzsys._Solnet-4.0.pdf

Grenaa in Denmark: Reduce the pressure on biomass

Grenaa Varmeværk offers the fifth lowest district heating price in a comparison study from June 2022 carried out by the Danish Supply Authority.

SØREN GERTSEN
Director at
Greena Varnemærk

“Our board of directors shares one vision: to use solar to supply consumers with cost-effective heat. And we will save costs when the system produces solar energy in summer because we can shut down one of our two wood chip boilers during that time.”

Photo: Savosolar

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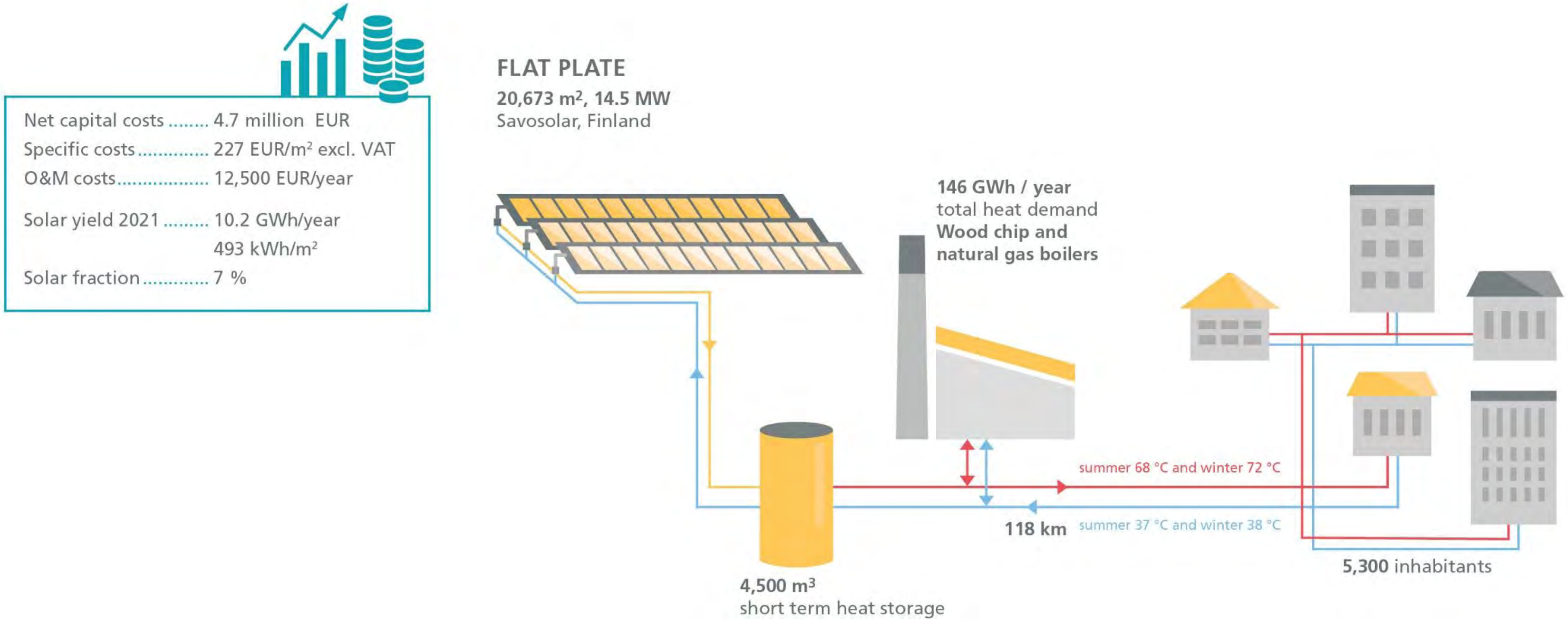
Grenaa in Denmark: Solar heat and biomass are a good match



Solar heat and biomass are a good match

Save money: thanks to the solar system, less wood chips need to be bought.

Preserve the biomass boiler: the solar system takes over the summer operation, the boiler is less stressed → service life is extended.

Protect the climate and the environment: reduced emissions through CO2 and air-pollutant-free solar energy.

Photo: Nahwärme Eugendorf, Austria

Latvian utility company is cutting down on fossil fuel use

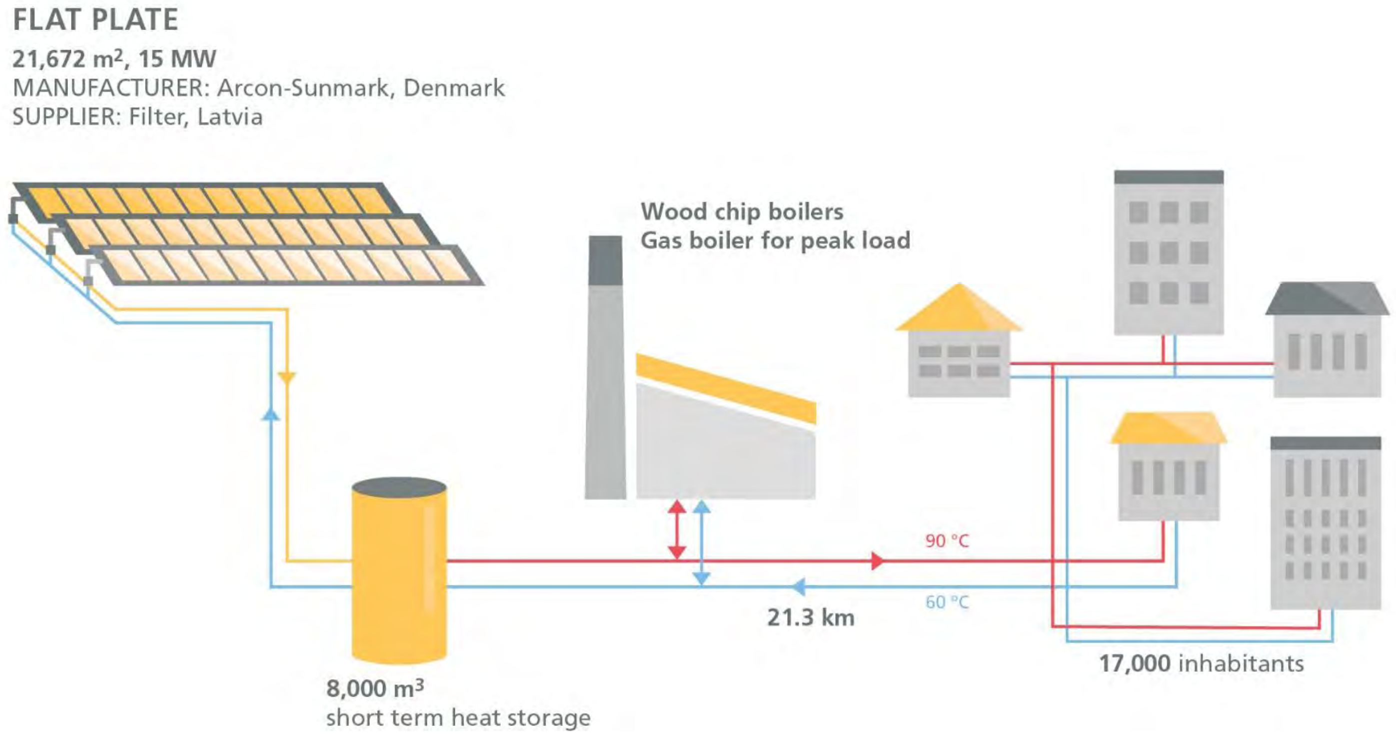
INA BERZINA-VEITA
Managing Director at
Salaspils Siltums

"We've been working on this project since we visited Denmark in 2016 to attend a conference on district heating. The aim is to reduce our carbon footprint and become less reliant on fossil fuels."

Photo: Salaspils Siltums

Salaspils, Latvia: 90 % renewable district heat since 2019

Contribution to total heat demand	65 GWh / year
Solar thermal	16 %
Biomass boilers + flue gas condenser	72 %
Gas boilers	12 %
Ø solar yield 2020/2021	486 kWh/m²a



Salaspils, Latvia: Constant solar heat prices over 25 years

News > Heating news > The price of heat energy for Salaspils Siltums customers will remain unchanged

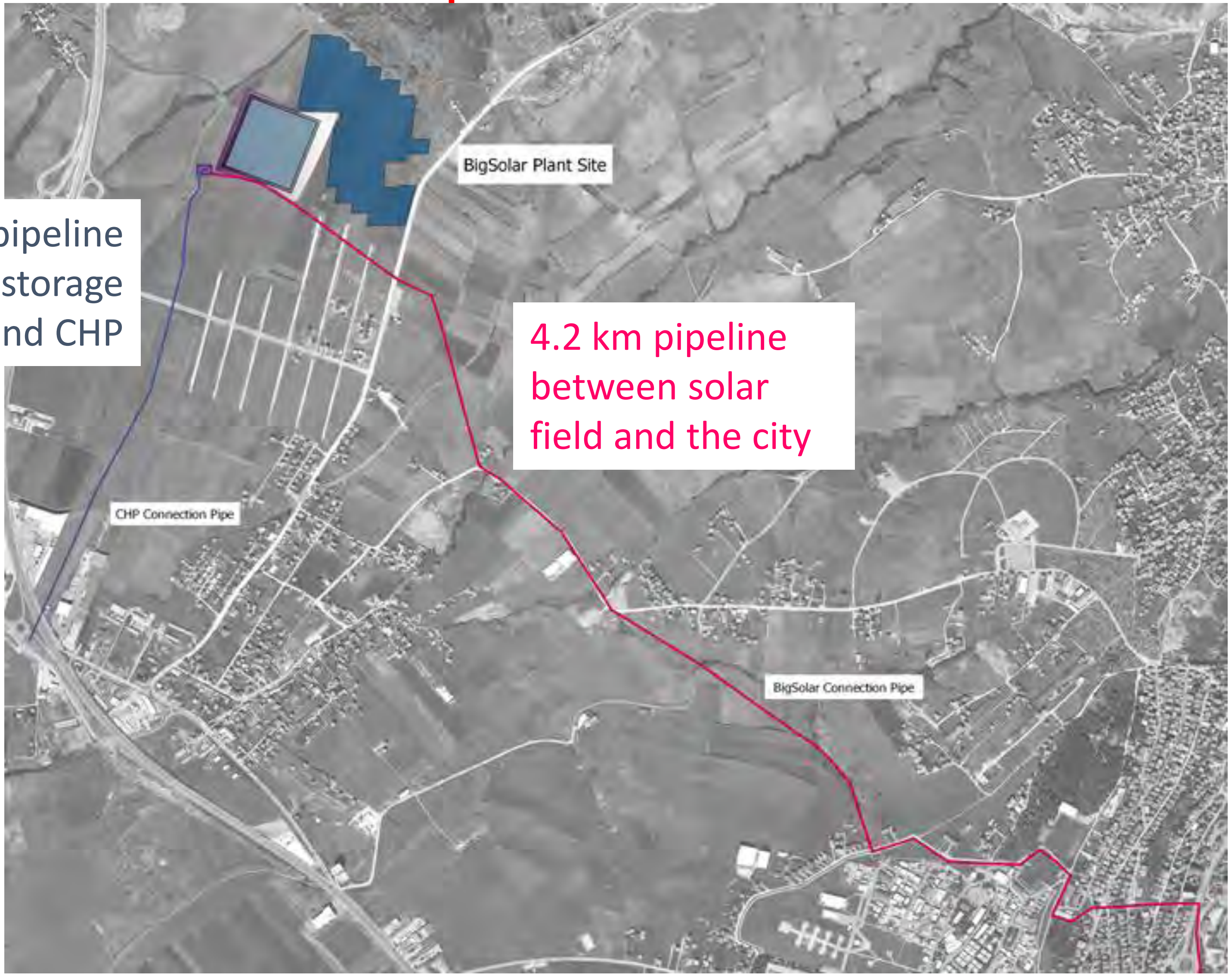
The price of heat energy for Salaspils Siltums customers will remain unchanged

31 August 2021 **HEATING NEWS**

Source: Screenshot from https://salaspilssiltums.lv/

"We are proud to have taken care of fuel diversification in the past, thus avoiding the effects of rapid fluctuations in the price of natural gas. The price of heat energy for Salaspils Siltums customers is stable and will not be increased."

Big Solar Pristina replaced coal-based electric heating



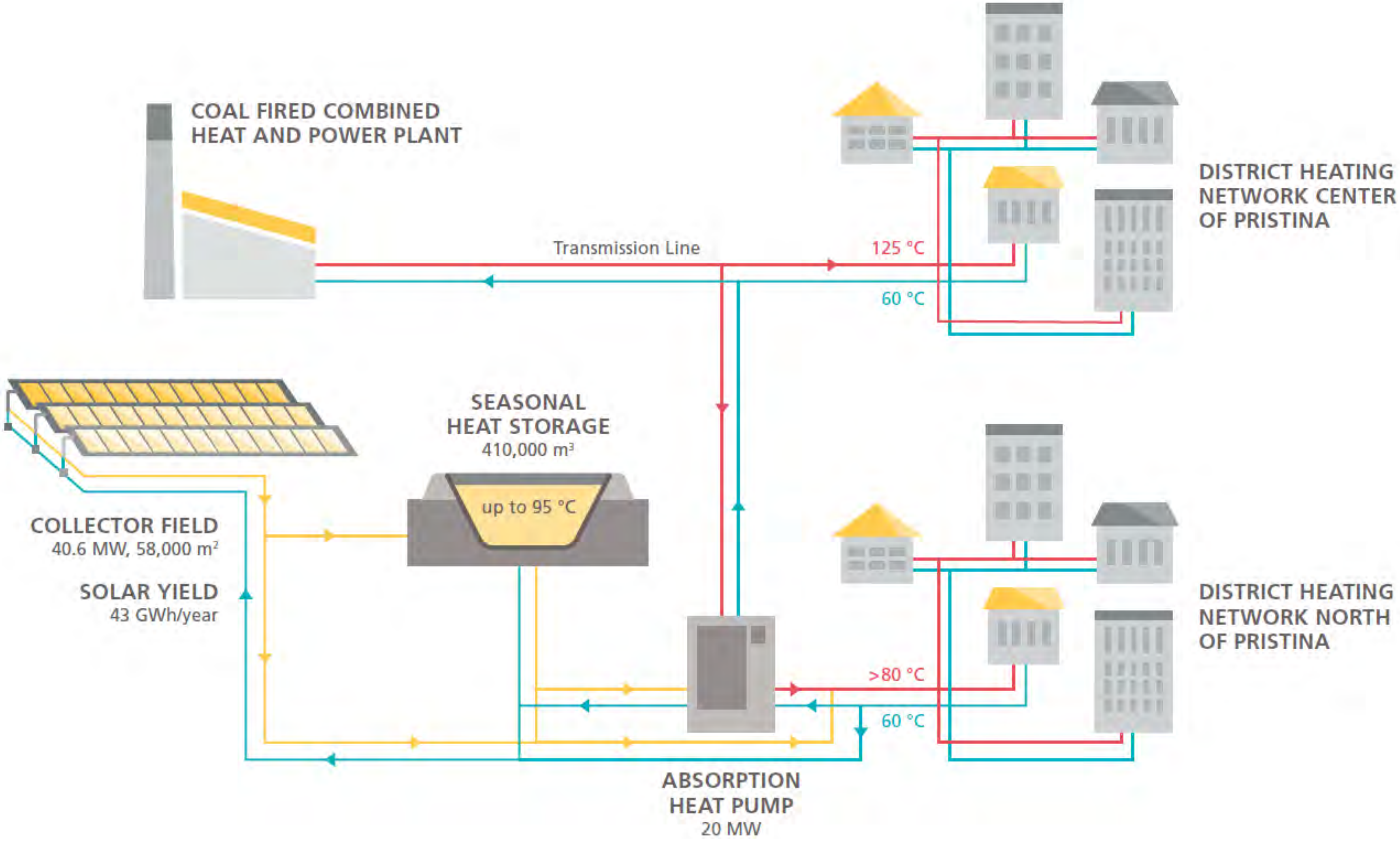
1.6 km pipeline between storage and CHP

4.2 km pipeline between solar field and the city

Graphic: CES clean energy solutions

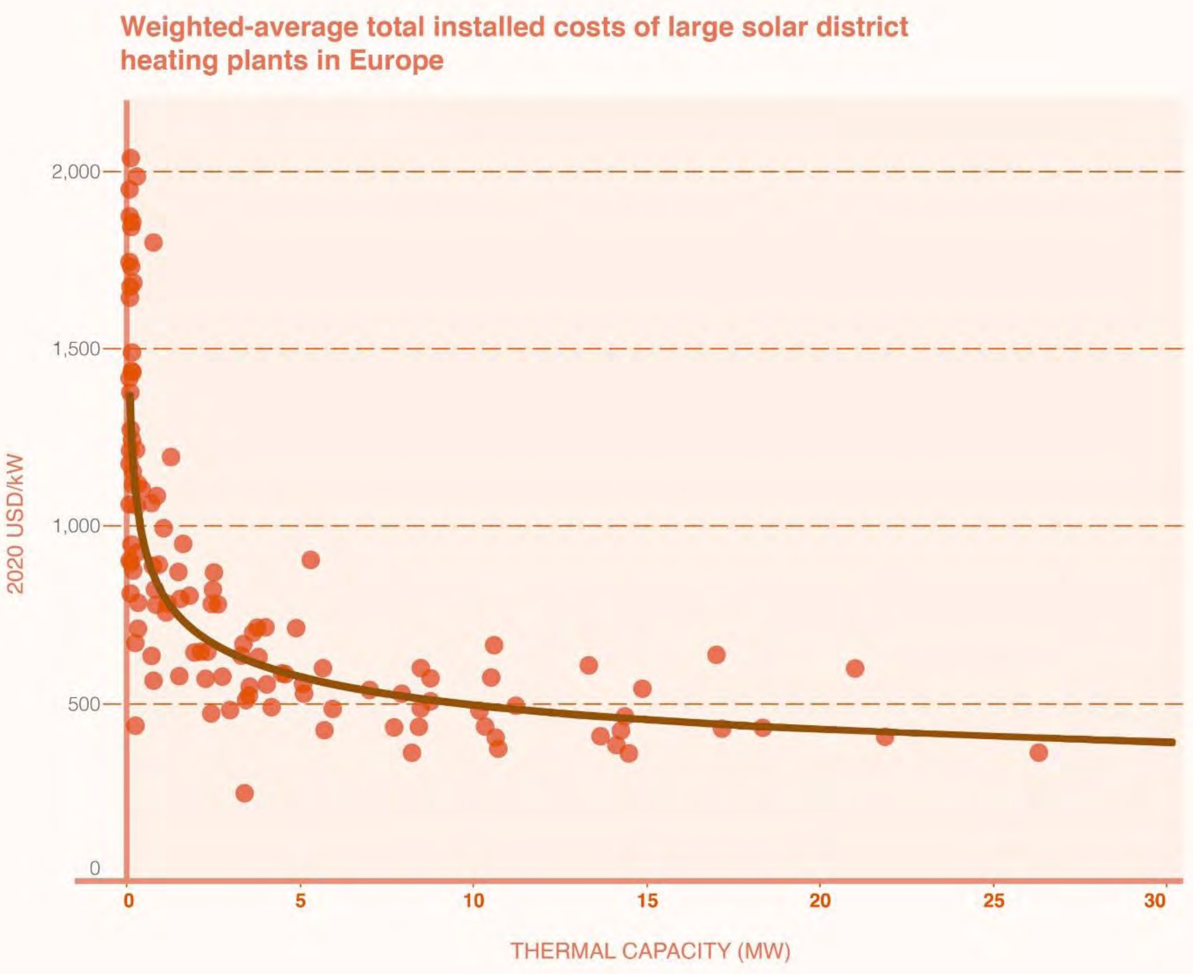
Site	Pristina, Kosovo
New district heat consumers	38,000
Annual solar share	12 %
Capacity of solar field	41 MW
Seasonal storage	408,000 m^3
Investment costs including extension of DH grid	EUR 80 million
Estimate start of construction	End of 2024

Big Solar Pristina: absorption heat pumps are key



The absorption heat pumps heat up the water from the seasonal storage tank, if it does not meet the demand of the supply line for the heating network.

Investment costs and heat prices



How to read this chart:

Each orange circle shows one SDH project commissioned between 2010 and 2021 in Europe. 97 % of the SDH projects have been installed in three countries Austria, Germany and Denmark.

Solar Payback

COST ANALYSIS: IRENA

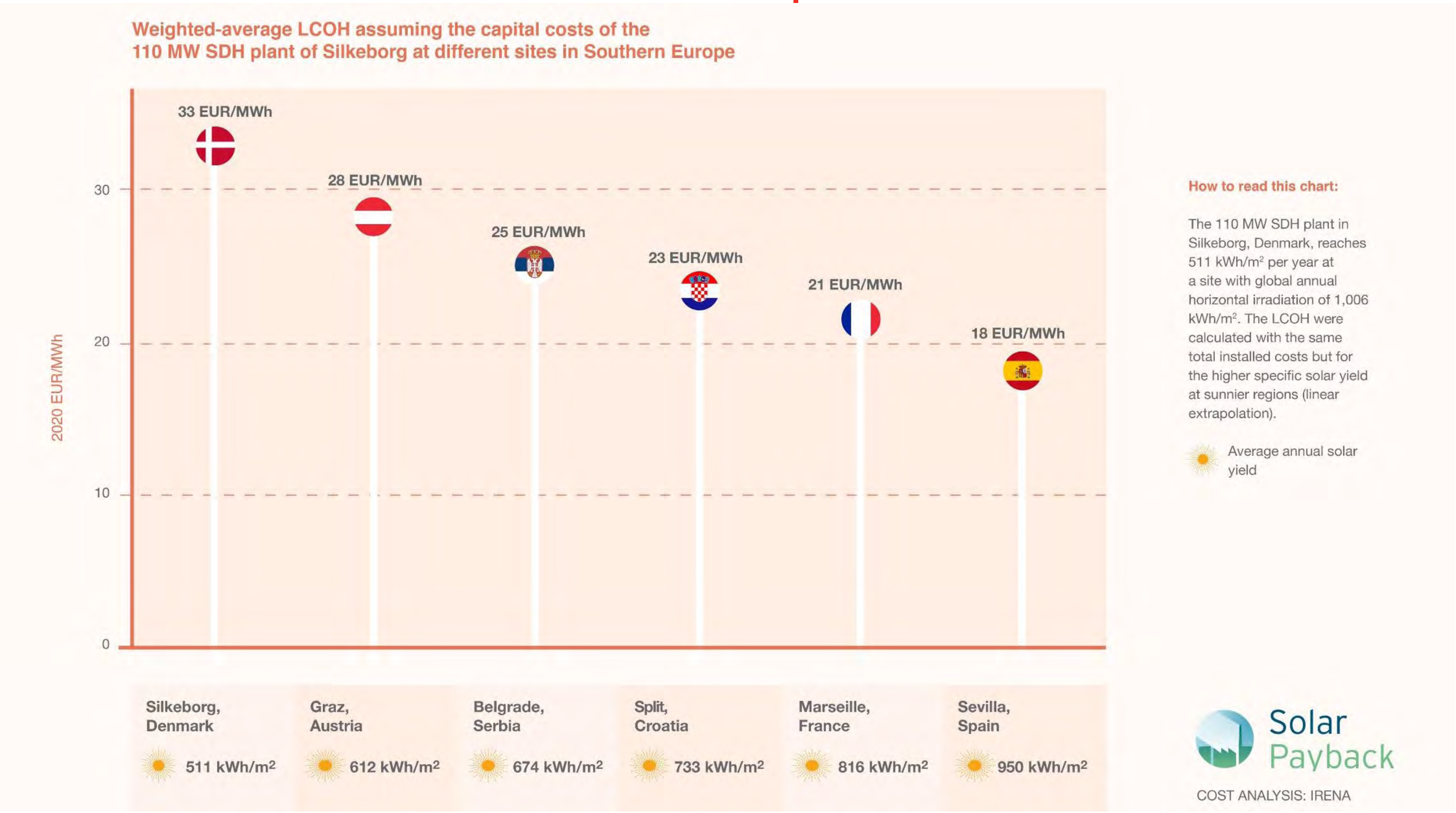
The trend curve suggests that for every doubling of the size of the plant, total installed costs decline by 14%.

110 MW in Silkeborg, Denmark, sets lowest benchmark costs

Photo: Arcon Sunmark

Site	Silkeborg, Denmark
Connected heat consumers	21,000
Annual solar share	20 %
Capacity of solar field	110 MW
Commissioning date	December 2016
Investment costs	DKK 250 million [in 2016] **EUR 35 million [in 2020]**

Investment costs and heat prices



Levelised cost of solar heat over 25 years of operation for a 110 MW plant is between 18 and 33 EUR/MWh.

Fast installation with prefabricated large collector panels

The larger the individual collectors, the easier and fast it is to install a system by crane. A dozen manufacturers in Germany, Austria and Finland have specialised in the manufacture of these prefabricated units with gross areas of 5 m^2 to 16 m^2.

Find a list of suppliers online: https://solarthermalworld.org/news/large-prefab-sdh-collectors-design-and-yields/

Photo: Greenonetec

Serbian municipality is striving for more after successful pilot project

Photo: JKP Grejanje

Design, planning and obtaining permissions usually takes much longer than the construction of the solar plant itself.

Dec 2011
Preliminary approval for funding

Oct 2015
Scheduling completion for the end of December 2016

Feb 2016
Starting procurement process

Jan 2017
JKP Grejanje started up the 906 m² plant

Jan 2019
Positive balance of two-years test phase

Jul 2019
Municipality council starts prefeasibility study

Oct 2019
Study finalised with 35,000 m² collector field, seasonal storage and 15-MW heat pump

Nov 2019
Commissioning of additional 495 m² collector area

Jul 2020
Municipality council agrees to conduct feasibility study and land surrounded by railroad tracks envisaged for the project

May 2021
Study confirmed 35,000 m² field with 150,000 m³ storage

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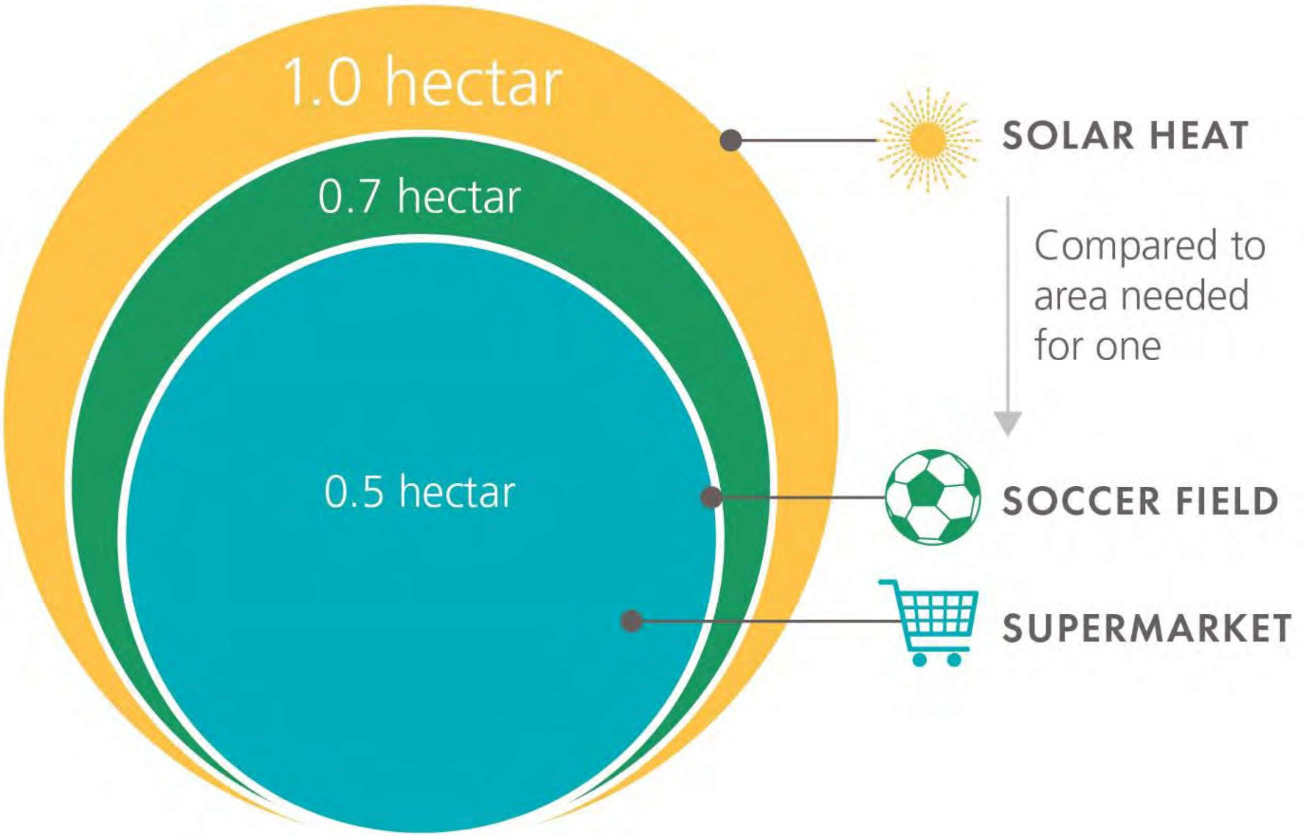
HOW MUCH AREA FOR SDH DO YOU NEED ...

... to meet 20 % of the total annual heat demand from 1,000 households living in old buildings?



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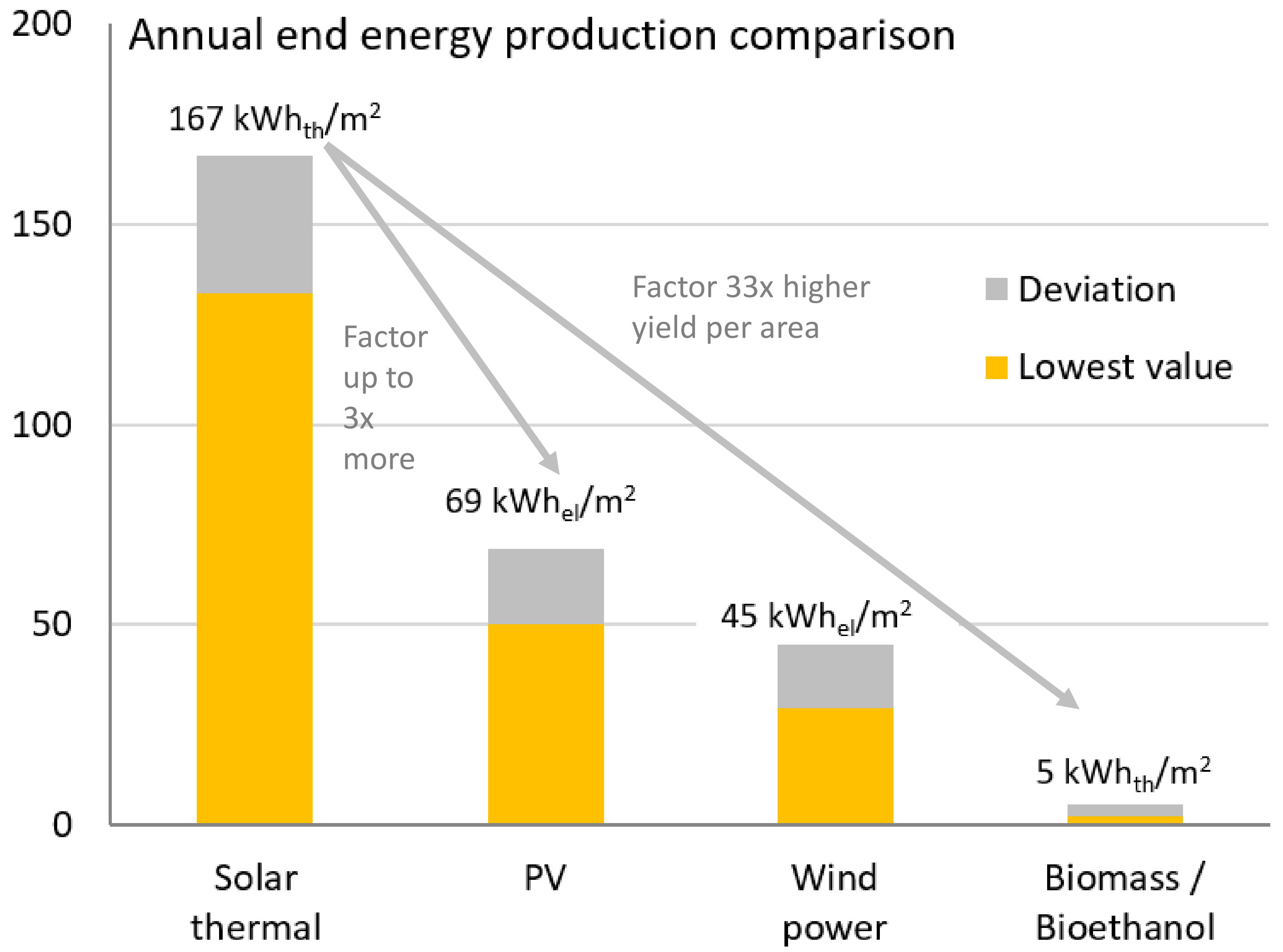
Yield per area comparison of different renewable technologies



Solar thermal harvests three times more kilowatt hours than photovoltaics and 33 times more than biomass on the same area.

1 MW solar heat capacity requires an area of 1,350 m^2

You need around twice as much land as the size of the collector field.

Source: Brochure about solar district heating from BSW Solar, Germany
Photos: Stadtwerke Senftenberg, Stadtwerke Lemgo, Stadtwerke Ludwigsburg-Kornwestheim

Each temperature level has a suitable collector type

Photo: Heliac

Concentrating collectors (Point Focus Fresnel) deliver heat at around **160 °C** in Hørsholm, Denmark

Photo: Aalborg CSP

Combination of flat plate collectors (up to 70 °C) and parabolic trough collectors (**here operated at 95 °C but could go higher**) in Taars, Denmark

112 smart cities in Europe

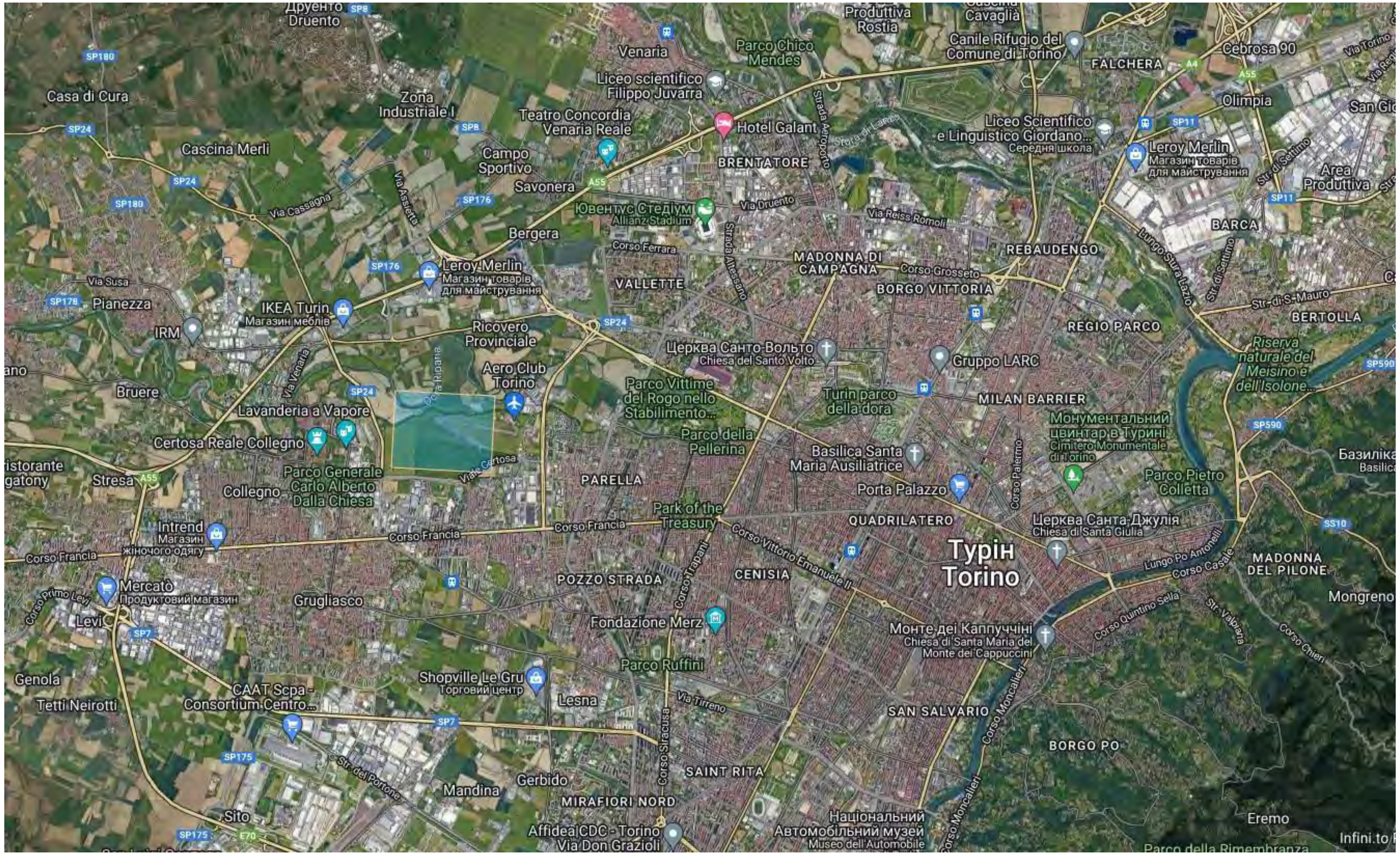
EU Commission's target: 112 selected mission cities should be climate-neutral by 2030.

The solar field simulator of Task 68 “Efficient Solar District Heating Systems” identifies the area that is necessary to cover 20 % of the total district heat demand in 12 of these cities using the sun.

Field simulator
https://www.absolicon.com/fs/

Source: https://eurocities.eu/

There is space for solar heat even in larger cities



Source: https://www.absolicon.com/fs/

Site	Turin/Torino, Italy
Inhabitants	847,000
Heat demand in heating grid	1,815 GWh/a
Solar irradiation	1,476 kWh/m2a
Land size of solar field	129.7 hectares
Capacity of solar field	401.1 MW
Solar share	20 %

There is space for solar heat even in larger cities

Source: https://www.absolicon.com/fs/

Site	Saragossa/ Zaragoza, Spain
Inhabitants	736,000
Heat demand in heating grid	1,412 GWh
Solar irradiation	1,877 kWh/m2a
Land size of solar field	75.5 hectares
Capacity of solar field	233.5 MW
Solar share	20 %

A golf course has between 60 and 90 hectare.

Solar collector areas with ecological upgrade

Collector fields do not seal the ground and give plants and animals a good chance of continuing to use the area.

Photos: Guido Bröer, Erik Christensen

Senftenberg in Germany: No solar storage needed

The 8,300 m^2 vacuum tube collector field in Senftenberg can cover the complete energy demand in the heat network on a normal summer day.

It contributes 4.2 % of the annual demand of the heat network, so no solar thermal storage is necessary.

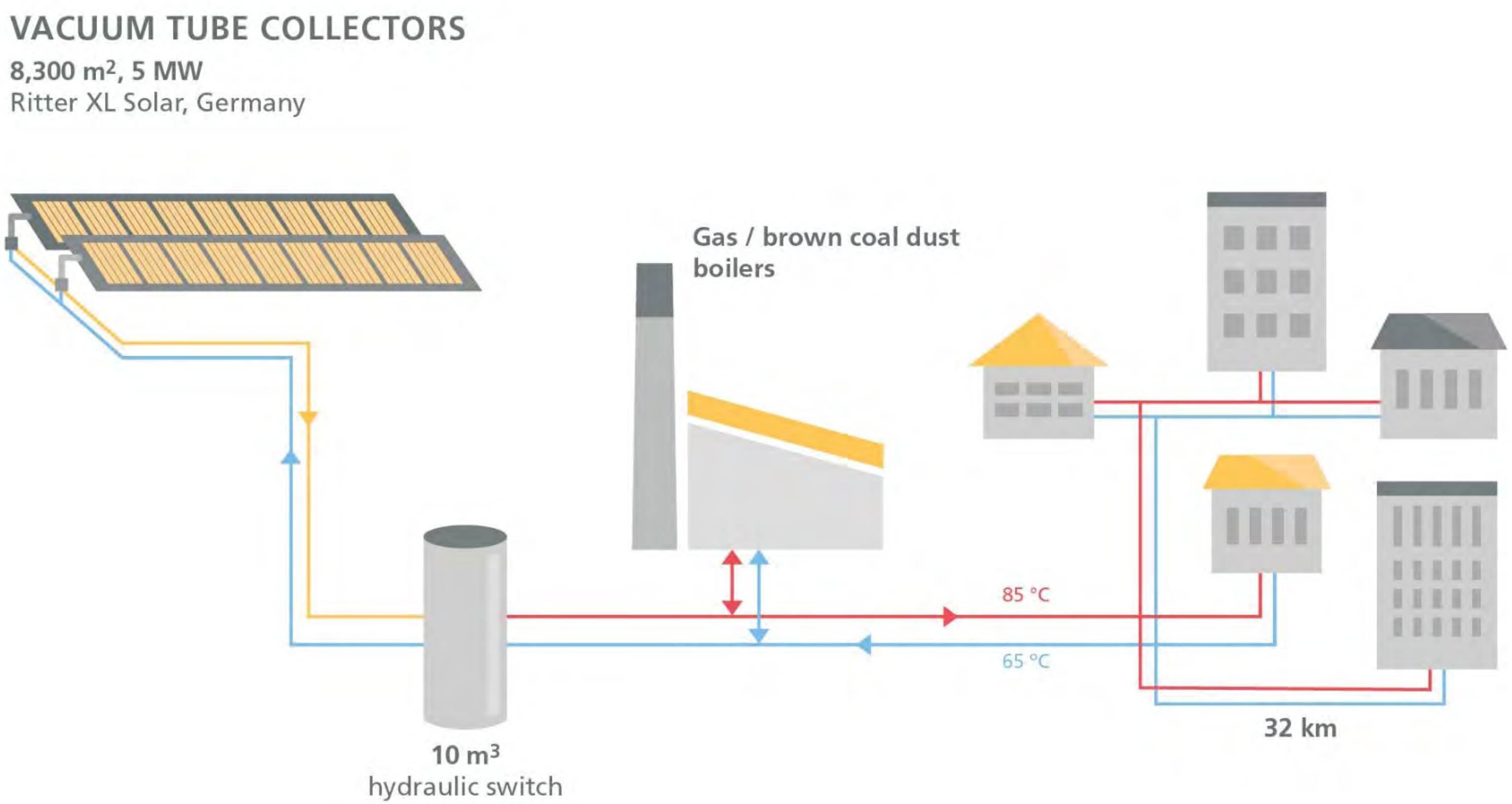
A bypass was also provided in the heating centre, so that the 2,000 m^3 water content of the heat network can absorb the solar heat of the collector field output on particularly sunny days.

Source: BSW Solar, Solare Nah/Fernwärme Deutschland: https://www.solarwirtschaft.de/wp-content/uploads/2022/05/bsw_solare_fernwaerme.pdf

Photo: Stadtwerke Senftenberg

Senftenberg in Germany: Good yields over five years

Total heat demand	100 GWh / year
Ø annual solar yield 2020/2021	4.2 GWh 506 kWh/m²
Solar fraction	4.2 %



Source: BSW Solar, Solare Nah/Fernwärme Deutschland: https://www.solarwirtschaft.de/wp-content/uploads/2022/05/bsw_solare_fernwaerme.pdf

Each temperature level has a suitable collector type

Photo: TVP Solar

This 816 m^2 solar field consists of special high-vacuum flat-plate collectors supplying heat to the heat network in Geneva, Switzerland, at a temperature of 85 °C, even in winter. In 2021, 539 MWh were delivered, equivalent to 687 kWh/m^2.

Each temperature level has a suitable collector type

This 9,118 m² vacuum tube collector field supplies heat at 90 °C to the district heating system of the German town of Lemgo.

Photo: Viessmann

By adjusting the speed of the pumps in the solar circuit, the target temperature of 90 °C is consistently achieved.

Distance between collector field and heat network

To minimise losses and reduce costs for the transport pipelines the collector field should be placed as close to the heat network as possible.

But the maximum distance between heat network and solar thermal plant is heavily dependent on the size of the collector field. If the costs of land are expensive close to towns and cities and the collector field is large, e.g. 70 MW, it can be placed three times further away than a 7 MW collector field, potentially resulting in the same costs.

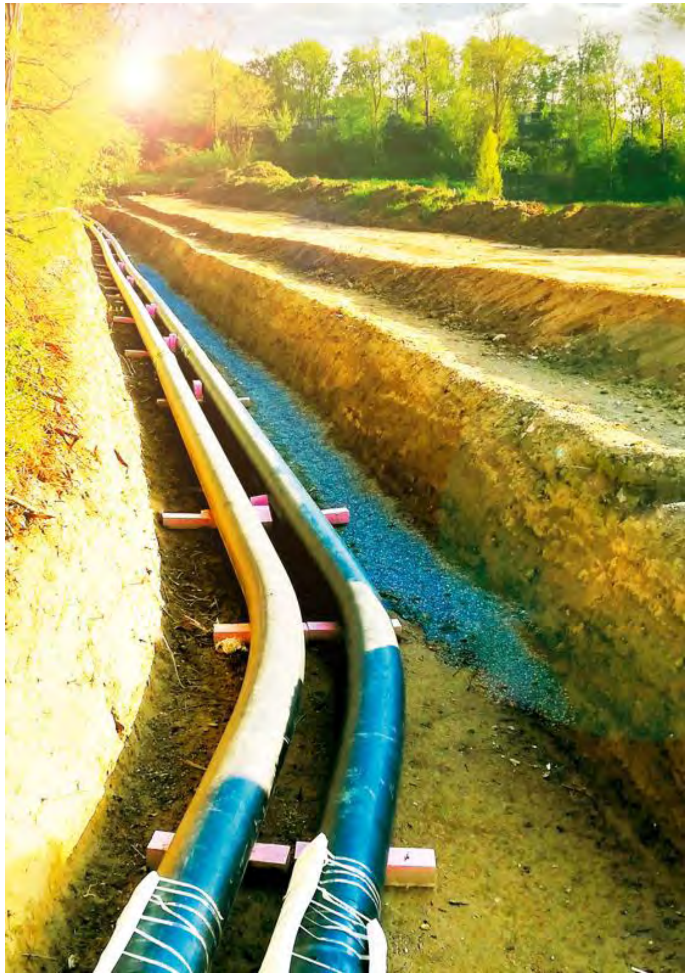


Photo: AEE INTEC

How big does the solar storage need to be?

- At solar shares below 5 % **no daily storage** tank is necessary.
- For solar shares between 10 and 20 % **a daily storage tank** is required with 50 and 100 litres of storage per square metre of collector area.
- If solar heat should cover **100 % of the heat demand** in the summer months, a storage volume of above 200 litres per square metre collector area is recommended.
- If solar shares of above 30 % over the year are to be achieved, then **a seasonal storage tank** can be required.

Photo: AEE INTEC

Storing solar energy in summer for heating in winter

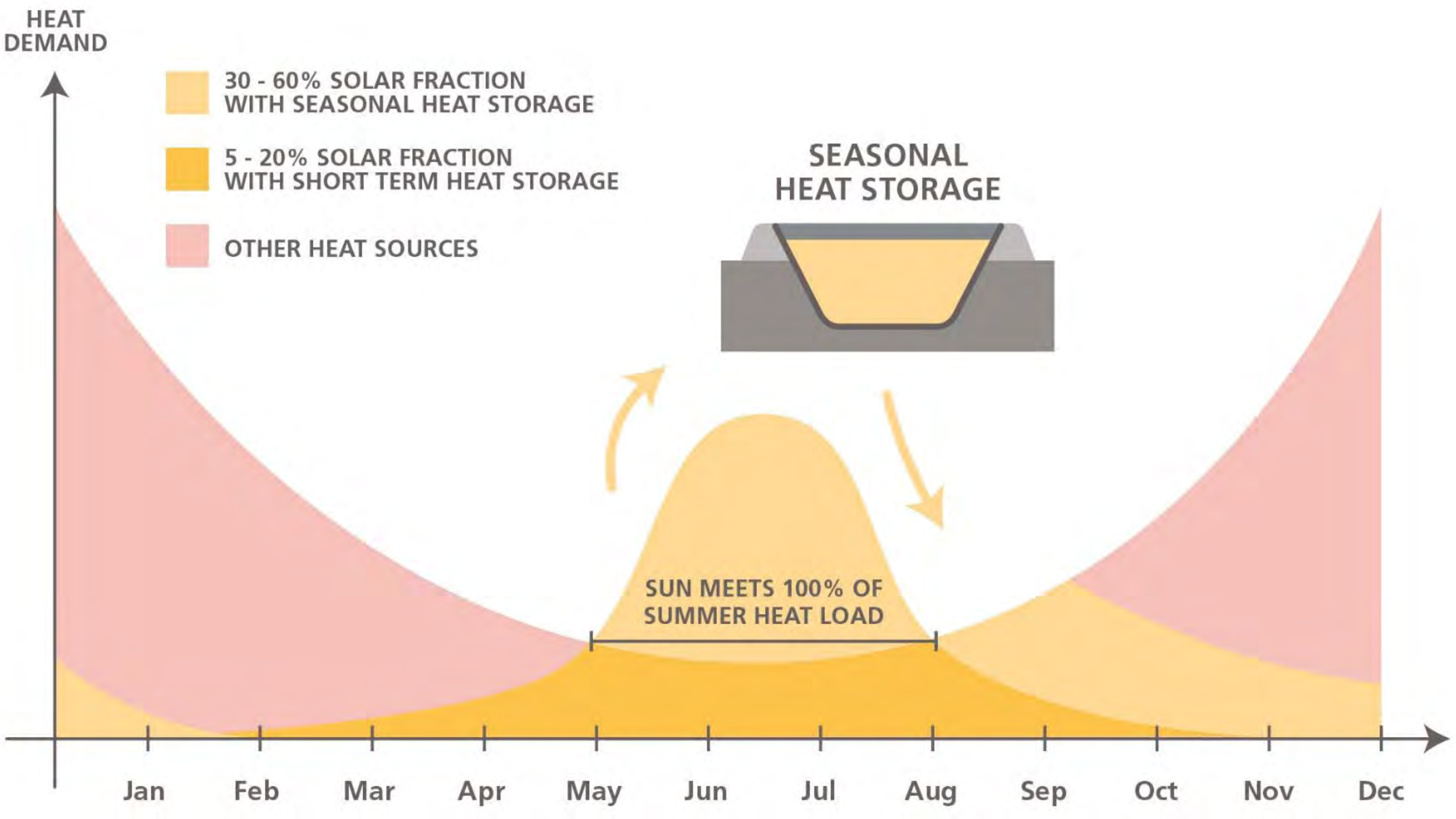


Chart: IEA SHC Task 55

Seasonal storage concepts

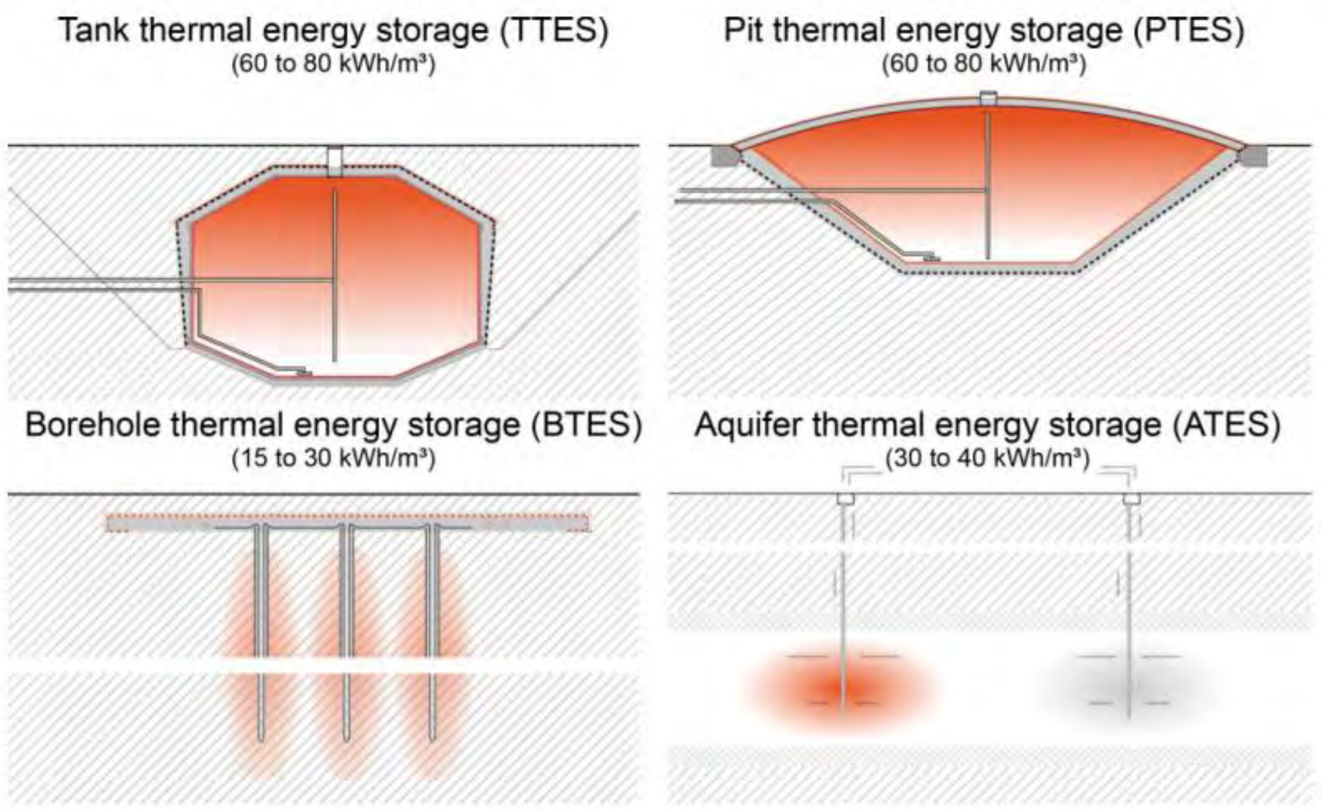


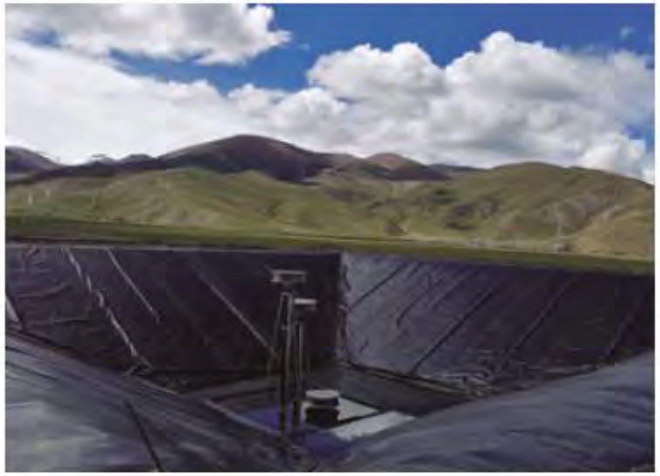
Chart: Solites

Solar district heating plants already have relevant experience with pit thermal energy stores, a proven and competitive seasonal energy storage option.

Construction of a pit heat storage

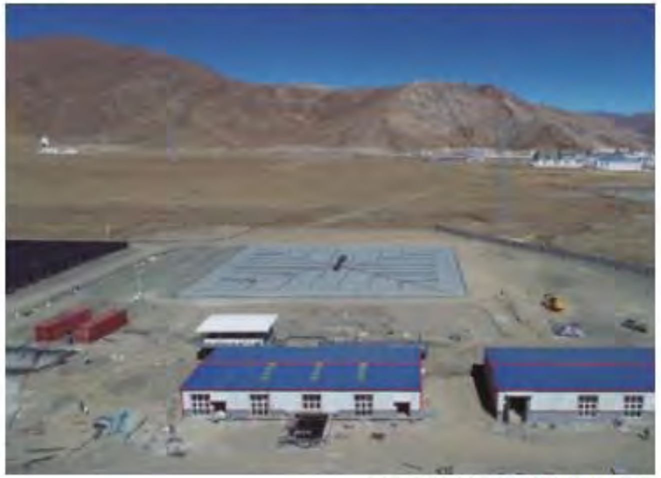
1. Dig a hole in the ground and put the soil around the edges.

2. Add a watertight liner at the bottom of the pit.



3. Fill the pit with water.

4. Put an insulating and floating cover on top.



PHOTOS: ARCON-SUNMARK

A pit heat storage tank with more than 50,000 m^3 loses 10 % of the stored energy over the year. The losses depend significantly on the size and construction of the cover.

Dronninglund in Denmark with 62,000 m^3 had measured losses 8 % over the year Source: Aalborg CSP

Summary: Solar heat is a team player

- ✓ Together with biomass boilers → to form a 100 % renewable supply
- ✓ Together with seasonal storages → to form a flexible and efficient energy management system including power to heat
- ✓ Together with heat pumps → to form a decarbonization strategy even for district heating grids with higher temperatures above 80 °C

Where can you get further technical advice?

Research and engineering services:

SHC SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

IEA SHC Task 68
task68.iea-shc.org/

PlanEnergi

planenergi.eu/ in
Denmark

BEST Bioenergy and Sustainable Technologies

www.best-research.eu
in Austria

solites

www.solites.de/en/ in
Germany

AEE INTEC

www.aee-intec.at/ in
Austria

Where can you get further technical advice?

Technology and turnkey suppliers:

Aalborg CSP, Denmark: https://www.aalborgcsp.com/

Absolicon, Sweden: https://www.absolicon.com/

Greenonetec, Austria: https://www.greenonetec.com/

Heliac, Denmark: https://www.heliac.dk/

New Heat, France: https://newheat.com/en/

Ritter XL Solar, Germany: https://www.ritter-xl-solar.de/

Savosolar, Finland: https://savosolar.com/

Solarlite CSP Technology, Germany: https://www.solarlite.de/

Solid Solar Energy Systems, Austria: https://www.solid.at/de/home.html

TVP Solar, Switzerland: https://www.tvpsolar.com/

Viessmann, Germany: https://www.viessmann.de/

Source: Fotolia_69214426_M

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Thanks for your attention!

IEA SHC Task 68: https://task68.iea-shc.org/