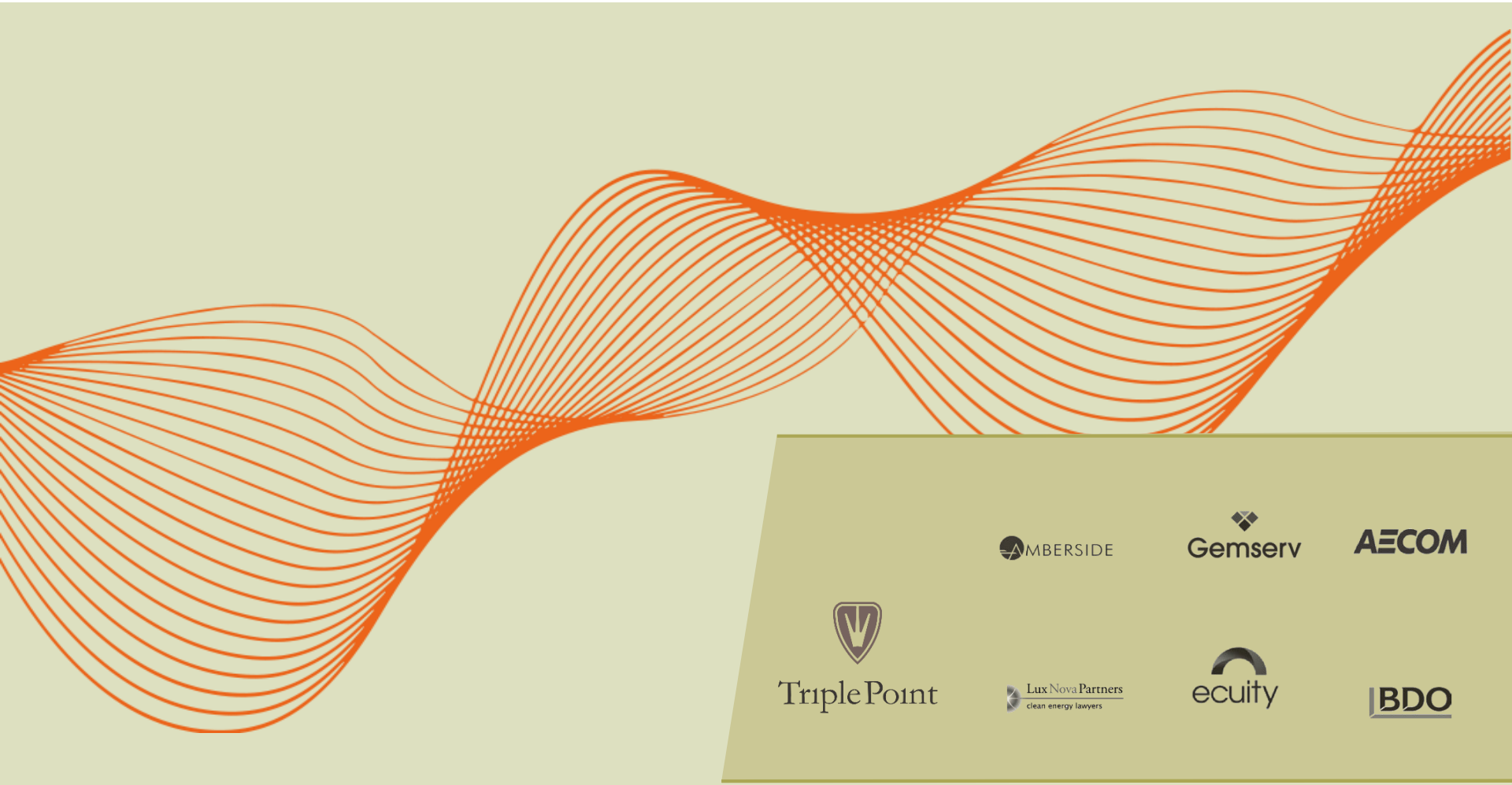
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HEAT NETWORKS
INVESTMENT MANAGEMENT

Renewable Heat for Heat Networks



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Renewable Heat for Heat Networks Conference

Triple Point HEAT NETWORKS INVESTMENT MANAGEMENT

Agenda

Time	Session	Speaker
8:30 – 9:00	Registration	
9:00 – 9:05	Housekeeping	James Higgins (TP Heat Networks)
9:05 – 9:20	Introduction to HNIP	Ken Hunnisett (TP Heat Networks)
9:20 – 09:50	Solar Heating and Cooling for Heat Networks	Dr Richard Hall (IEA Solar Heating and Cooling Technology Collaboration Programme and the Solar Trade Association)
		Grant Feasey (AES Solar)
		Magdalena Kowalska (PlanEnergi)
		Christian Holter (SOLID Solar Energy Systems)
		Renaldi Renaldi (Oxford University)
9:50 – 10:10	Heat Pumps and Heat Networks	Roger Hitchin (IEA Heat Pump Technology Collaboration Programme)
10:10-10:30	Integration of innovative technologies	Dr Anton Ianakiev (Professor in Sustainable Energy Systems, Nottingham Trent University)
10:30 – 10:50	Panel Discussion	
10:50 – 11:10	Refreshment break & Networking	

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Agenda

Time	Session	Speaker
10:50 – 11:10	Refreshment break & Networking	
11:10 – 11:25	ESCO Models for Renewable Heat Networks	Christian Holter (SOLID Solar Energy Systems)
11:25 – 11:45	HNIP Heat Decarbonisation Assessment Overview	Dr Andrew Cripps (TP Heat Networks)
11:45 – 12:05	District Heating Technology	Robin Wiltshire (IEA District Heating Technology Collaboration Programme)
12:05 – 12:25	Lessons learned from Denmark - a multifaceted approach	Jacob Byskov Kristensen (Danish Embassy)
12:25 – 12:45	Panel Discussion	
12:45 – 13:00	Closing remarks	TP Heat Networks
13:00 – 14:00	Lunch & Networking	
13:30 – 14:30	Funding surgery (HNIP & District Heating and Cooling TCP)	Business Development Managers (TP Heat Networks) & Robin Wiltshire (District Heating and Cooling TCP)

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Heat Networks Investment Project – The Story so Far

Ken Hunnisett
(Tripe Point Heat Networks Investment Management)

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Climate Change Commitments

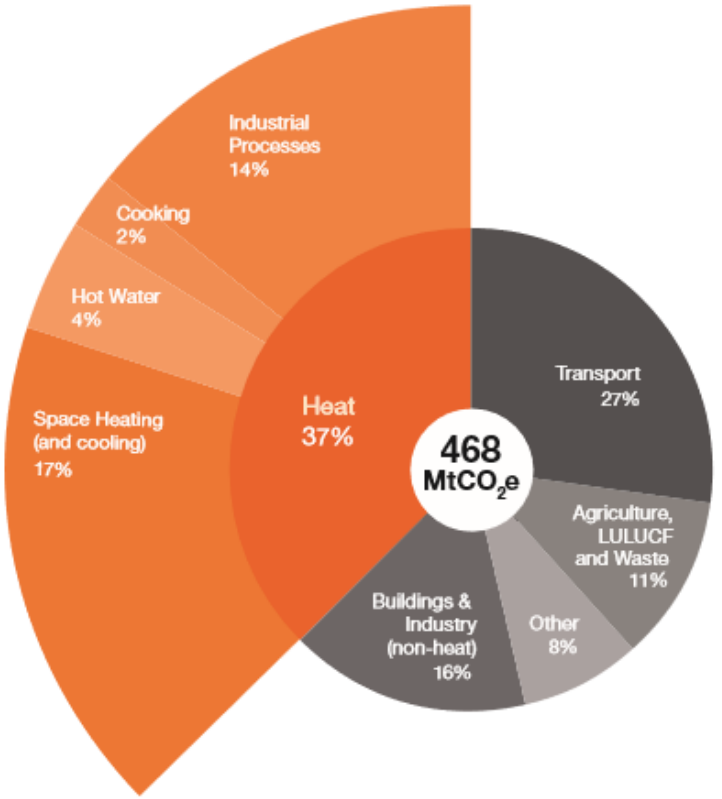
- The UK was first major economy to pass **net zero** emissions by 2050 target into law
- It is estimated by the Committee on Climate Change that around **18%** of UK heat will need to come from heat networks by 2050 if the UK is to meet its carbon targets cost-effectively
- Only **2%** of buildings are currently connected to heat networks

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Carbon emissions

EMISSIONS FROM HEAT = 37%

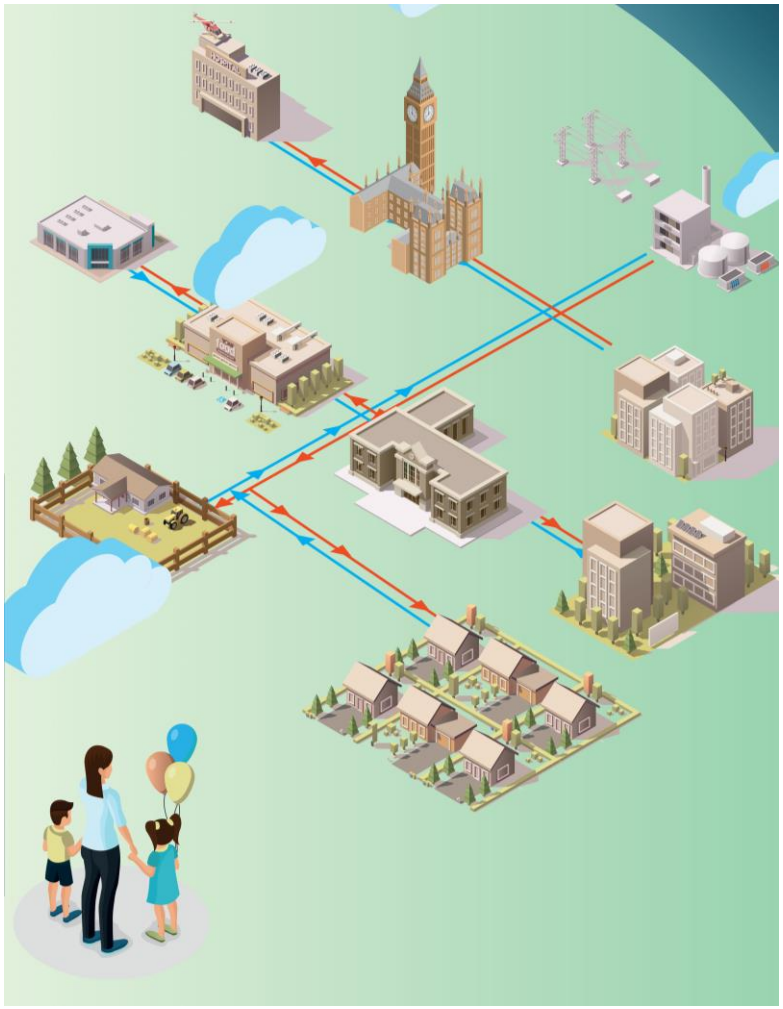
Estimated UK Emissions Attributable to Heating, 2016



Source: BEIS 2018, Transforming Heat

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Heat networks part of the solution

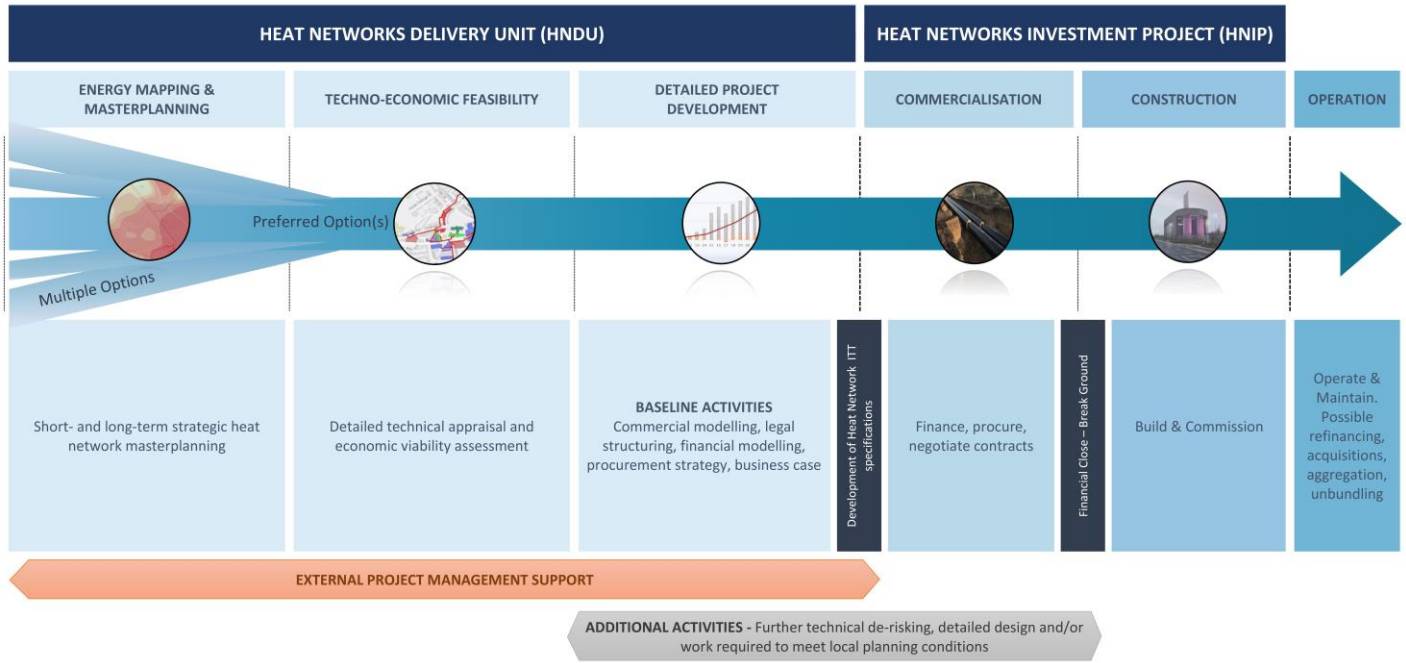


- Central source of production through to multiple sites
- Reduce emissions
- Reduce bills
- Increase resilience
- Increase flexibility

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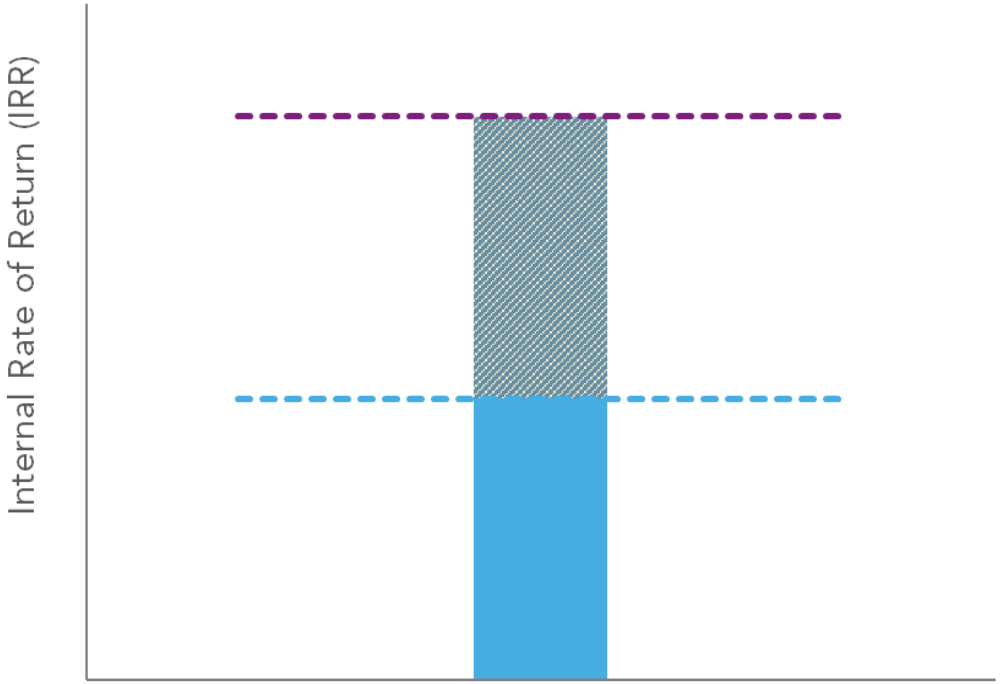
Heat Networks Investment Project

The Heat Networks Investment Project (HNIP) is a major Government project which will invest up to £320m of capital funding in heat network projects, leveraging around £1bn of private investment.



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How are grants/loan amounts calculated?



Post HNIP funding, IRR sufficient to fully fund project

HNIP gap funding

Pre HNIP funding, IRR too low to fully fund project

We use our model based on your inputs to work out how much grant (or loan) is needed to enable your scheme to reach the required IRR

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Timeline



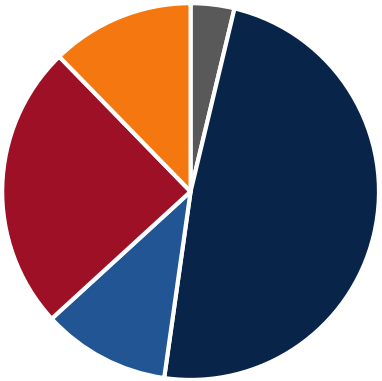
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Strong pipeline and investor engagement

CAPEX Pipeline

£1,358m of which £51m is under construction and £658.8m relates to HNIP projects

Heat Networks 2019 Q3 Pipeline: CAPEX by Development Stage



- Construction (in progress or complete)
- HNIP (not included in COMM/DPD)
- Commercialisation (inprogress) / DPD (complete)
- Feasibility (complete)
- Heat Mapping and Masterplanning (complete)



- Over 500 people have registered for our events to date.
- The investor conference had approximately 100 attendees.



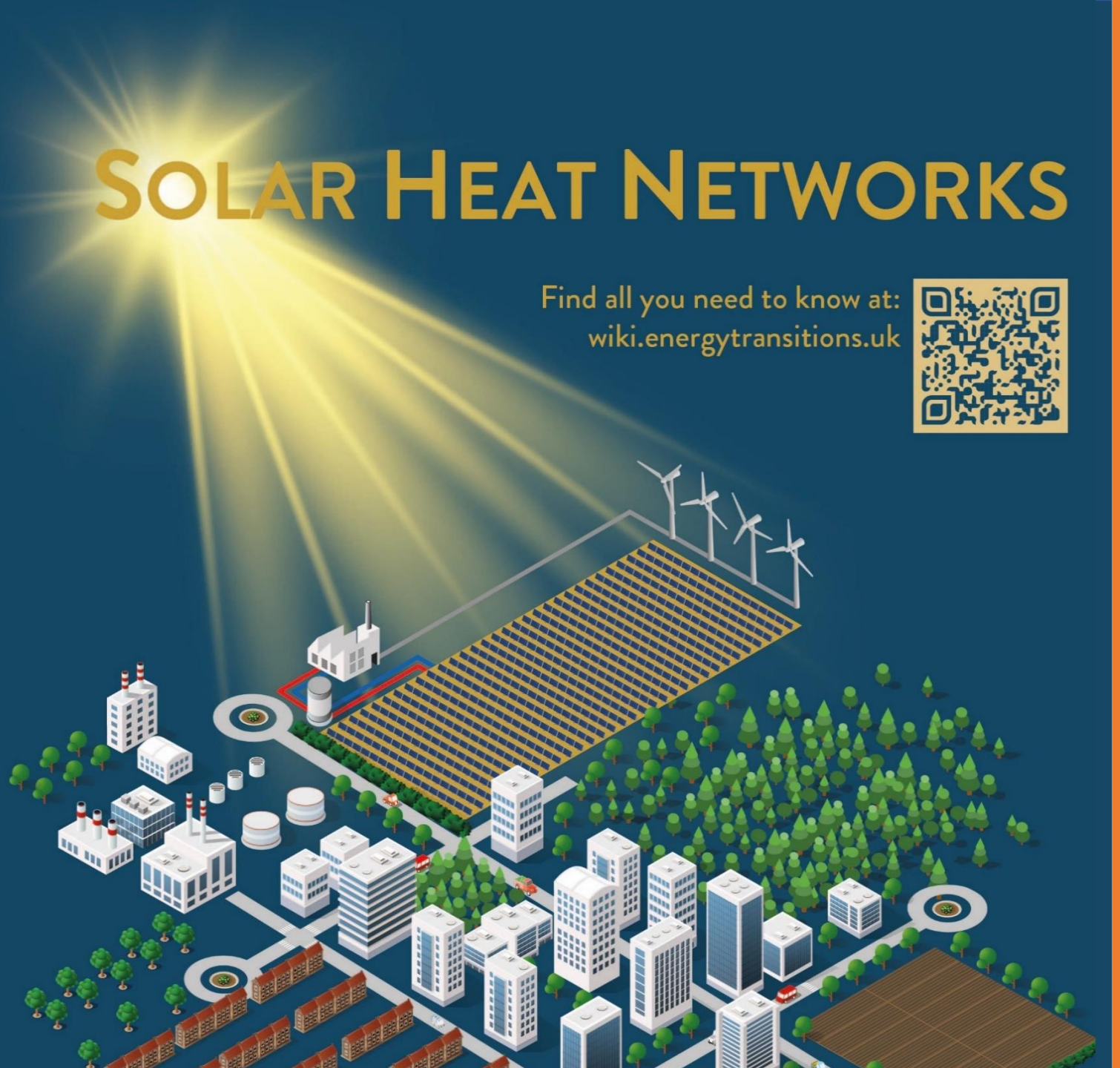


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Solar Heating and Cooling

Dr Richard Hall
(International Energy Agency's Solar Heating and Cooling Technology Collaboration Programme and the Solar Trade Association)



Speakers:

Richard Hall

Grant Feasey

Magdalena Kowalska

Christian Holter

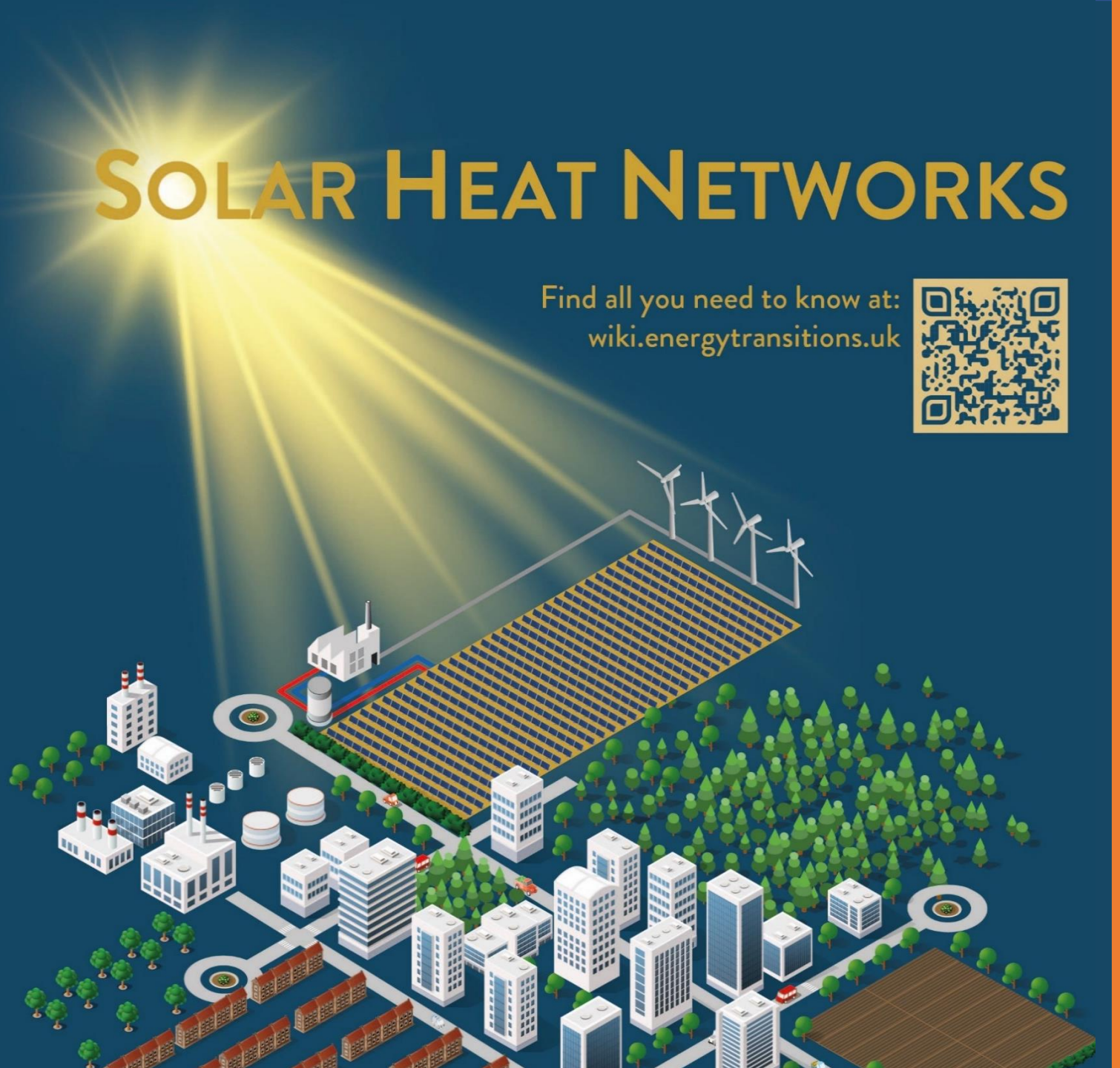
Renaldi Renaldi

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Introduction:

Richard Hall

1. Solar Heat Network Resources
2. Introduction to Solar Fraction
3. Introduction to Speakers / Agenda

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3. Solar Heat Networks Wiki Page

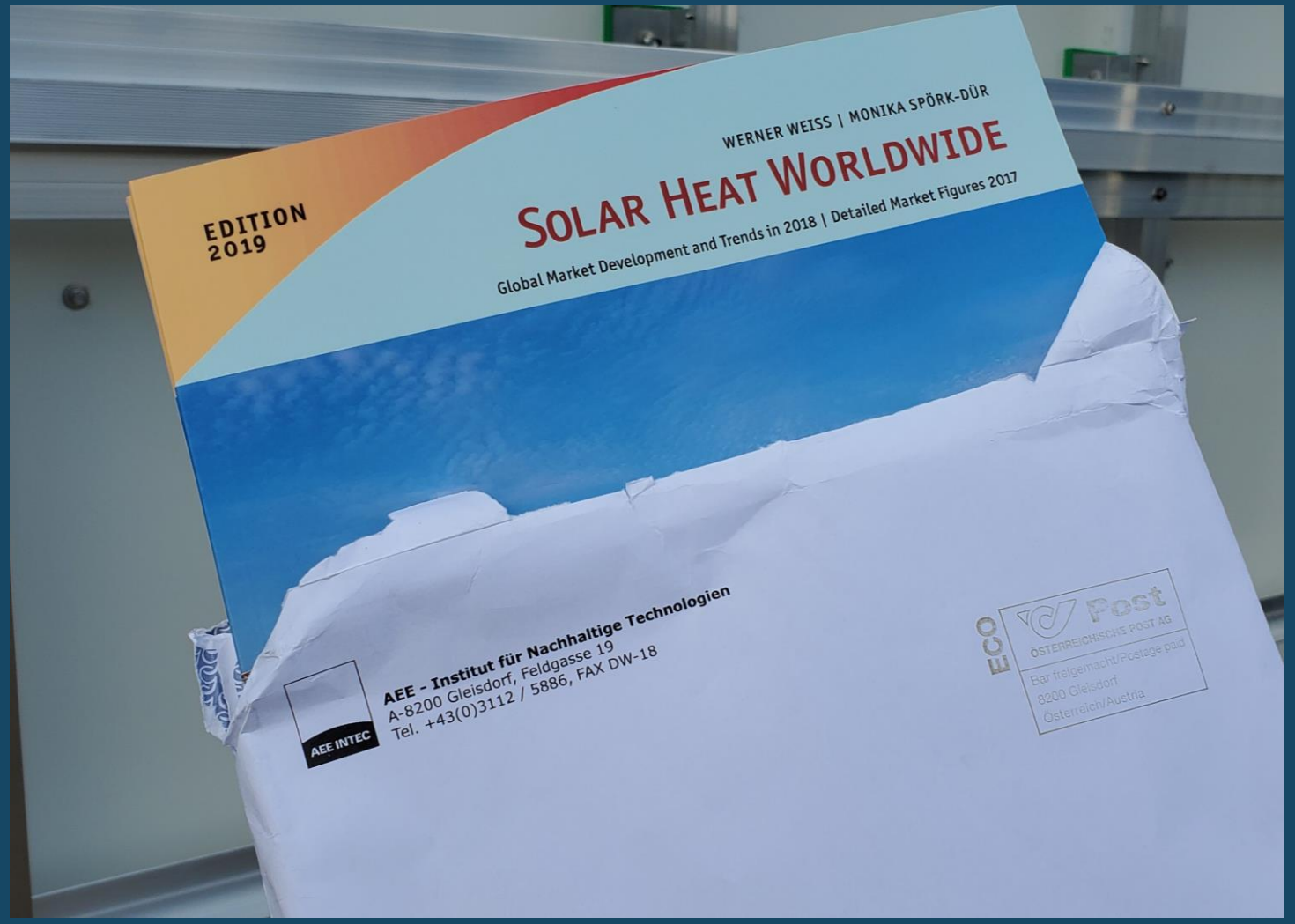
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https://www.iea-shc.org/solar-heat-worldwide

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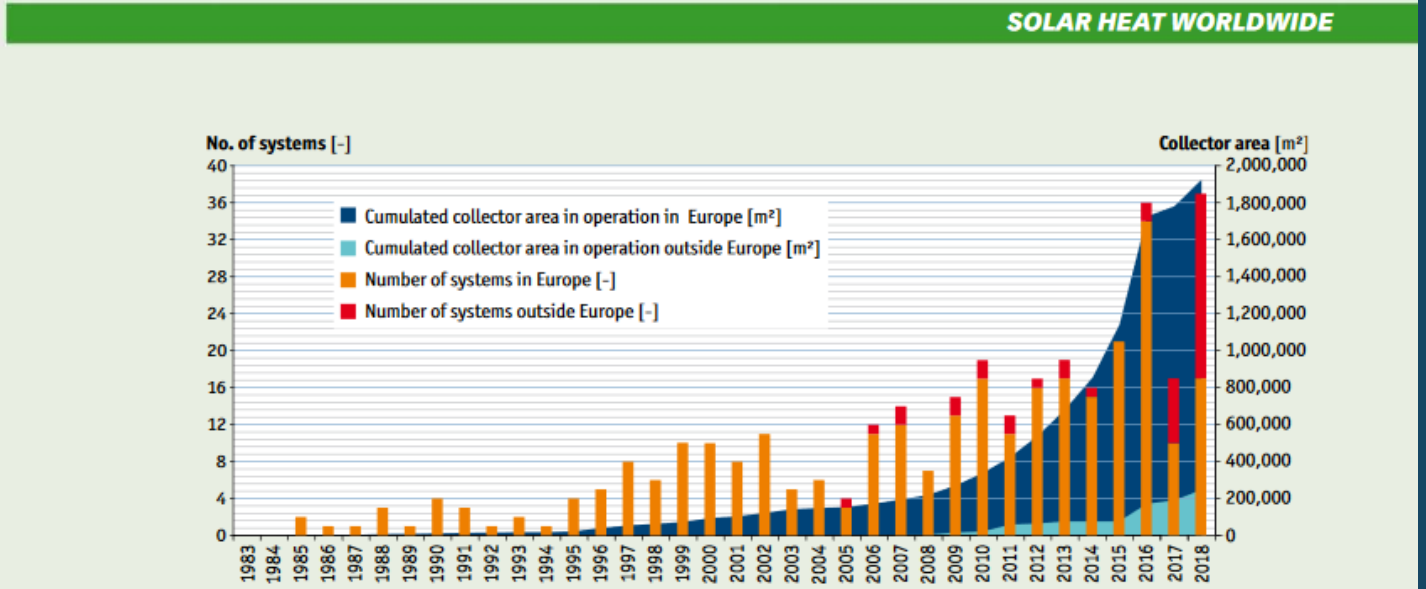


Figure 6: *Large-scale systems for solar district heating and large residential, commercial and public buildings worldwide – annual achievements and cumulated area in operation in 2018*

(Data source: Daniel Trier - PlanEnergi, DK, Jan-Olof Dalenbäck - Chalmers University of Technology, SE, Sabine Putz - IEA SHC Task 45, AT, Bärbel Epp - solarthermalworld.org, DE)

https://www.iea-shc.org/solar-heat-worldwide

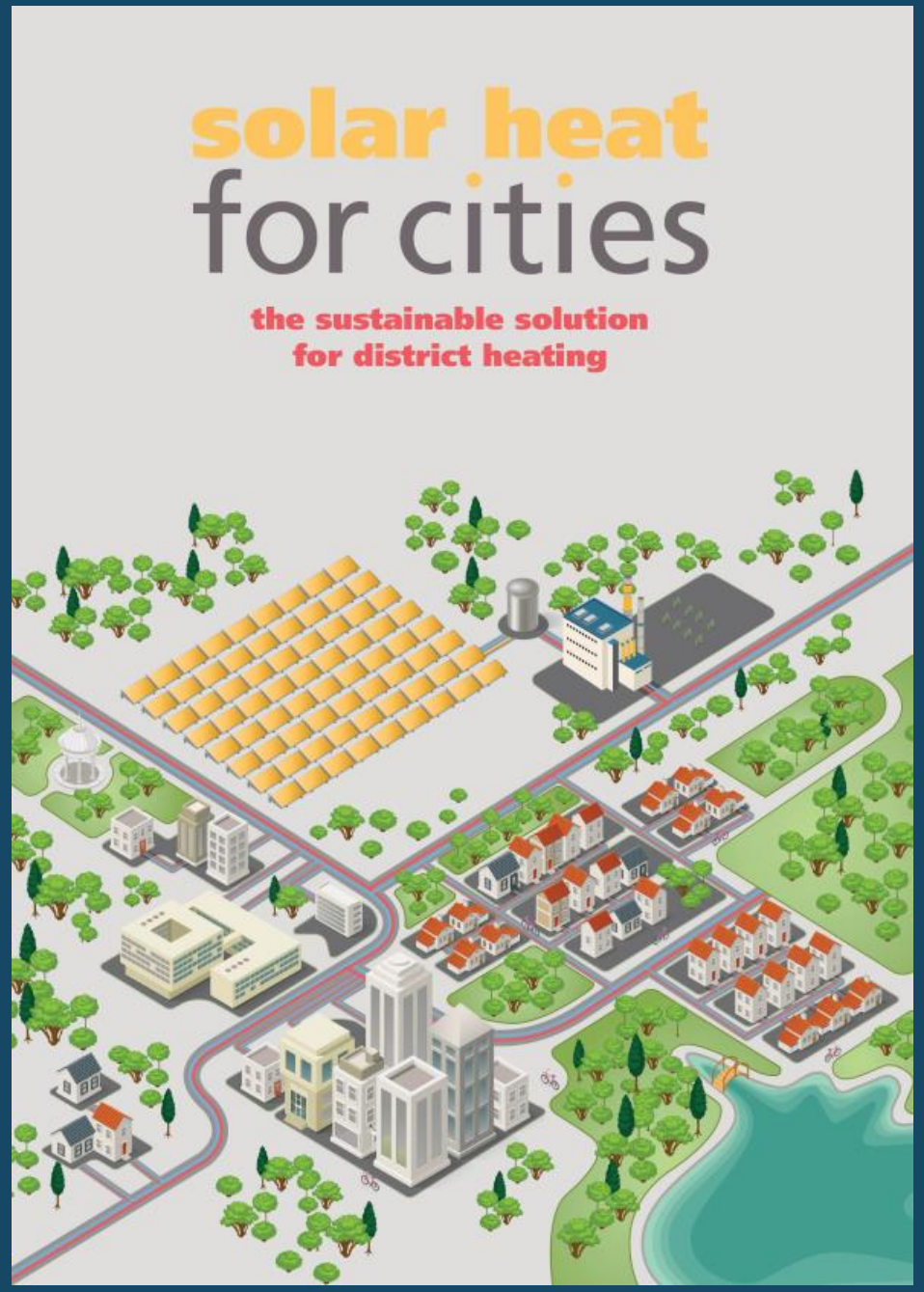
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Energy Transitions

First fully subsidised
SDH system in Tibet
Sun meets 90 % of space heating demand

Half the households in the Tibetan town of Langkazi have been connected to a new solar district heating plant since December 2018. Its solar fraction is above 90 % because solar heat is used to provide thermal comfort in winter only. Surplus energy produced in summer is directed to a pit storage system. Centralised devices producing hot water for showering are not common in these parts of China.

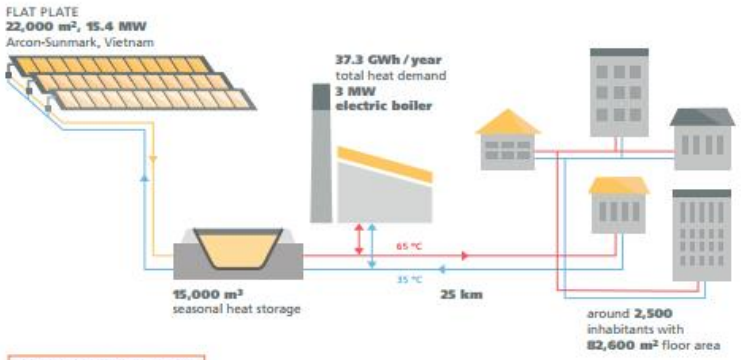




PHOTO: ARCON-SUNMARK

Who is who

Owner of system
Municipality of Langkazi
100 % sponsor of system
Central Chinese Government
Manufacturer of collectors
Arcon-Sunmark, Vietnam
Turnkey SDH supplier and operator
Solareast Arcon-Sunmark Large-Scale Solar Systems Integration, China

Only eight months to project completion was quite an achievement, considering the extreme weather in this part of the world and the logistics of getting personnel, equipment and material to the remote town.

"Between December 2018 and May 2019, the SDH plant has reached a solar fraction of 100 %, so that room temperatures in the connected buildings have remained at 16 °C or above."

AARON FENG GAO, *MANAGING DIRECTOR*

Solar Heat Network Resources

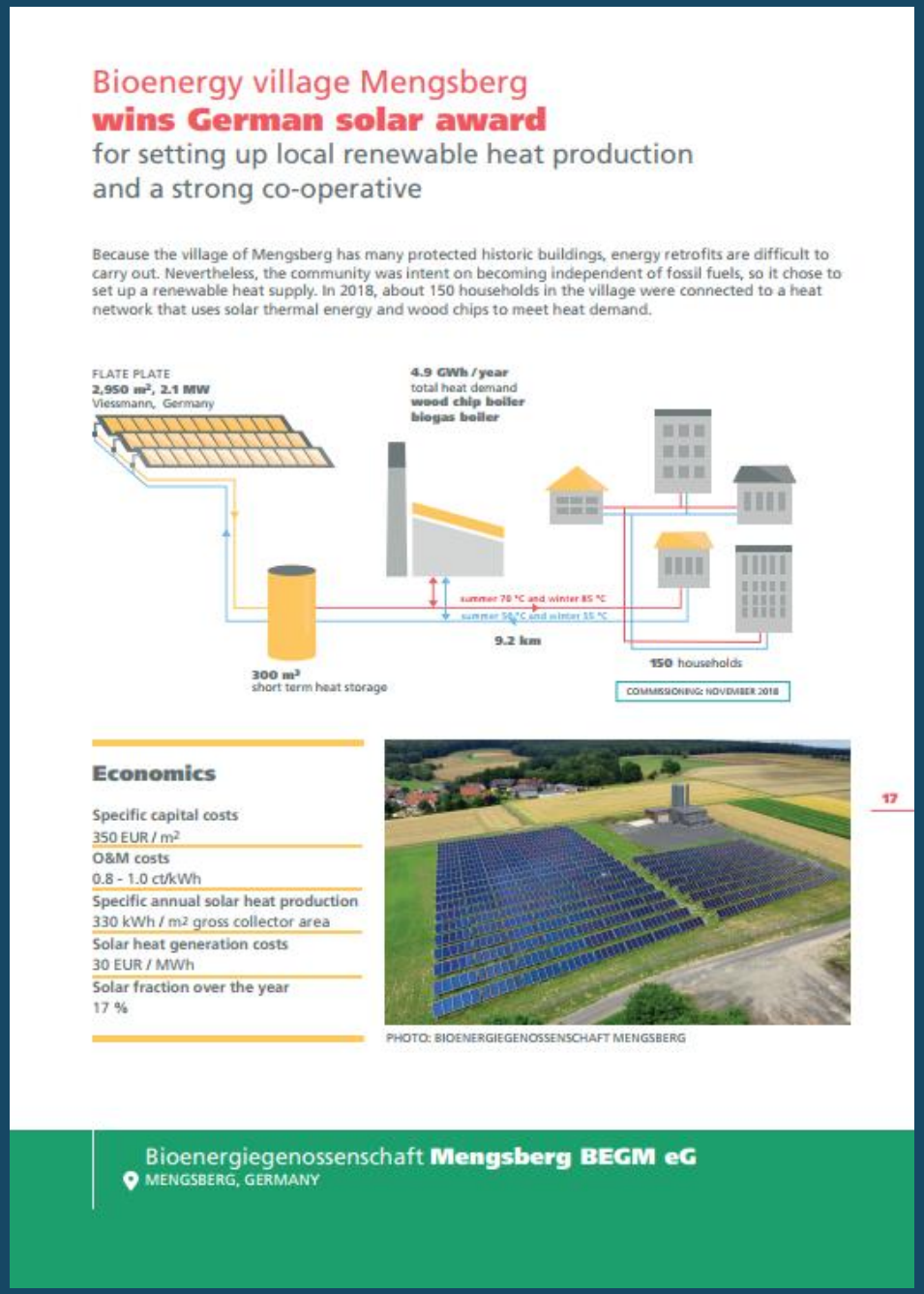
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Bioenergy village Mengsberg
wins German solar award
for setting up local renewable heat production
and a strong co-operative

Because the village of Mengsberg has many protected historic buildings, energy retrofits are difficult to carry out. Nevertheless, the community was intent on becoming independent of fossil fuels, so it chose to set up a renewable heat supply. In 2018, about 150 households in the village were connected to a heat network that uses solar thermal energy and wood chips to meet heat demand.

Economics

Specific capital costs	350 EUR / m²
O&M costs	0.8 - 1.0 ct/kWh
Specific annual solar heat production	330 kWh / m² gross collector area
Solar heat generation costs	30 EUR / MWh
Solar fraction over the year	17 %

PHOTO: BIOENERGIEGENOSSENSCHAFT MENGSBERG

17

Bioenergiegenossenschaft **Mengsberg BEGM eG**
MENGSBERG, GERMANY

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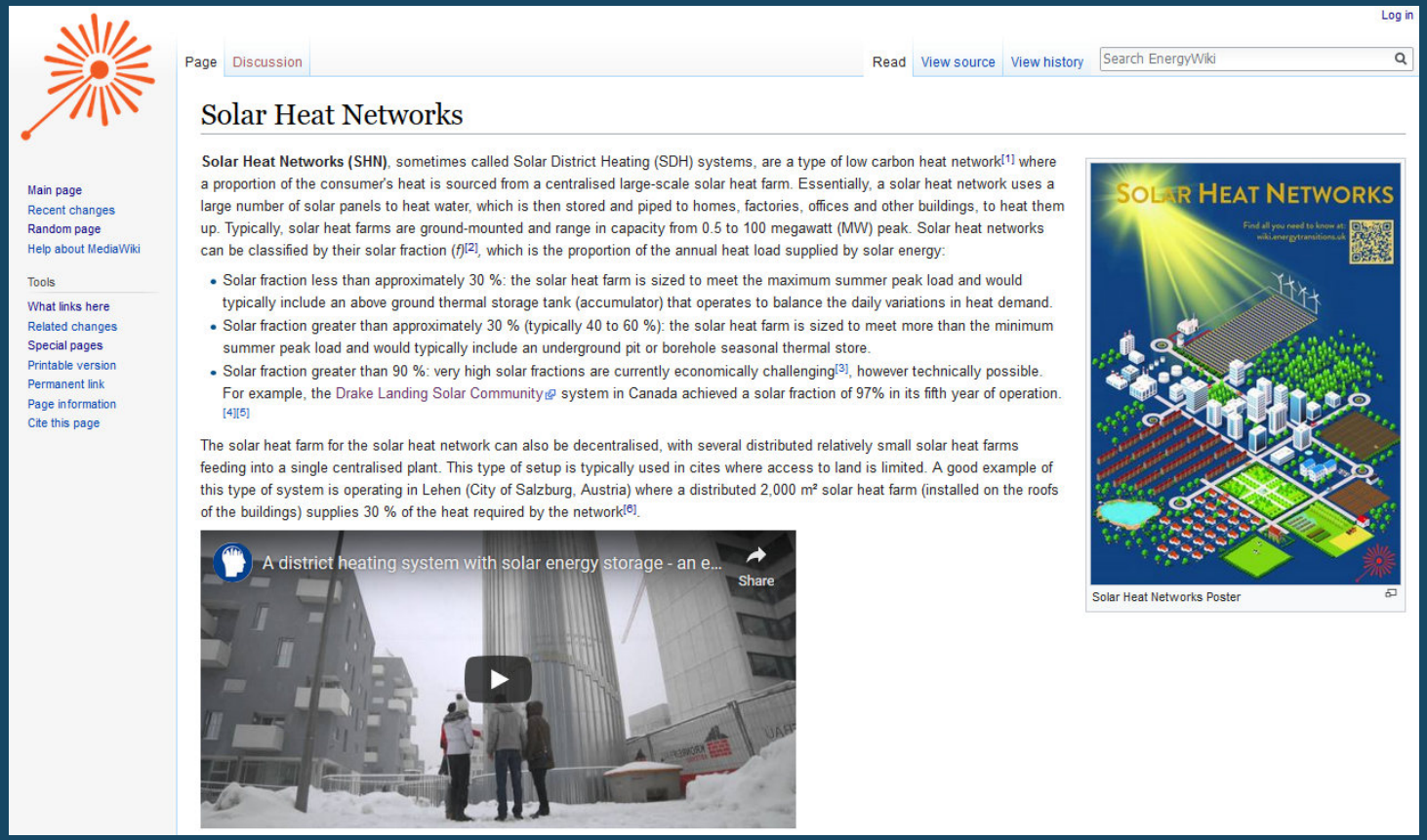
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Deployment

History



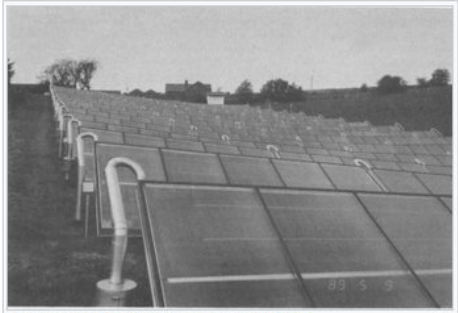
Northview Junior High School (USA) solar energy system, designed and installed by Honeywell in 1974[9]

The first large-scale solar heat networks started to be deployed in the USA and Europe around the 1970s.

In 1973, the Research Applied to National Needs (RANN) organisation in the USA fast-tracked the Solar Energy School Heating Augmentation Experiment project with the aim of demonstrating the use of solar heat at large-scales. The Northview Junior High School (Osseo, Minnesota) solar energy system (see image on left) was designed as a solar heat network and consisted of a 465 m^2 ground-mounted solar heat array (flat plate collectors) and a 13.6 m^3 hot water tank (the system was designed and installed by Honeywell).[9]

In Europe, the first solar heat networks were installed in Sweden from around 1979. By 2007, there were around 119 solar heat networks installed across Europe.[10]

The first solar heat network in Denmark was installed in 1985 at Vester Nebel. It consisted of 300 m^2 of flat plate collectors, which were installed on the field in front of the district heating substation (straw and oil) and supplied approximately 100 houses with solar heat.[12]



Solar heating plan in Saltum, Denmark (1988)[11]

The second system was installed in 1988 in Saltum, a village of about 600 inhabitants. This system, installed by Saltum Varmevaerk A.m.b.A, consisted of 1,100 m^2 of ground-mounted flat plate collectors (5 % solar fraction).[13] The solar heat farm was installed on a slope at the boarder of the village and mounted on concrete blocks placed on top of the soil (see image on right).[14]

The concept of sizing a solar heat farm to provide 100 % of the summer heat load of the heat network (approximately 20 % solar fraction) appears to have originated from the development of the Marstal Fjernvarme A.m.b.a. (Marstal District Heating Ltd.) solar heat farm in Ærø, Denmark[15]. In the document 'Summary technical description of the SUNSTORE 4 plant in Marstal' it states that the system was designed (in 1994) so that the "solar fraction should be 100 % in the summer months, the demand to the supply temperature was 72 –70° C" and "to comply with this demand, it was considered to build the system with adjustable flow to reach a higher supply temperature, even when the solar radiation was low. This method of controlling a solar collector plant was however not very known, most plants runs with constantly high flow and a variable supply temperature"[16][17][18][19].

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Detailed Guidance

Links to detailed guidance on various aspects of the design, feasibility, modelling and performance of solar heat networks, amongst other topics, can be found in the table below.

Funding Models		
Public participation models for solar district heating	Austria Solar	Download
A funding programme of the Climate and Energy Fund for the Heat Transition	Austria Solar	Download
General Guidance	**Author / Source**	**Download**
Nomenclature	solar-district-heating.eu/	Download
Solar district heating: Inspiration and experiences from Denmark	PlanEnergi	Download
Success factors in solar district heating	solar-district-heating.eu/	Download
Solar district heating guidelines: Collection of fact sheets	solar-district-heating.eu/	Download
Categories of solar district heating systems	solar-district-heating.eu/	Download
Introduction to solar district heating: From idea to operating system	solar-district-heating.eu/	Download
Supervision of construction and commissioning	solar-district-heating.eu/	Download
Solar heat combined with other fuels	solar-district-heating.eu/	Download
Feasibility		
Preliminary investigations	solar-district-heating.eu/	Download
Solar district heating in urban planning	solar-district-heating.eu/	Download
Calculation tools and methods	solar-district-heating.eu/	Download
Implementation of solar heat networks in cites	solar-district-heating.eu/	Download
Collector Field		
Solar collectors	solar-district-heating.eu/	Download
Where to place the solar collectors	solar-district-heating.eu/	Download
Temperature variations	solar-district-heating.eu/	Download
Correction of collector efficiency parameters depending on variations in collector type, fluid type, collector flow rate and collector tilt	DTU	Download
Requirements & guidelines for collector loop installation	AEE-INTEC	Download

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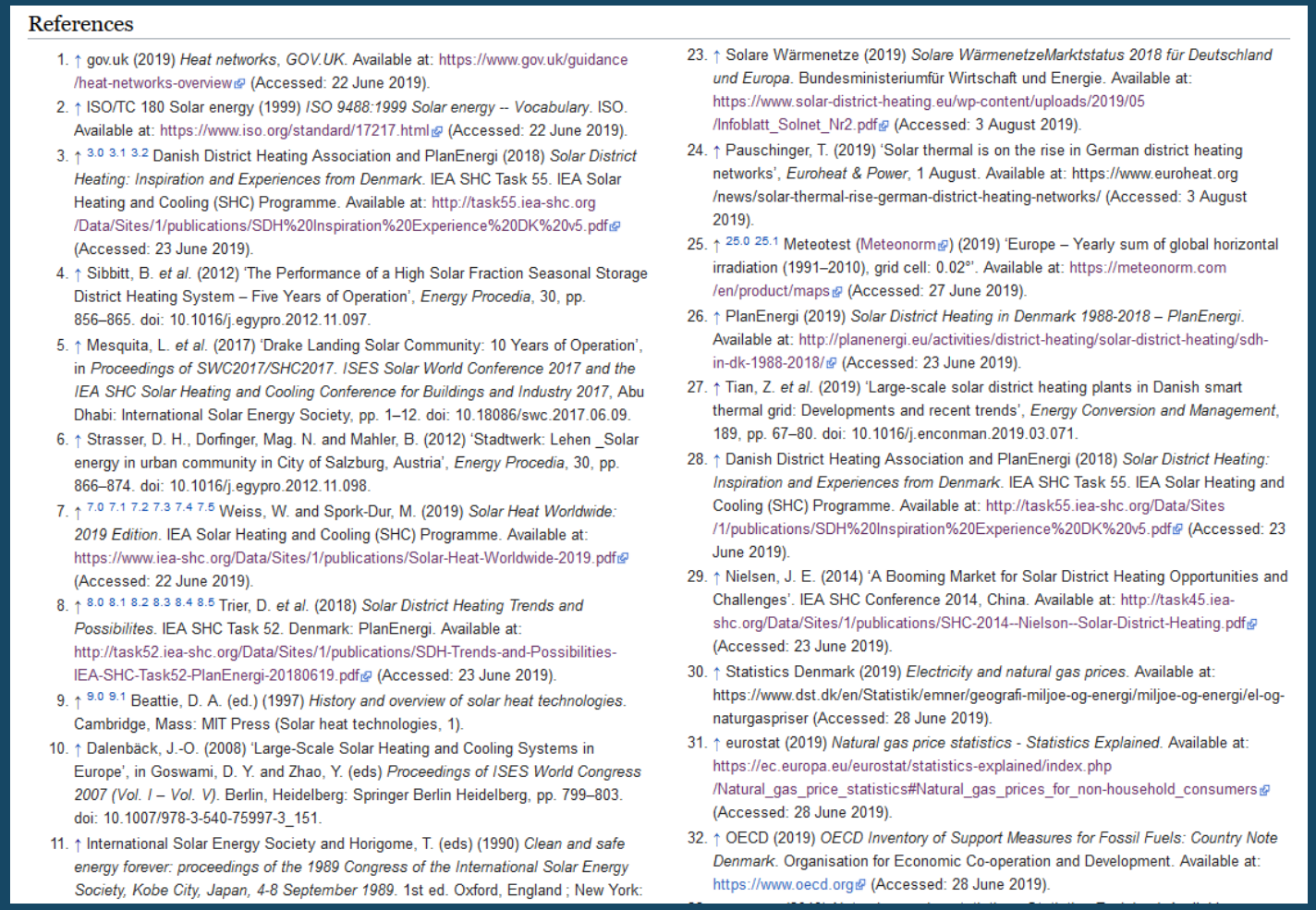
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3. ↑ 3.0 3.1 3.2 Danish District Heating Association and PlanEnergi (2018) *Solar District Heating: Inspiration and Experiences from Denmark*. IEA SHC Task 55. IEA Solar Heating and Cooling (SHC) Programme. Available at: http://task55.iea-shc.org/Data/Sites/1/publications/SDH%20Inspiration%20Experience%20DK%20v5.pdf (Accessed: 23 June 2019).
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7. ↑ 7.0 7.1 7.2 7.3 7.4 7.5 Weiss, W. and Spork-Dur, M. (2019) *Solar Heat Worldwide: 2019 Edition*. IEA Solar Heating and Cooling (SHC) Programme. Available at: https://www.iea-shc.org/Data/Sites/1/publications/Solar-Heat-Worldwide-2019.pdf (Accessed: 22 June 2019).
8. ↑ 8.0 8.1 8.2 8.3 8.4 8.5 Trier, D. *et al.* (2018) *Solar District Heating Trends and Possibilites*. IEA SHC Task 52. Denmark: PlanEnergi. Available at: http://task52.iea-shc.org/Data/Sites/1/publications/SDH-Trends-and-Possibilities-IEA-SHC-Task52-PlanEnergi-20180619.pdf (Accessed: 23 June 2019).
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25. ↑ 25.0 25.1 Meteotest (Meteonorm) (2019) 'Europe – Yearly sum of global horizontal irradiation (1991–2010), grid cell: 0.02°'. Available at: https://meteonorm.com/en/product/maps (Accessed: 27 June 2019).
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27. ↑ Tian, Z. *et al.* (2019) 'Large-scale solar district heating plants in Danish smart thermal grid: Developments and recent trends', *Energy Conversion and Management*, 189, pp. 67–80. doi: 10.1016/j.enconman.2019.03.071.
28. ↑ Danish District Heating Association and PlanEnergi (2018) *Solar District Heating: Inspiration and Experiences from Denmark*. IEA SHC Task 55. IEA Solar Heating and Cooling (SHC) Programme. Available at: http://task55.iea-shc.org/Data/Sites/1/publications/SDH%20Inspiration%20Experience%20DK%20v5.pdf (Accessed: 23 June 2019).
29. ↑ Nielsen, J. E. (2014) 'A Booming Market for Solar District Heating Opportunities and Challenges'. IEA SHC Conference 2014, China. Available at: http://task45.iea-shc.org/Data/Sites/1/publications/SHC-2014--Nielson--Solar-District-Heating.pdf (Accessed: 23 June 2019).
30. ↑ Statistics Denmark (2019) *Electricity and natural gas prices*. Available at: https://www.dst.dk/en/Statistik/emner/geografi-miljoe-og-energi/miljoe-og-energi/el-og-naturgaspriser (Accessed: 28 June 2019).
31. ↑ eurostat (2019) *Natural gas price statistics - Statistics Explained*. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Natural_gas_price_statistics#Natural_gas_prices_for_non-household_consumers (Accessed: 28 June 2019).
32. ↑ OECD (2019) *OECD Inventory of Support Measures for Fossil Fuels: Country Note Denmark*. Organisation for Economic Co-operation and Development. Available at: https://www.oecd.org (Accessed: 28 June 2019).

https://wiki.energytransitions.uk/wiki/Solar_Heat_Networks

Solar Heat Network Resources

1. Solar Heat Worldwide
2. Solar Heat for Cities
3. **Solar Heat Networks Wiki Page**

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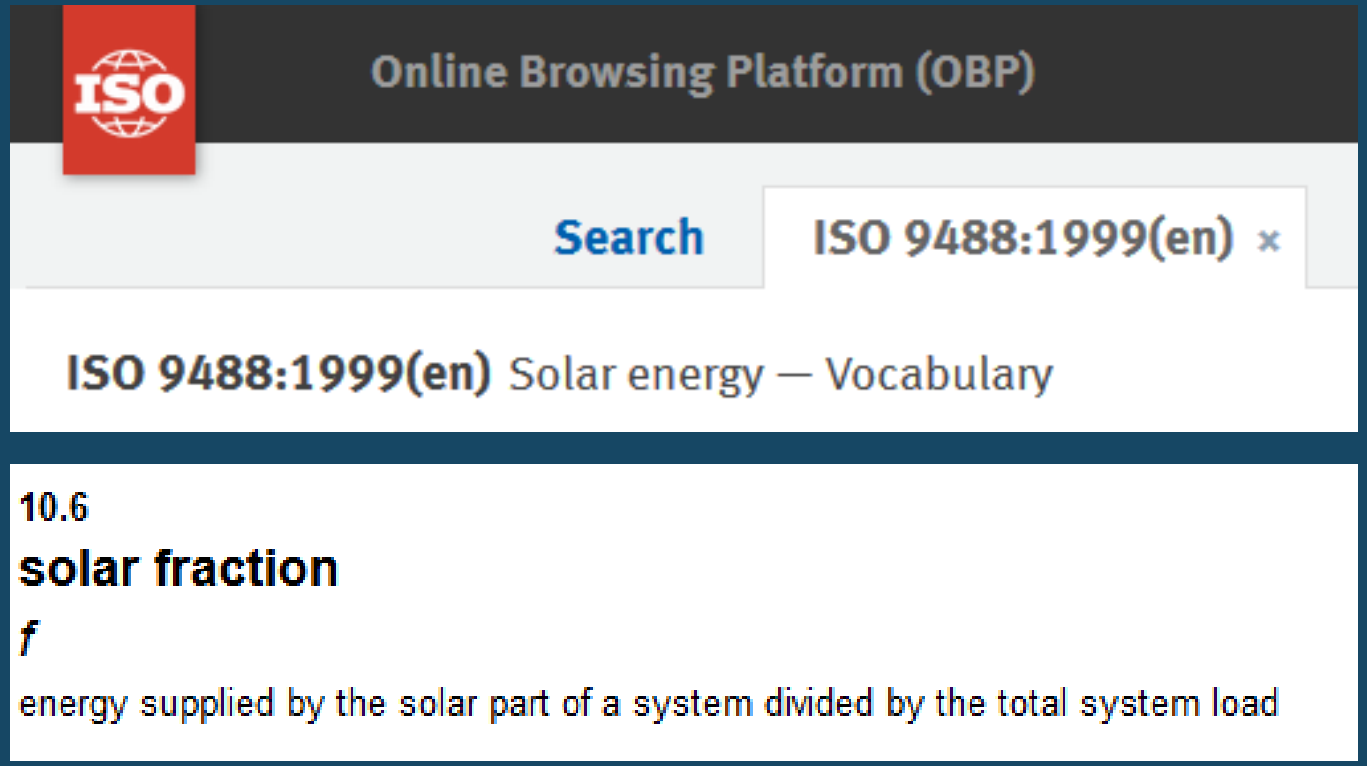
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SOLAR TRADE ASSOCIATION HEAT

Energy Transitions

Introduction to Solar Fraction

= the usable solar energy output divided by total energy delivered from the heat network each year



https://www.iso.org

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Concept of Solar Fraction

= the usable solar energy output divided by total energy delivered from the heat network each year

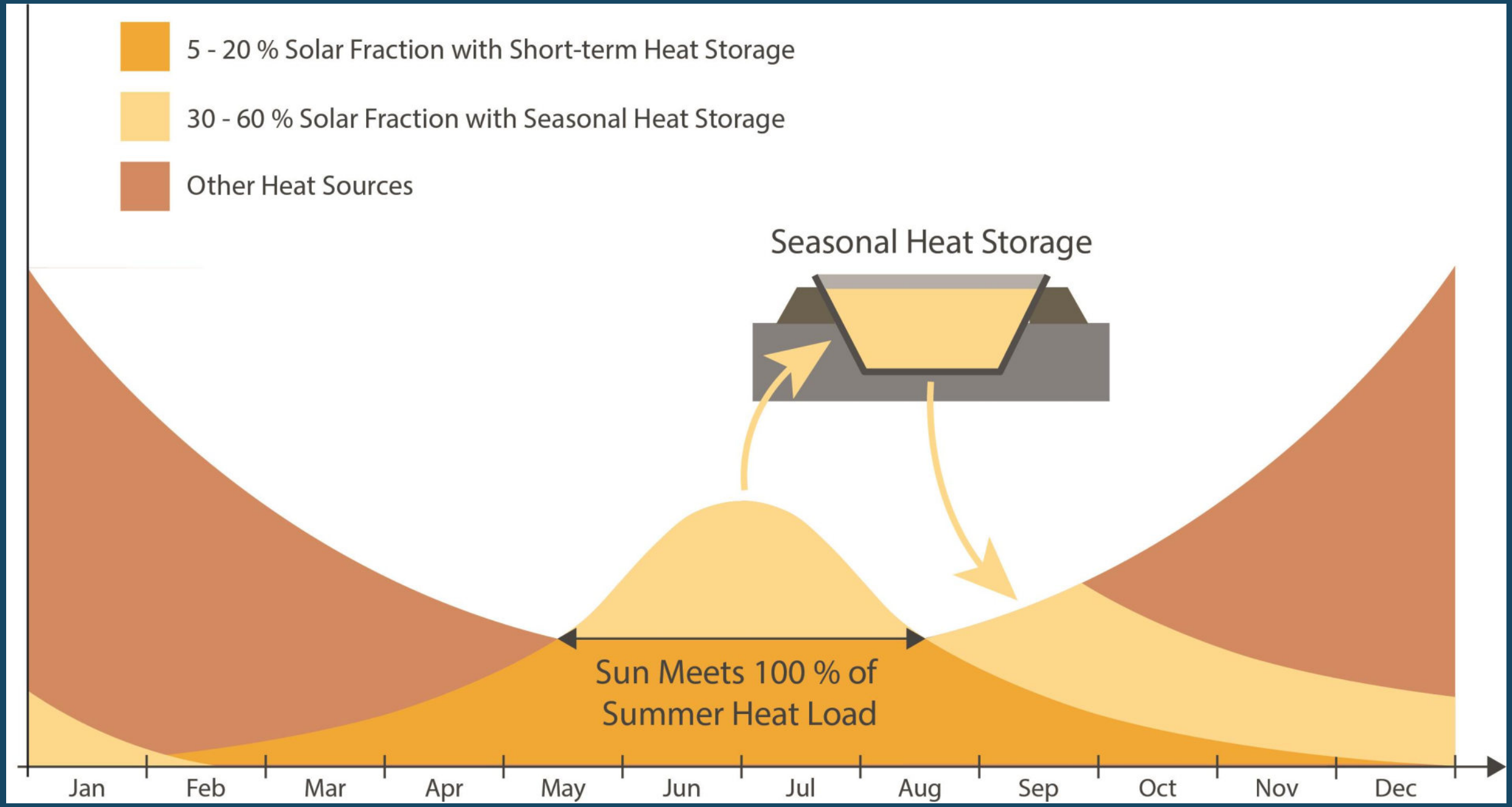
- **Solar fraction less than approximately 30 %:** solar heat farm is sized to meet maximum summer peak load & would typically include an above ground thermal storage tank (accumulator) that operates to balance daily variations in heat demand
- **Solar fraction greater than approximately 30 % (typically 40 to 60 %):** solar heat farm is sized to meet more than minimum summer peak load & would typically include an underground pit or borehole seasonal thermal store
- **Solar fraction greater than 90 %:** very high solar fractions are currently economically challenging, but technically possible. E.g. Drake Landing Solar Community system in Canada achieved solar fraction of 97% in fifth year of operation

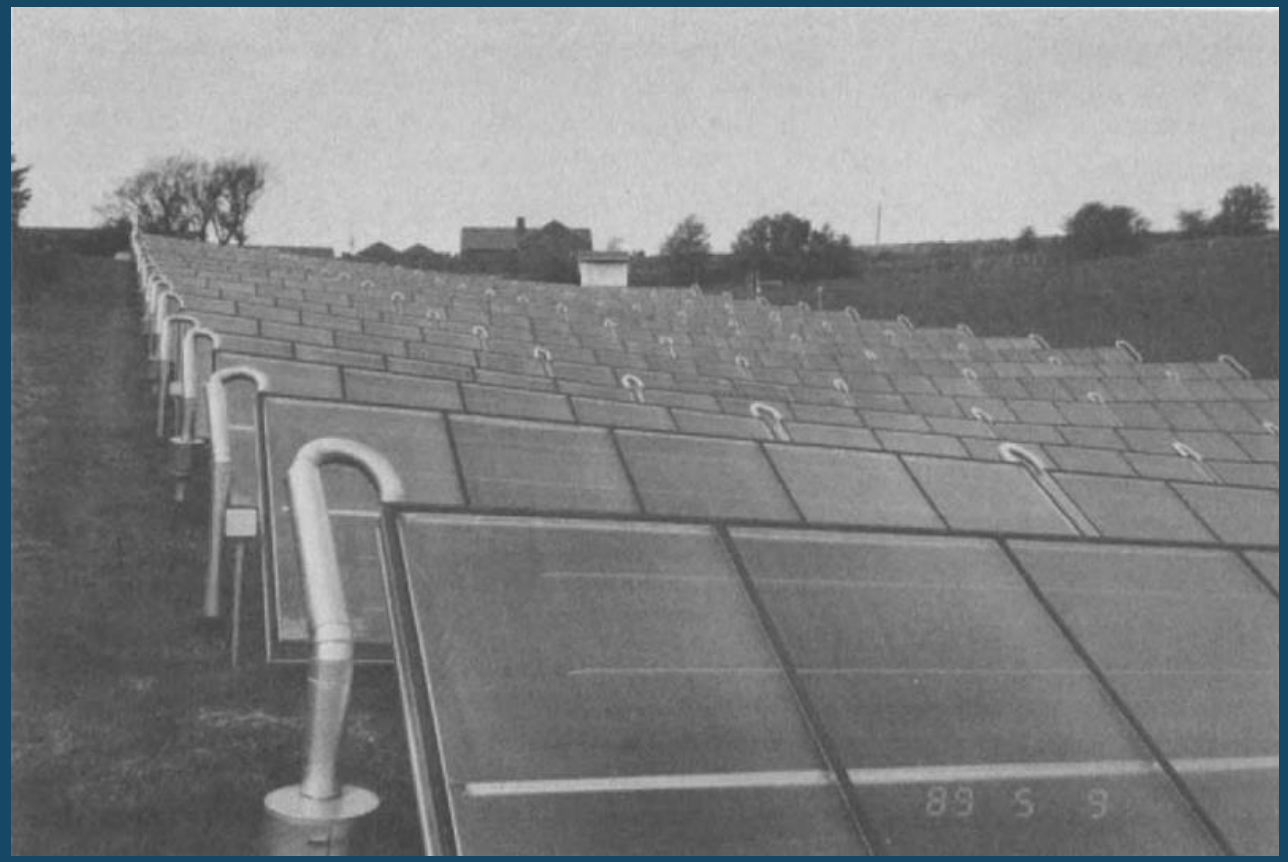
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5 - 20 % Solar Fraction with Short-term Heat Storage
30 - 60 % Solar Fraction with Seasonal Heat Storage
Other Heat Sources
Seasonal Heat Storage
Sun Meets 100 % of
Summer Heat Load
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec



The second system in Denmark was installed in 1988 in Saltum (village of ~ 600 inhabitants). Installed by Saltum Varmevaerk A.m.b.A, it consisted of 1,100 m^2 of ground-mounted flat plate collectors **(5 % solar fraction)**. It was installed on a slope at the border of the village & mounted on concrete blocks placed on top of the soil.

Concept of Solar Fraction

= the usable solar energy output divided by total energy delivered from the heat network each year

5 %

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"445 times in the past seven months a truck has been loaded with solar collectors at the Arcon-Sunmark headquarters in Denmark, in order to make the an hour and a half drive to the construction site of the world's largest solar heating system. 12.436 collectors each measuring 12,6 m^2 giving a total aperture area of 156.694 m^2"

http://arcon-sunmark.com

Concept of Solar Fraction

= the usable solar energy output divided by total energy delivered from the heat network each year

20 %

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"On a sunny summer day 2,7 million litres of water will pass through the system every hour. The system is connected to the main heating facility by 1,2 kilometres of piping. With an annual yield of 80.000 MWh the system will cover the heating requirement of 4.400 average households or **20% of the annual demand**."

http://arcon-sunmark.com

Concept of Solar Fraction

= the usable solar energy output divided by total energy delivered from the heat network each year

20 %

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"The 22,000 m2 solar collector field will from now on cover more than **90% of the heat demand** in Langkazi. The system also has a 15,000 m3 storage pit in order to store the energy so it can be used when demanded. As part of the project a 25,000 meter long piping infrastructure has been constructed in the town in order to connect 82,000 m2 households to the solar district heating system"

http://arcon-sunmark.com

Concept of Solar Fraction

= the usable solar energy output divided by total energy delivered from the heat network each year

90 %

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Takeaway Message

20 is Plenty

Concept of Solar Fraction

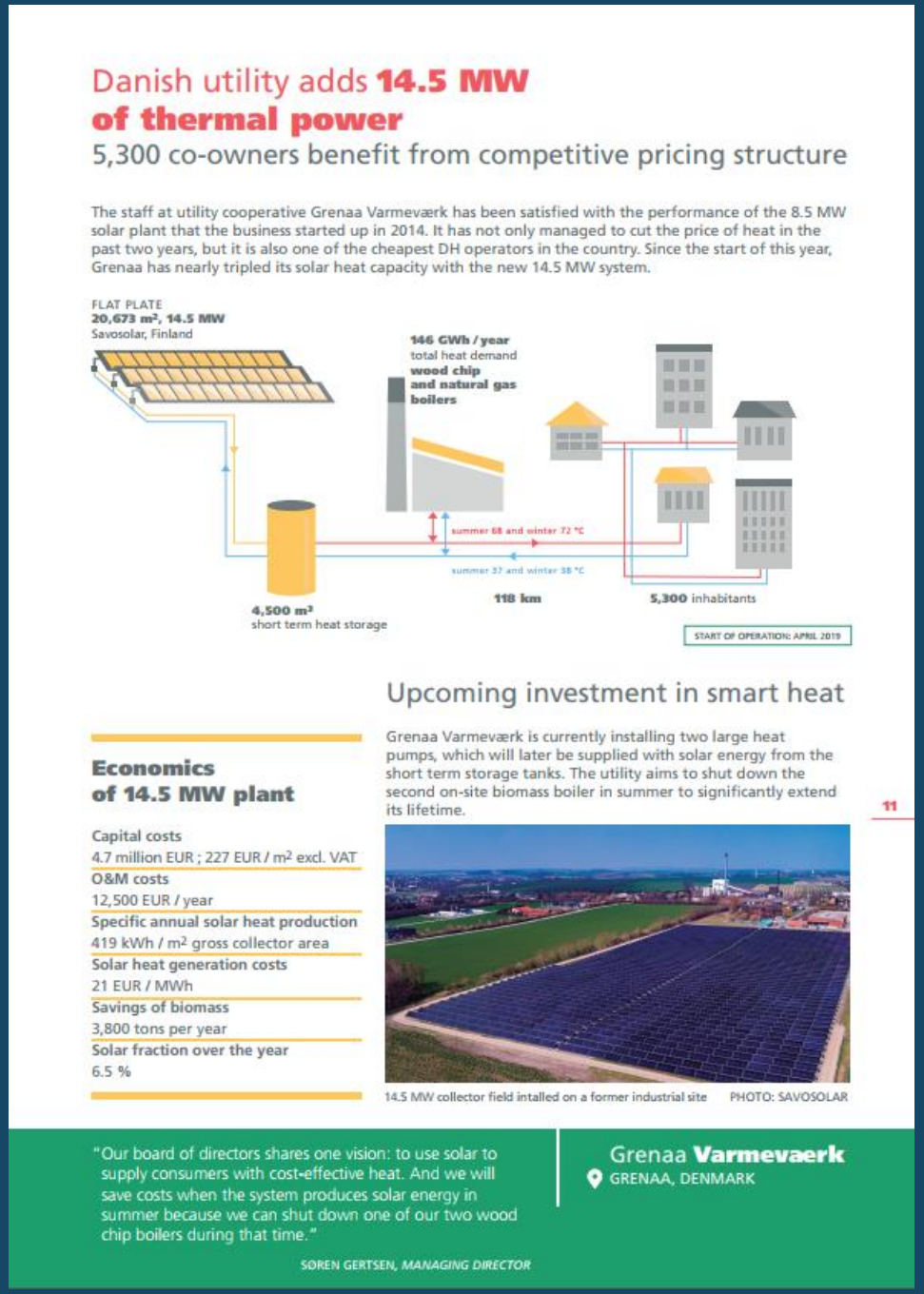
= the usable solar energy output divided by total energy delivered from the heat network each year

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Danish utility adds **14.5 MW of thermal power**

5,300 co-owners benefit from competitive pricing structure

The staff at utility cooperative Grenaa Varmeværk has been satisfied with the performance of the 8.5 MW solar plant that the business started up in 2014. It has not only managed to cut the price of heat in the past two years, but it is also one of the cheapest DH operators in the country. Since the start of this year, Grenaa has nearly tripled its solar heat capacity with the new 14.5 MW system.

Upcoming investment in smart heat

Grenaa Varmeværk is currently installing two large heat pumps, which will later be supplied with solar energy from the short term storage tanks. The utility aims to shut down the second on-site biomass boiler in summer to significantly extend its lifetime.

Economics of 14.5 MW plant

Capital costs	4.7 million EUR ; 227 EUR / m² excl. VAT
O&M costs	12,500 EUR / year
Specific annual solar heat production	419 kWh / m² gross collector area
Solar heat generation costs	21 EUR / MWh
Savings of biomass	3,800 tons per year
Solar fraction over the year	6.5 %

14.5 MW collector field intalled on a former industrial site PHOTO: SAVOSOLAR

11

"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."

SØREN GERTSEN, *MANAGING DIRECTOR*

Grenaa **Varmevaerk**
GRENAA, DENMARK

Concept of Solar Fraction

= the usable solar energy output divided by total energy delivered from the heat network each year

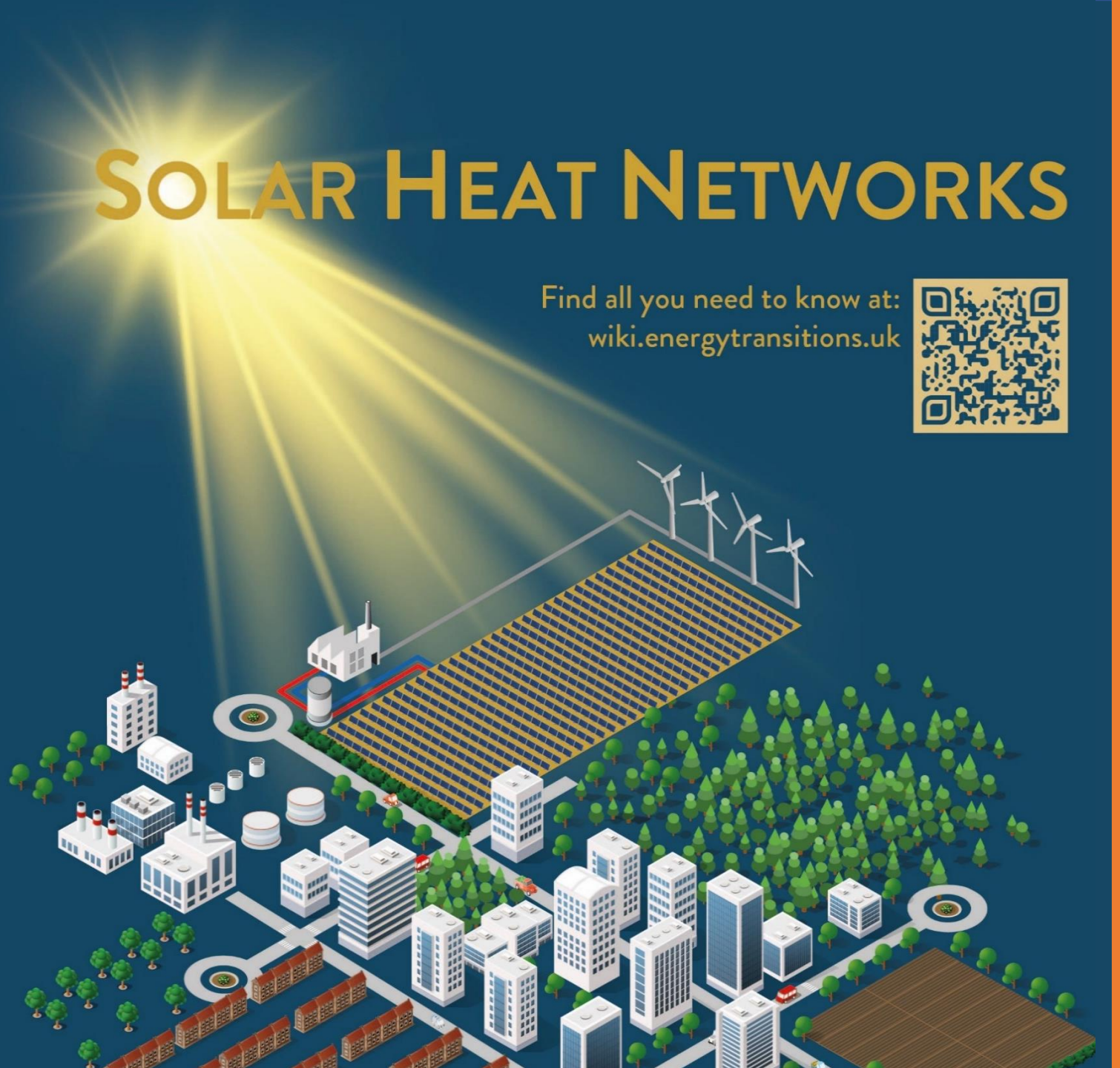
6.5 %

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Agenda:

Grant Feasey — AES Solar Established 1979

Magdalena Kowalska — PlanEnergi

Christian Holter — SOLID solarinstallation+design

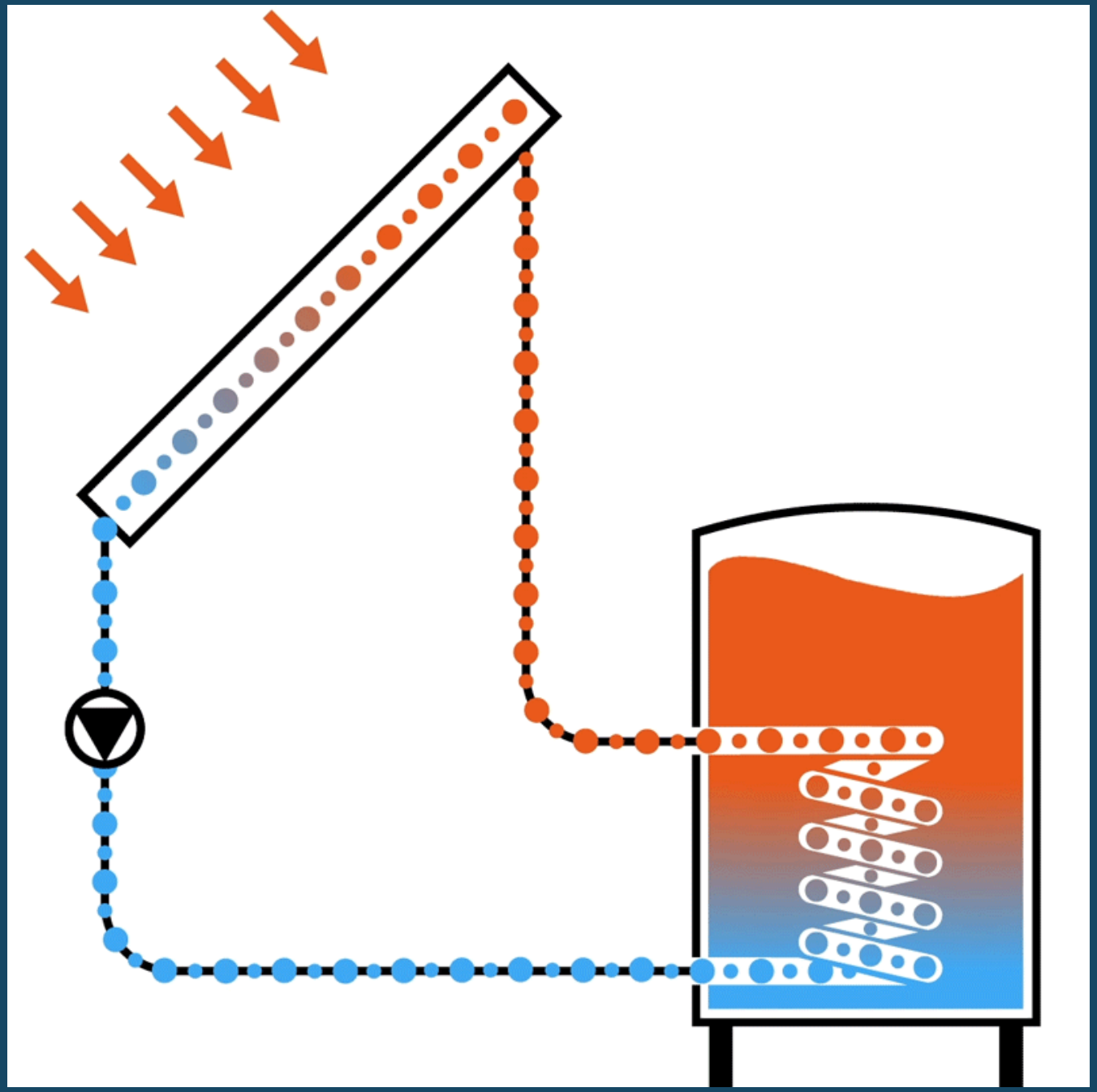
Renaldi Renaldi — Oxford Martin School, University of Oxford

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Grant Feasey



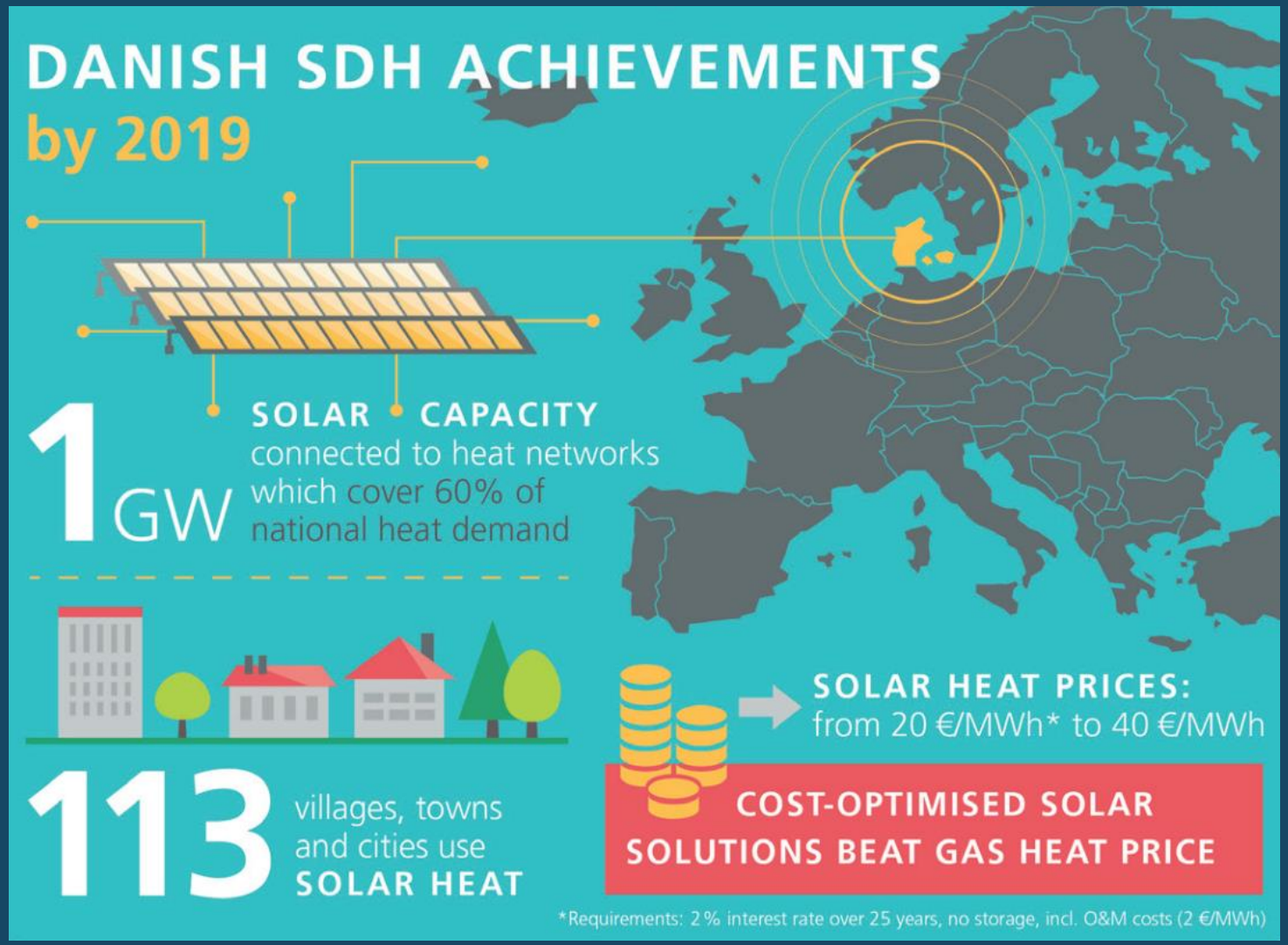
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Magdalena Kowalska



PlanEnergi

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Canada: District Heating with 90 % Solar Fraction

Submitted by Baerbel Epp on September 24, 2011



As Bruce Sibbitt, Engineer at Natural Resources Canada (NRCan), announced during his presentation at the Solar World Congress in Kassel, Germany, in September, the solar district heating system at the Drake Landing Solar Community has - in its fourth year in operation - almost reached the planned solar fraction of 90 %. In addition to borehole heat storage of 34,000 m^3, the system is equipped with two short-term storage tanks, which have a capacity of 120 m^3 of water each.

Photo: Natural Resources Canada

https://www.solarthermalworld.org/news/canada-district-heating-90-solar-fraction

Renaldi Renaldi



OXFORD MARTIN SCHOOL

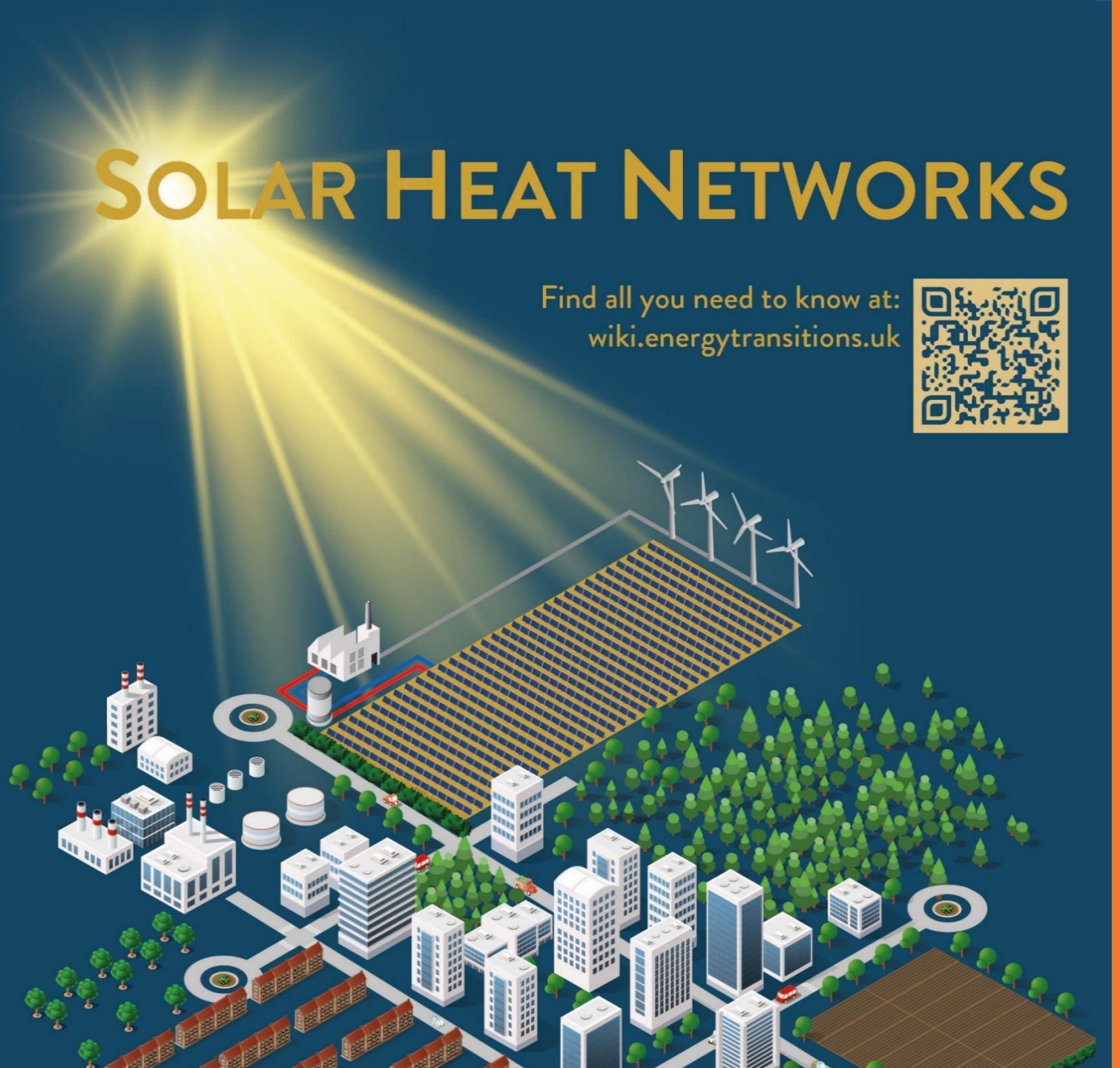
UNIVERSITY OF OXFORD

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Speakers:

Richard Hall

Grant Feasey

Magdalena Kowalska

Christian Holter

Renaldi Renaldi

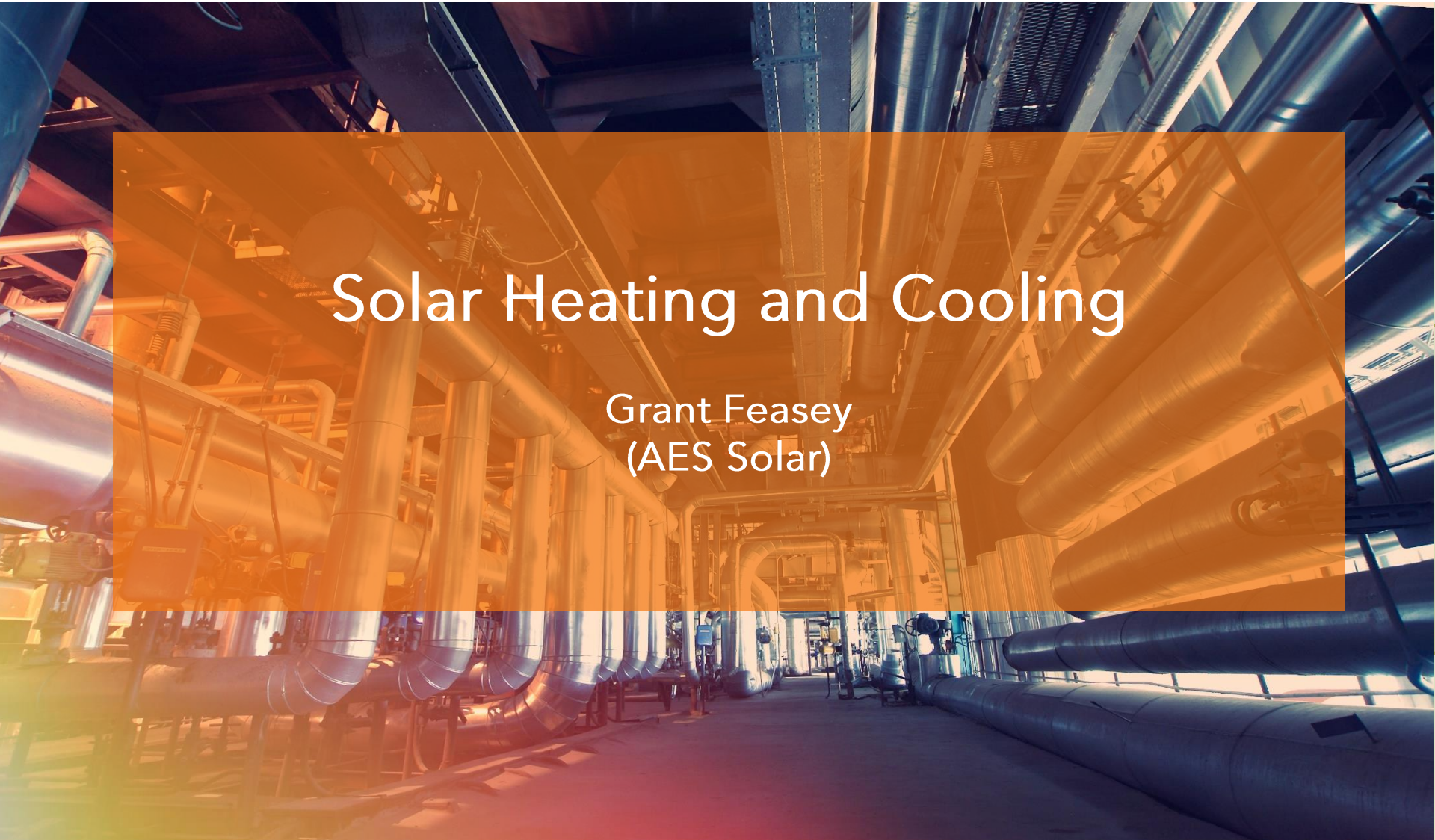
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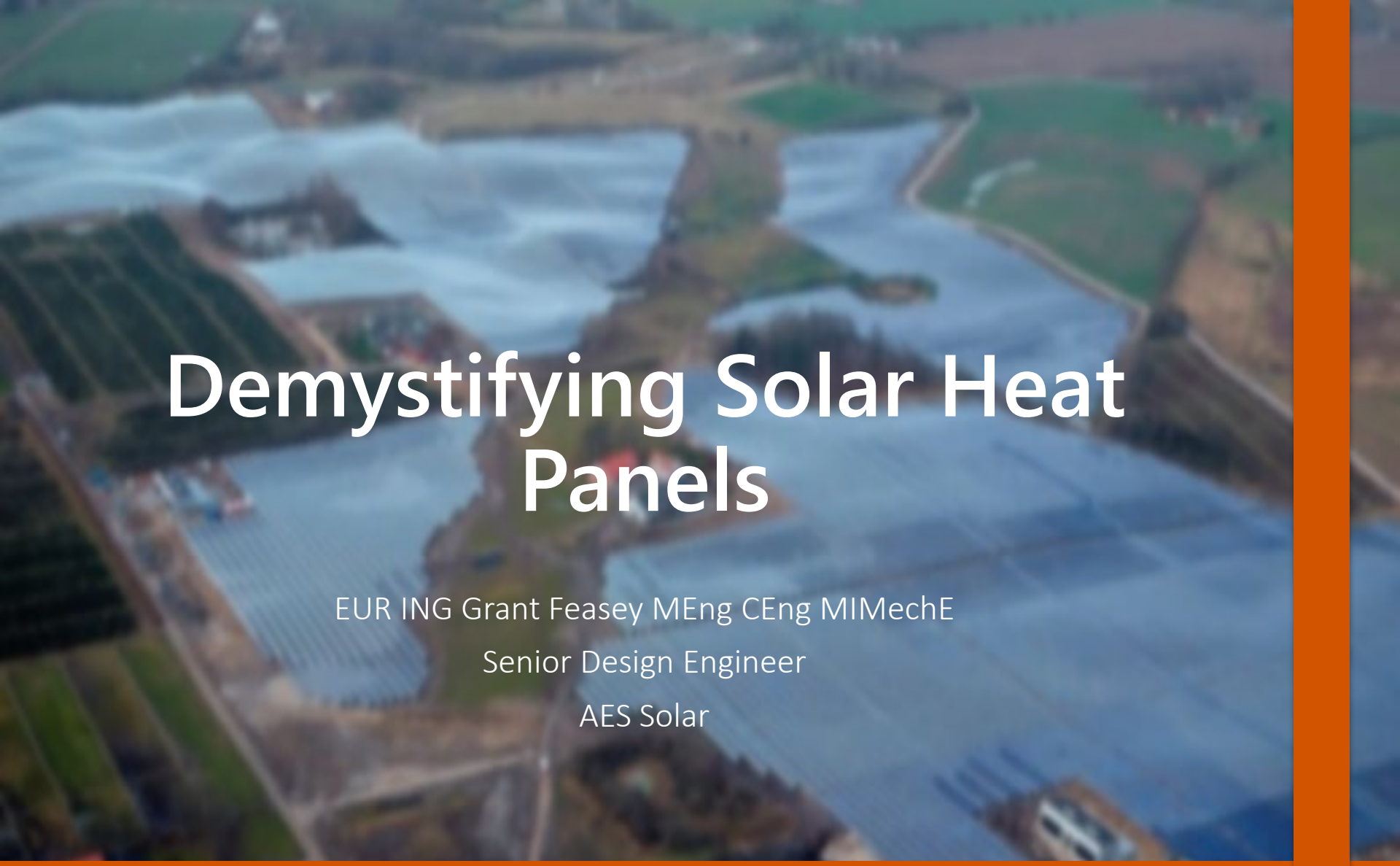
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Triple Point
HEAT NETWORKS
INVESTMENT MANAGEMENT



Solar Heating and Cooling

Grant Feasey
(AES Solar)



Demystifying Solar Heat Panels

EUR ING Grant Feasey MEng CEng MIMechE

Senior Design Engineer

AES Solar

www.aessolar.co.uk

AES Solar

Established 1979

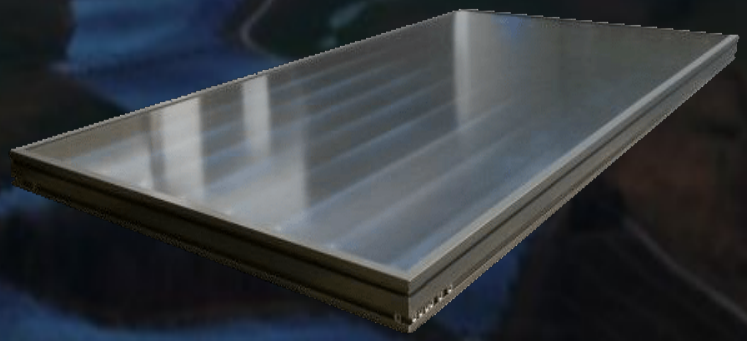
Contents

- Intro to AES
- Capturing Solar Heat
- Collector Type's
- Selection Criteria

AES Solar
Established 1979

Intro to AES

- Established 1979 – 40 this year!
- Manufacture Flat Plate Solar Thermal Collectors
- Now Manufacture, Design, Install, Maintain, Consult
- Multiple International R&D Projects
- Moved into Solar PV, Electrical Energy Storage, Heat Storage, Off-grid
- Installation capability UK wide
- Scottish Solar Partner for Nissan and Ikea





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Installations





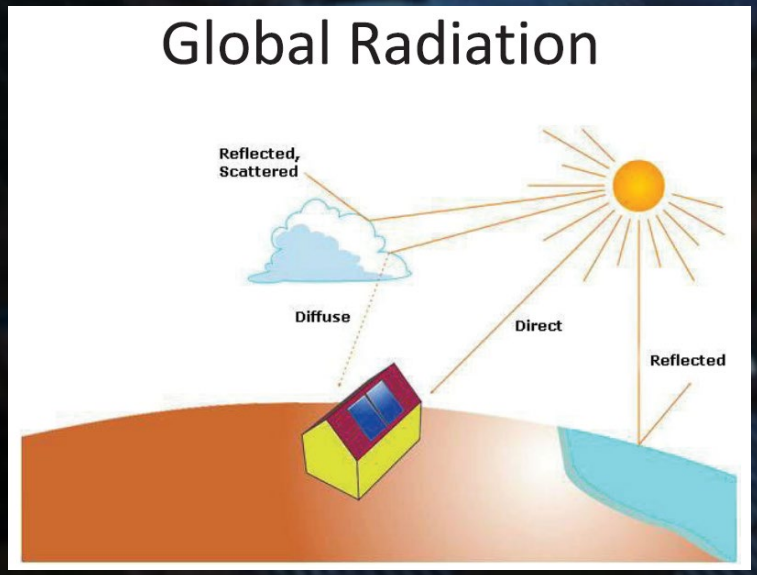


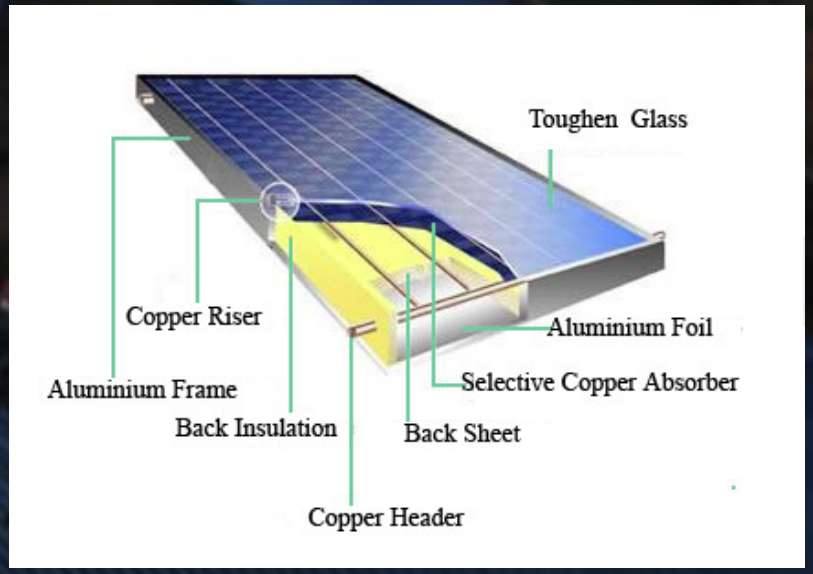


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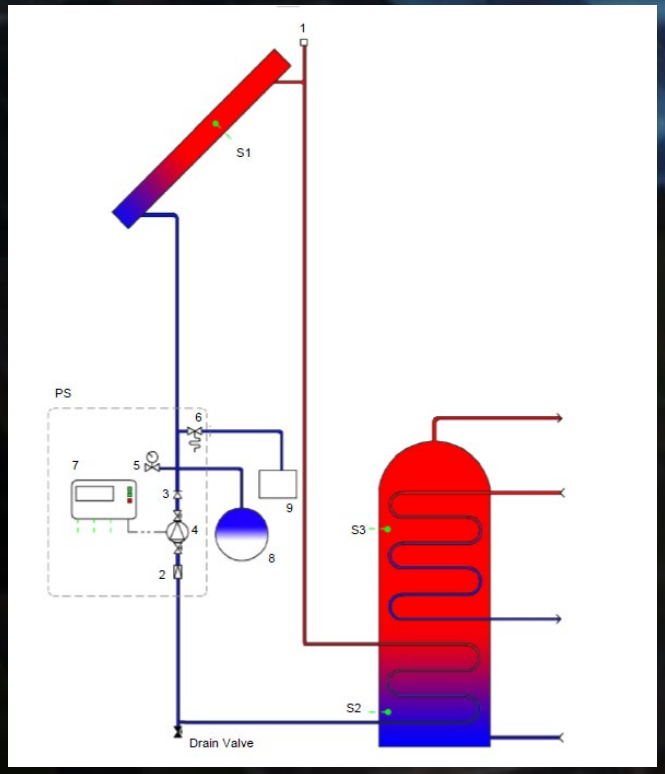
Capturing Solar Heat

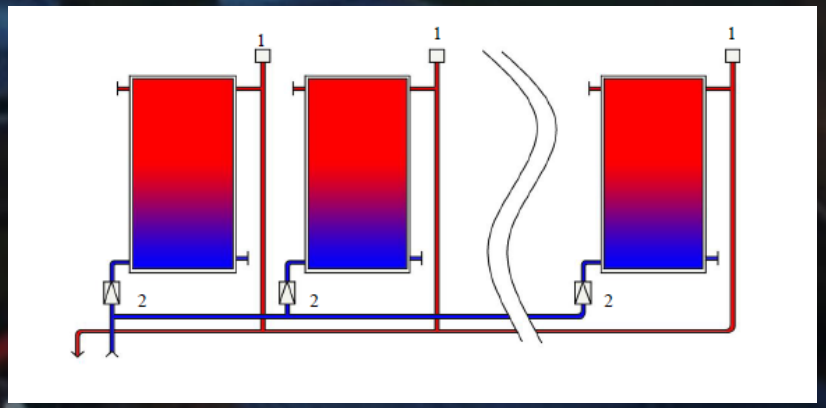




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Capturing Solar Heat



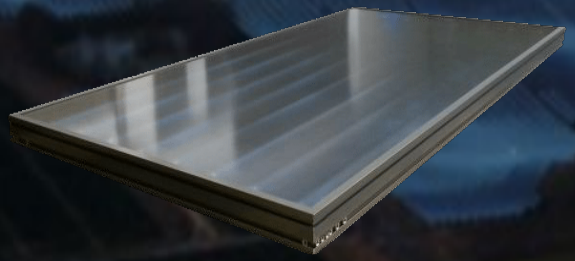




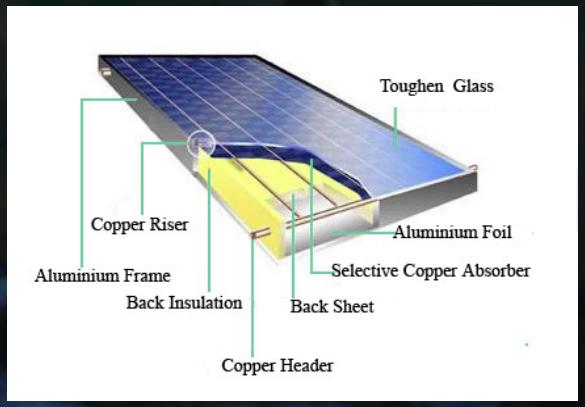
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Collector Type's

Flat Plate



AES Supremacy Flat Plate Collector

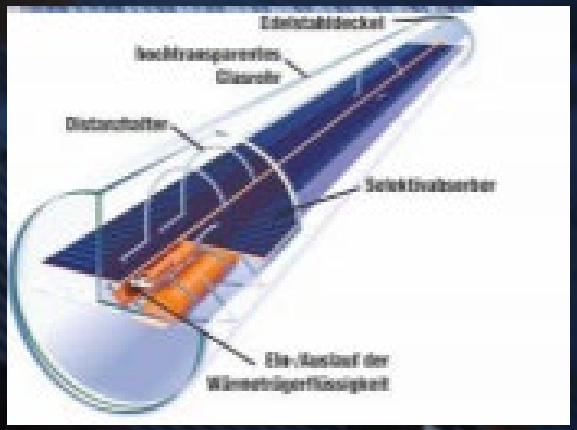


Flat Plate Cross Section

Evacuated Tube



Kingspan Thermomax Evacuated Tube Collector



Evacuated Tube Cross Section

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Collector Type's

PVT – PV/ Thermal



Source: Naked Solar

CPC – Concentrating Parabolic Collector



Source: Absolicon

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Collector Type's



Fresnel Lens
(Heliac)





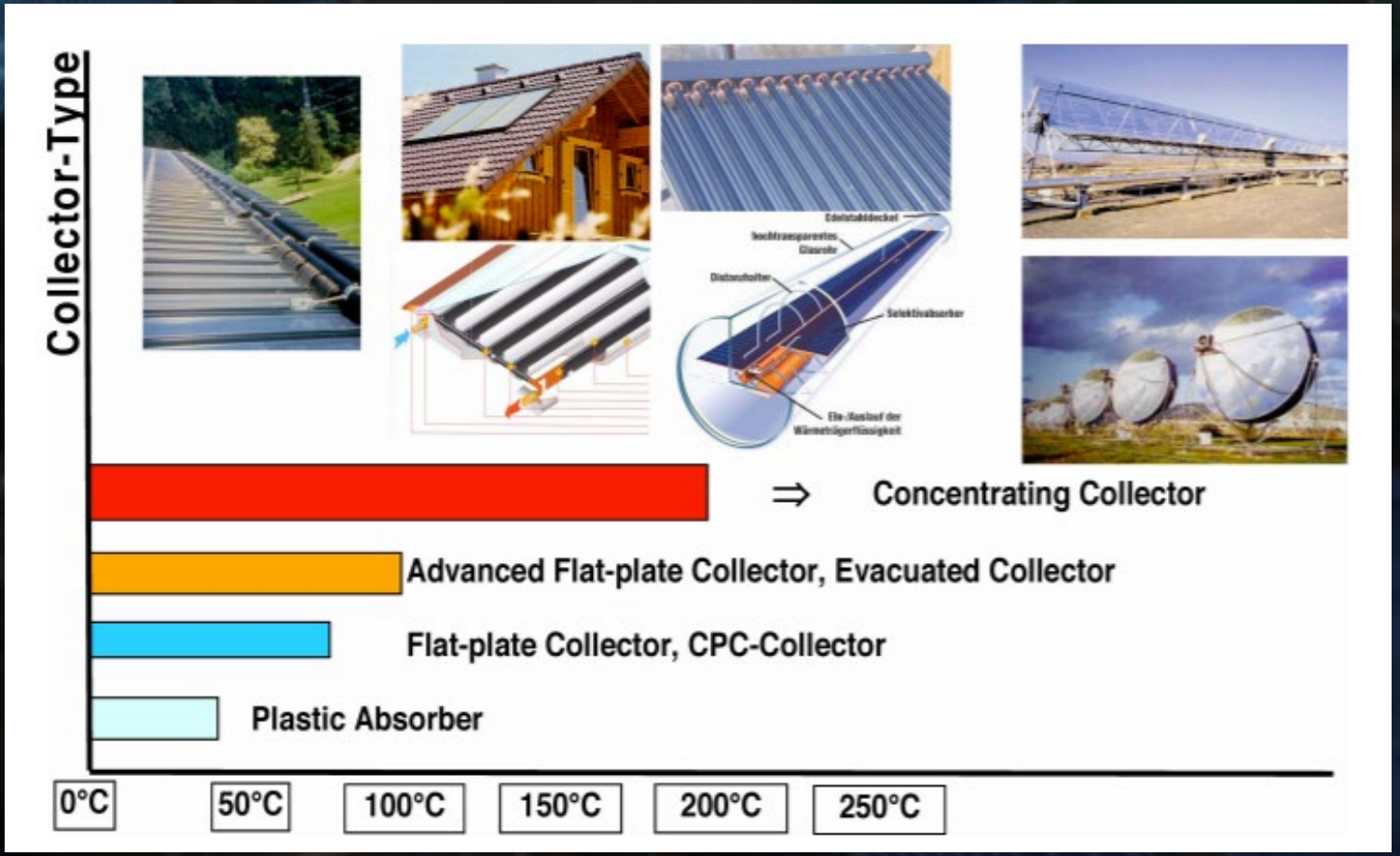
Solar Concentrator Dish - 650°C
(Plataforma Solar De Almeria)



Heliostat Concentrator - 1000°C+! Peak concentration 3200kW/m² and 60kW peak power
(Plataforma Solar De Almeria)

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Collector Type's



Source: 'The potential of Solar Thermal Technologies in a sustainable Future'; Gerhard Faninger; 2011; IEA Solar Heating & Cooling Programme

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Selection Criteria for SDH

Collector Selection

- Flat Plate
  - Robust, easy to install, cost effective
  - Best temperatures 25°C to 75°C
- Evacuated Tube
  - Higher temperatures but more expensive than flat plate
  - Provide more output per m^2
  - Higher grade heat – cost is usually prohibitive for low grade heat networks
- Evacuated Flat Plate or Concentrating Collectors
  - Designed for >150°C
  - Usually for very large networks or for higher grade heat
- Ongoing improvement of existing technology's and development of new methods







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Triple Point
HEAT NETWORKS
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Solar Heating and Cooling

Magdalena Kowalska
(PlanEnergi)

PlanEnergi

Magda Kowalska
mk@planenergi.dk



Renewable Heat for Heat Networks Conference

Solar Heat Networks in Denmark



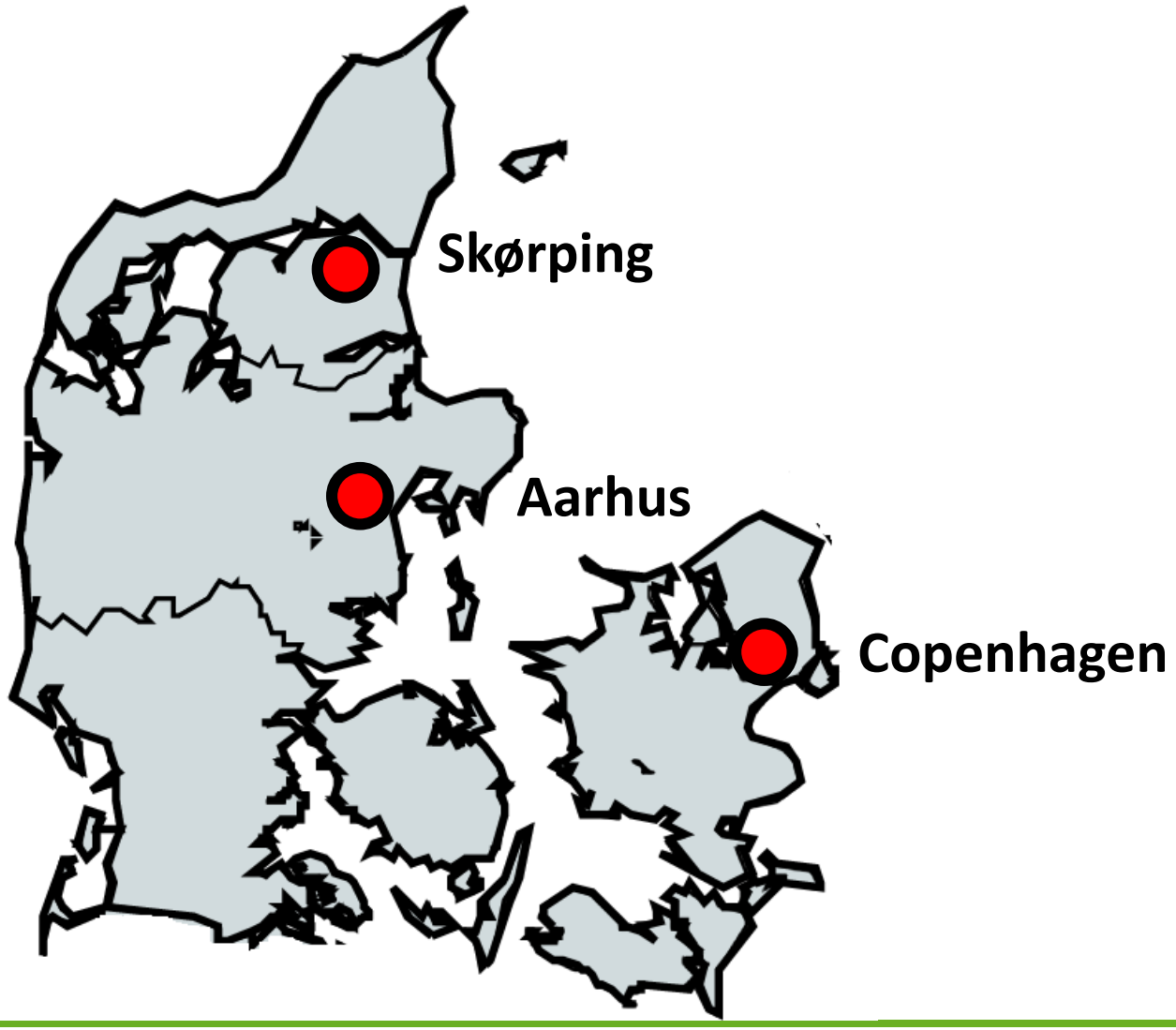




PlanEnergi

- Consultants & Engineers
- 40 employees
- 35 years with renewable heating
  - biomass, biogas, solar heat, heat pumps, district heating, energy planning…

PlanEnergi offices



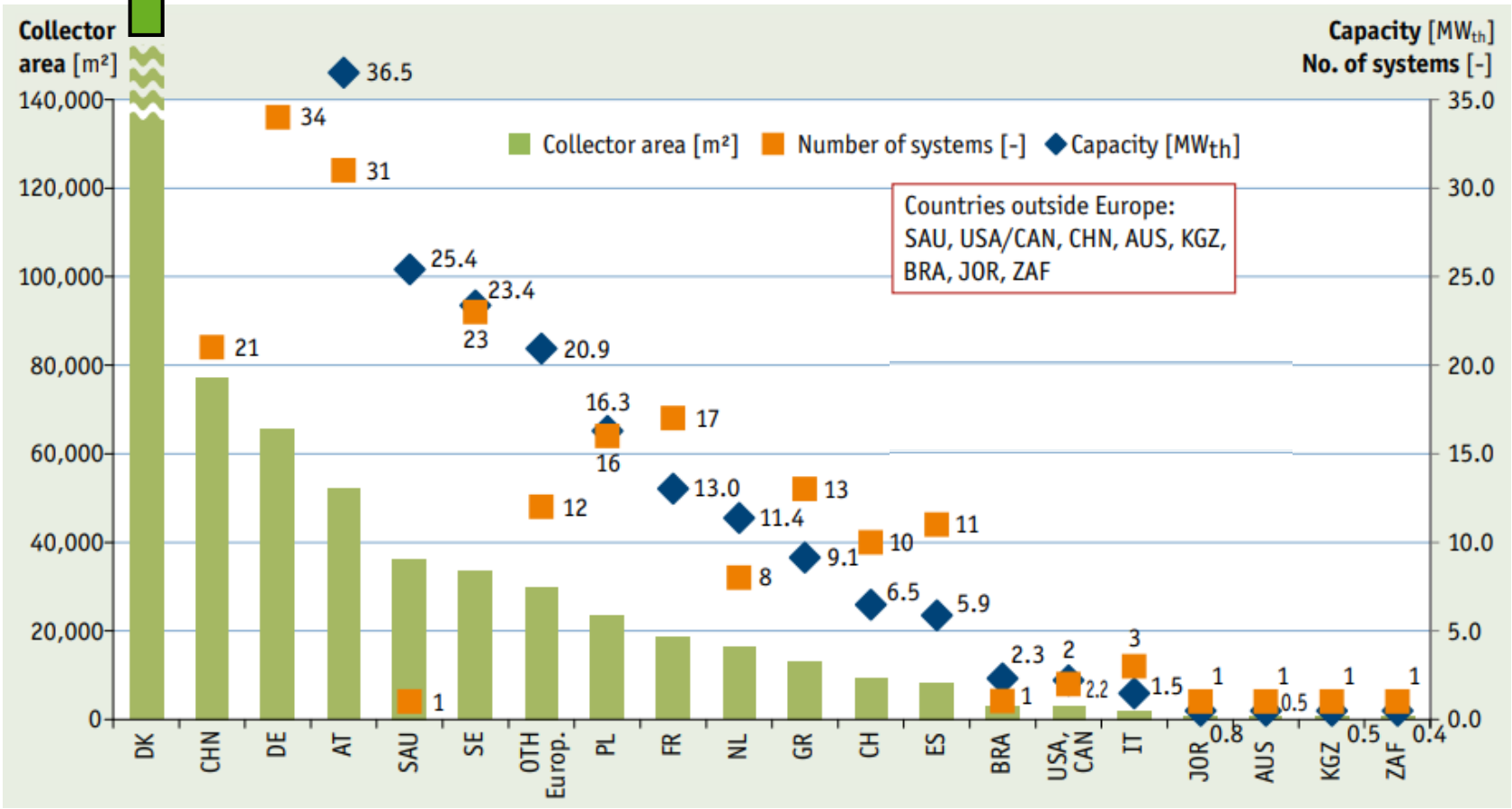
Silkeborg: The largest SDH plant in the world



Source: http://dk.arcon-sunmark.com

Large-scale solar thermal <500m²

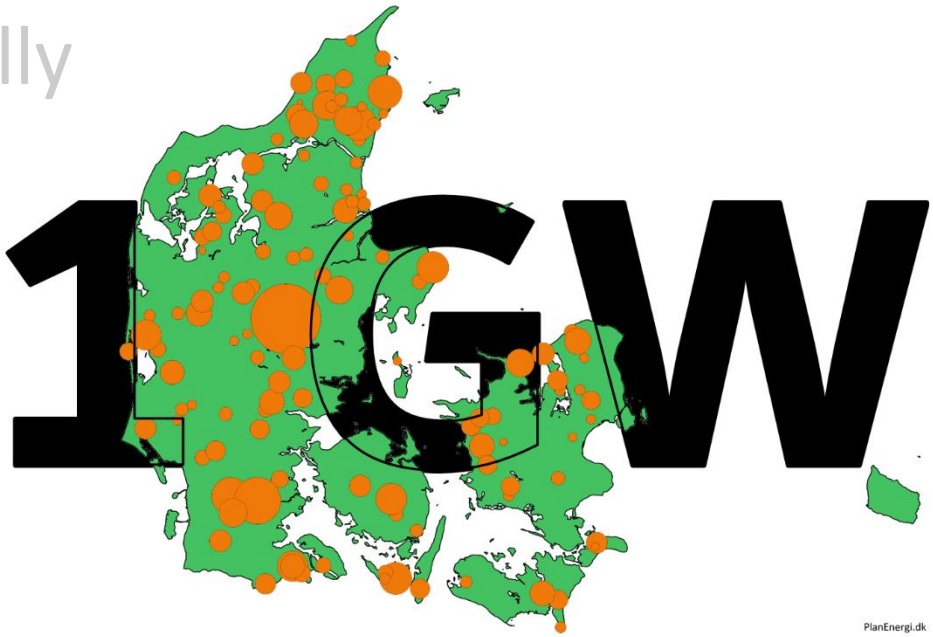
DK:
Collector area: 1,366,550 m²
Capacity: 956.6 MW_{th}
No. of systems: 117



Source: iea-shc.org/Data/Sites/1/publications/Solar-Heat-Worldwide-2019.pdf

Why such a development in Denmark?

- Optimal climate conditions? No
- Subsidies? Only partially



So why?

1. National politics

§ § §

a) High taxation on fossil fuels
b) Strict regulation on DH plant options
c) Ambitious Danish plan on phasing out fossil fuels
d) Long time tradition for both strategic energy planning and widespread use of (also decentralised) DH
   → Not only DH in large cities
e) Non-profit DH business
   → Transparency & shared information and experiences



2. Technical conditions

a) Low temperature DH (70-80 °C / 40-50 °C)
b) High (increased) performance of the solar collector fields
c) Long lifetime

So why?

3. Economic conditions

a) Community/public ownership
b) Favourable financing options
c) Relatively low land costs
d) Indirect subsidy (solar heat in “heat savings agreement”)
e) Competition between collector manufacturers
f) Competitive heat production price

€ € €

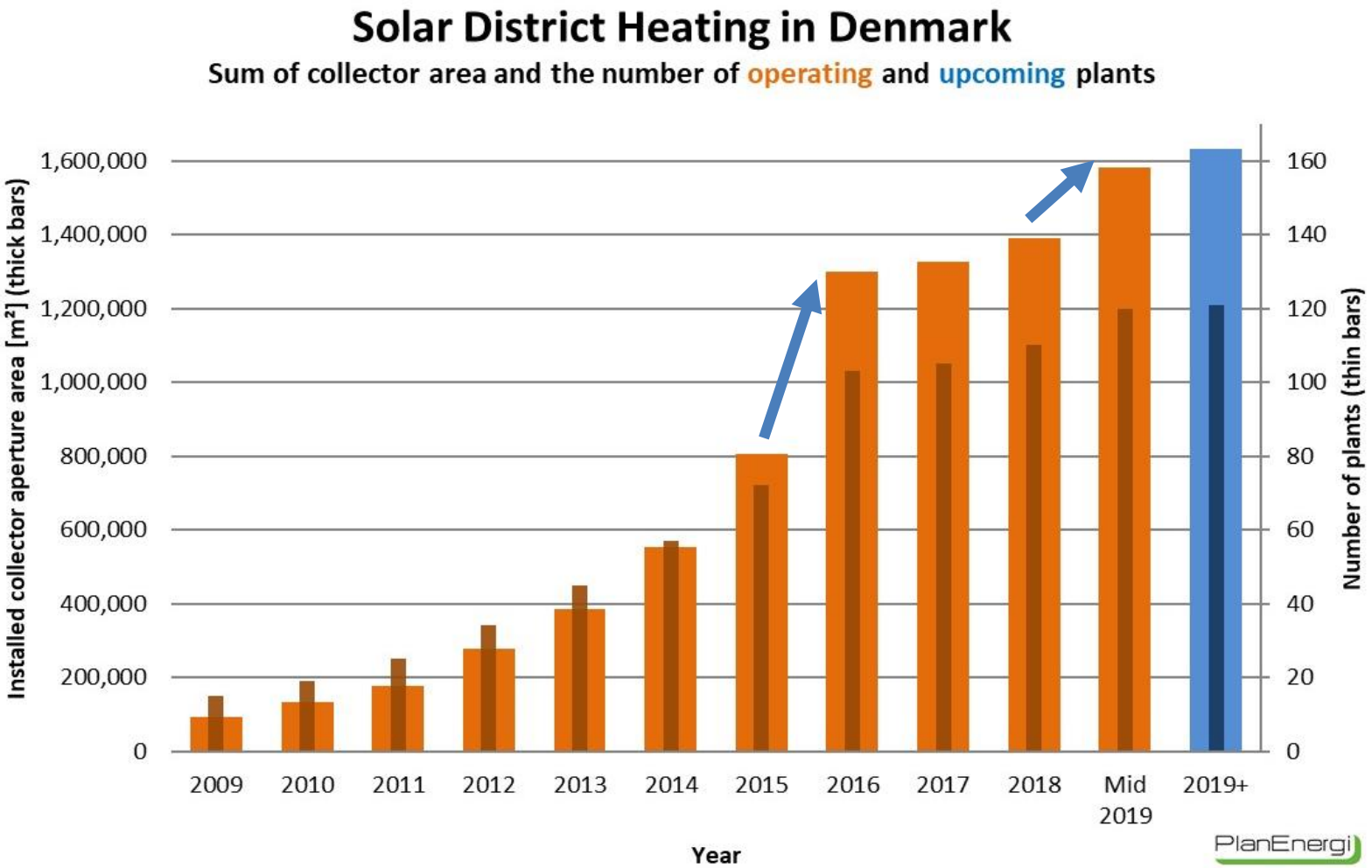
4. Non-technical conditions

a) Well-known & reliable
b) Know-how available
c) No emissions
d) Stable heat cost (not dependent of fuel provider)
e) Local communities



Source: Brædstrup Fjernvarme

Historical development of SDH in Denmark



Source: http://planenergi.eu/activities/district-heating/solar-district-heating/

Danish SDH typical plant

The typical Danish SDH system…

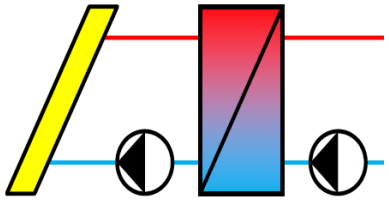


- is in the range of 5,000-20,000 m^2;
- has an annual yield of 410-460 kWh/$m^2_{apert.}$;
- requires an investment of 1.3-3 M€;
- financed by long (20-25 years) low interest (2-3 %) loan;
- covers 20 % of the DH demand (solar fraction);
- relatively small town with ~4,000 people;
- located within 200 m of the DH network;
- it replaces natural gas in a CHP plant;
- has a daily storage with a volume of ~0.2 m^3 per $m^2_{collect.}$;
- It is listed on www.solarheatdata.eu.

What type of systems?

So far – mostly very simple systems for low solar fractions:

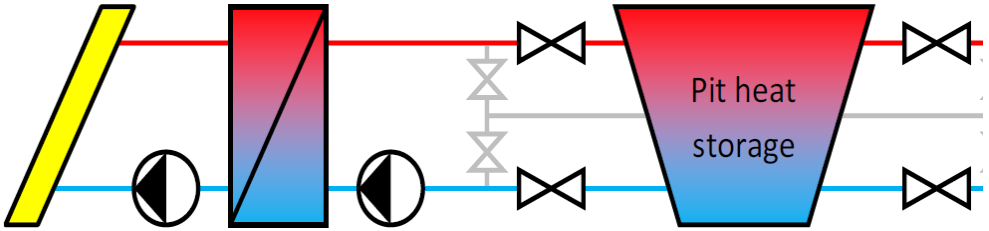






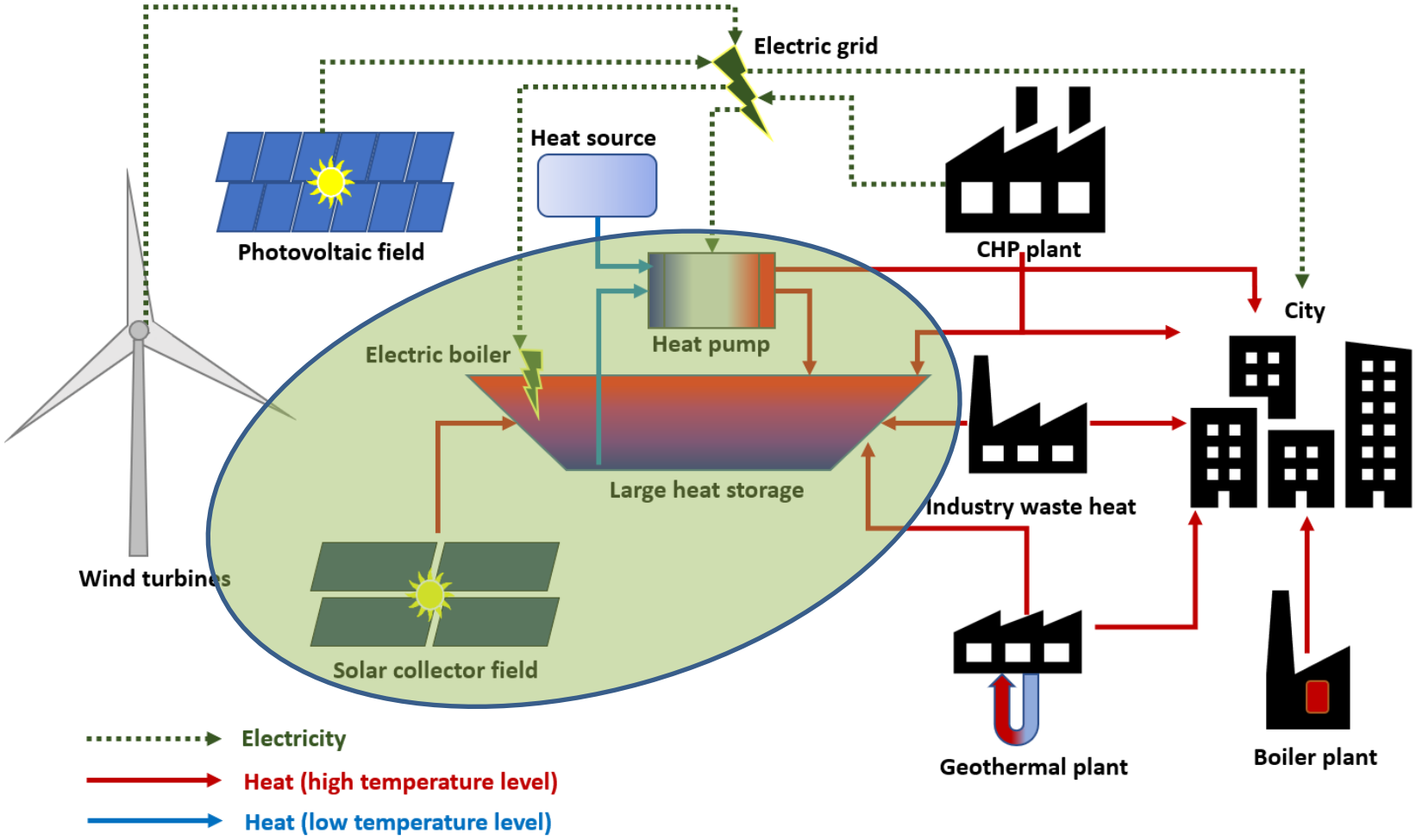
But it seems relevant to consider also higher solar fractions via long term storage:





What type of systems?

So far – mostly very simple systems for low solar fractions:



Typical SDH

Aulum - key parameters



- Year: 2015
- 16,000 m^2 solar collectors
- 3,600 m^3 water tank
- Solar fraction: 21%
- Other sources: gas CHP, gas boiler, electric boiler

Typical SDH

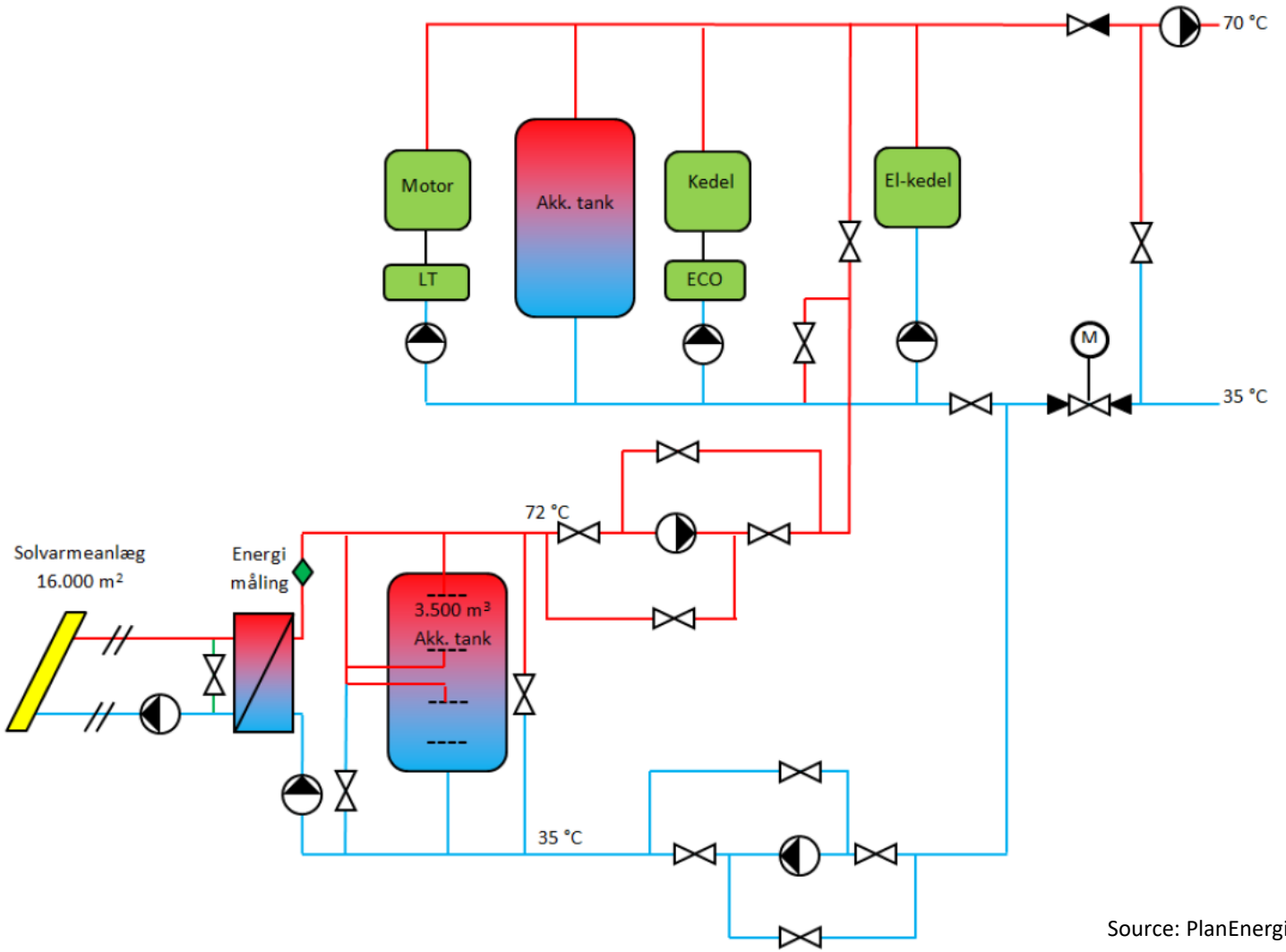
Aulum - aerial view



Source: https://www.herningfolkeblad.dk/artikel/52ba4119-a03e-4537-84ee-d3f06b95758d/

Typical SDH

Aulum - principle diagram



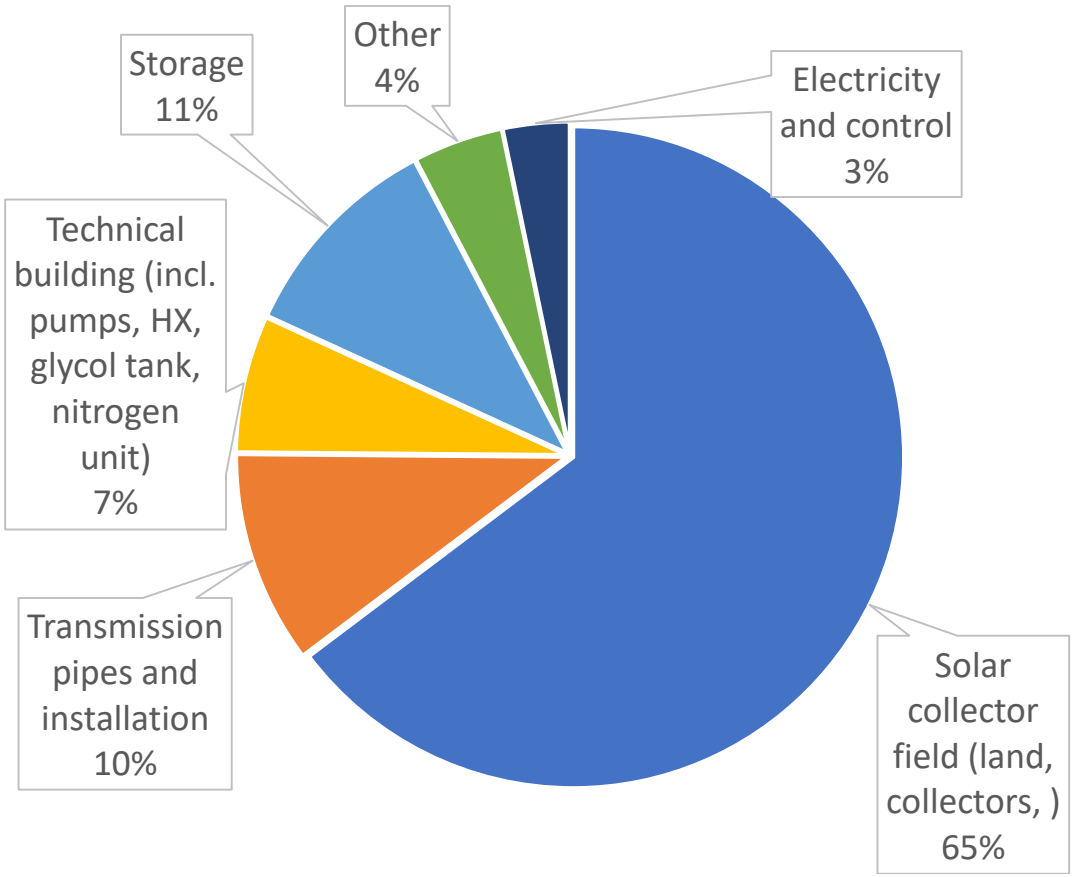
Source: PlanEnergi

Typical SDH

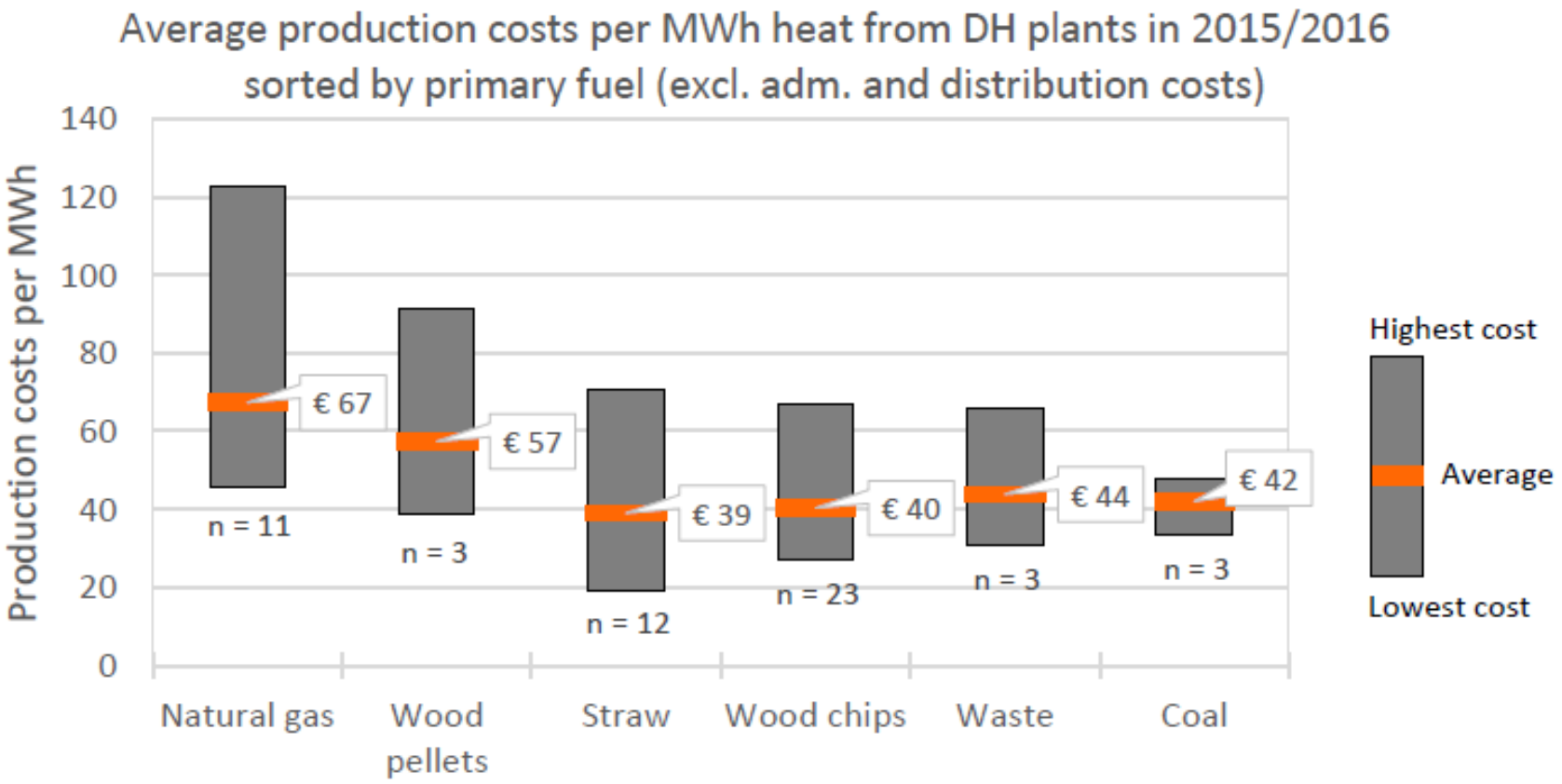
Aulum - economy

- Overall cost: 3.8 M€
  (7% from energy saving)
- Heat to the DH:
  7,700 MWh
- Assuming
  - 20 year loan
  - 3% interest
  - 1 €/MWh as O&M

  → **heat cost: 34 €/MWh**

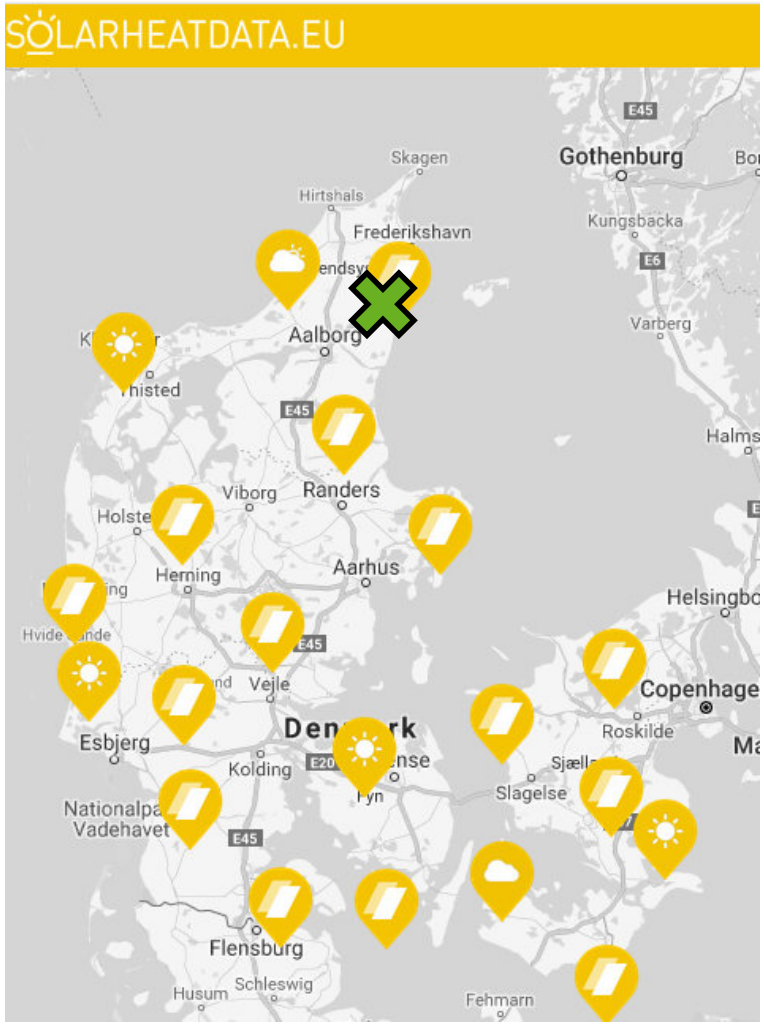


Heat production cost in Danish DH systems



SDH+ seasonal storage

Dronninglund - key parameters



- Year: 2013
- 37,500 m^2 solar collector field
- 60,000 m^3 water pit storage
- 2.1 $MW_{cooling}$ absorption HP
- Solar fraction: 41%
- Combined with existing bio-oil boilers and gas CHP

Link to detailed project description:
https://energiteknologi.dk/sites/energiteknologi.dk/files/slutrapporter/sunstore_3_-_final_report_1_23102015_1501.pdf

SDH+ seasonal storage

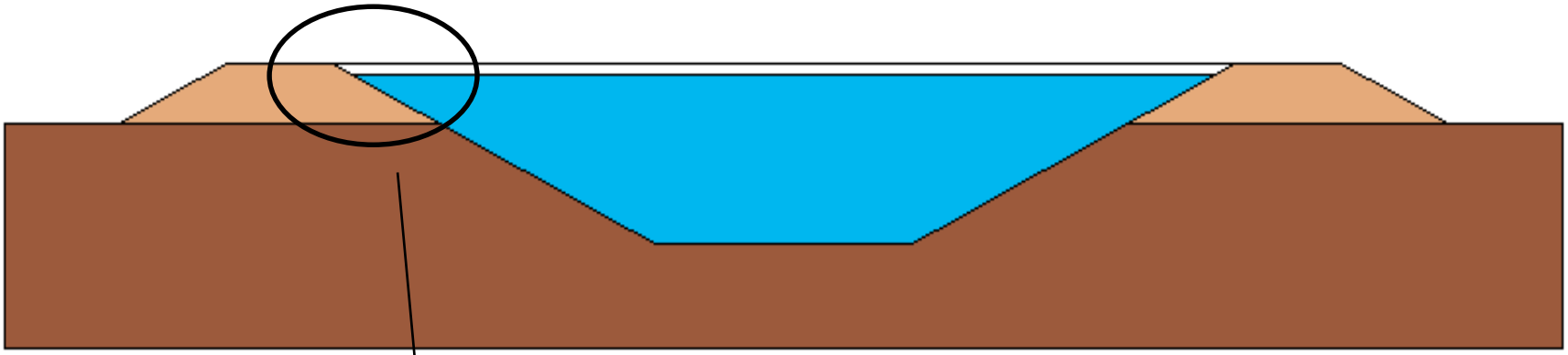
Dronninglund - aerial view



Source: planenergi.dk/arbejdsomraader/fjernvarme/saesonvarmelagre/dronninglund-fjernvarme

Dronninglund - Water Pit Storage

- Cheap storage technology for large volumes



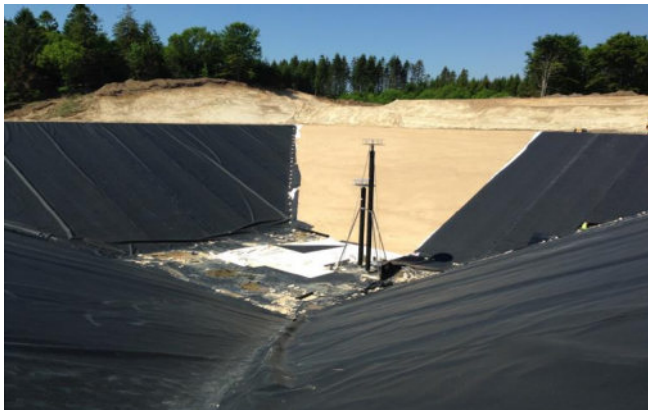
- Floating lid with insulation
- No insulation to the ground

Dronninglund - Water pit storage construction

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.**

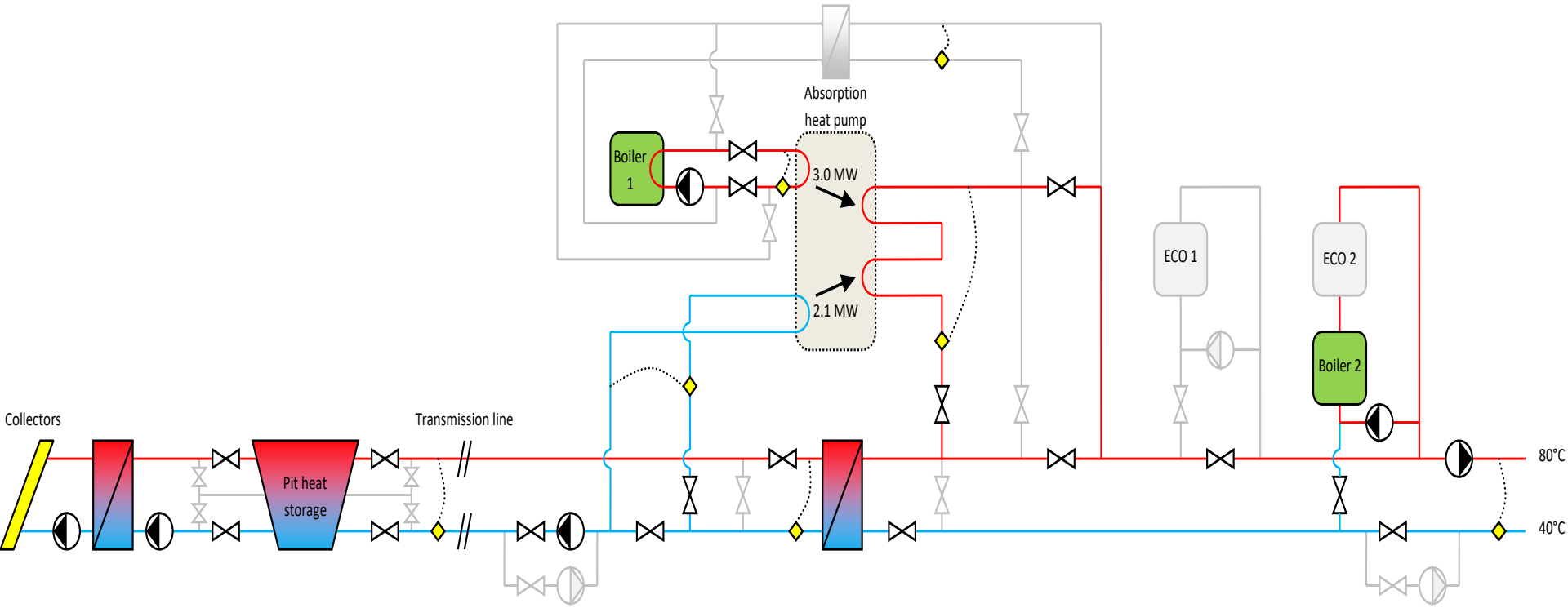


4. **Put an insulating and floating cover on top.**



SDH+ seasonal storage

Dronninglund - principle diagram

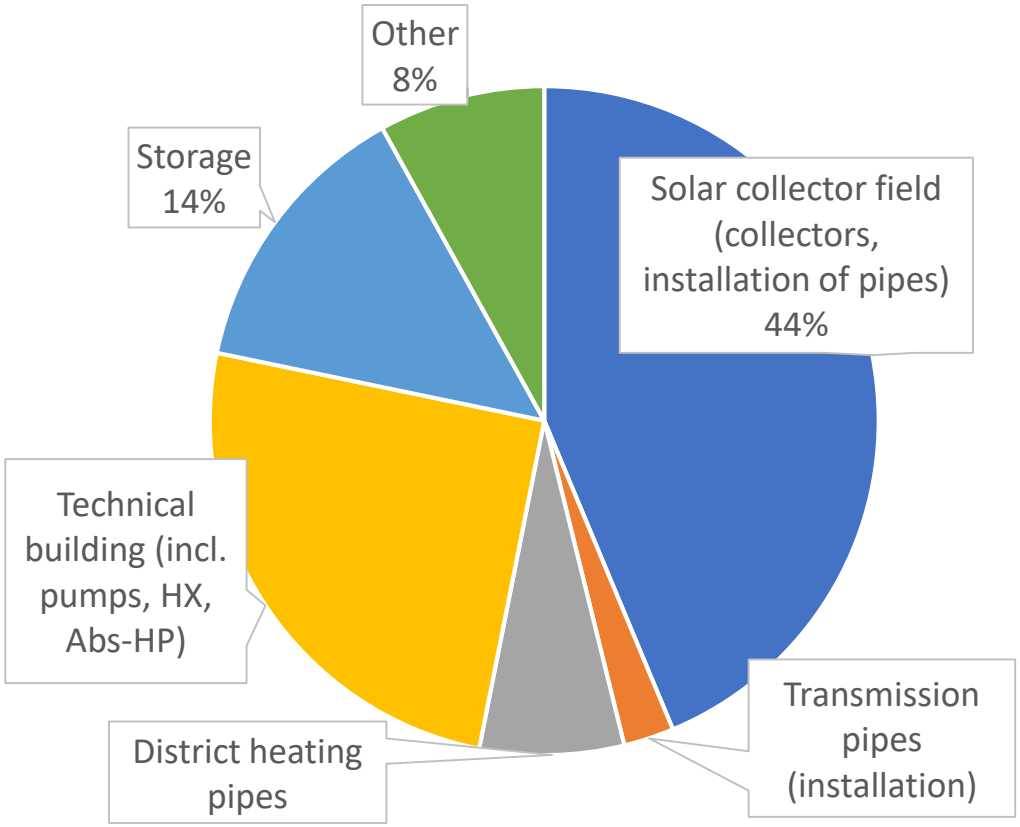


SDH+ seasonal storage

Dronninglund - economy

- Overall cost: 14 M€ (16% subsides)
- Heat to the DH: ~16,000 MWh
- Assuming
  - 20 year loan
  - 3% interest
  - 3 €/MWh as O&M

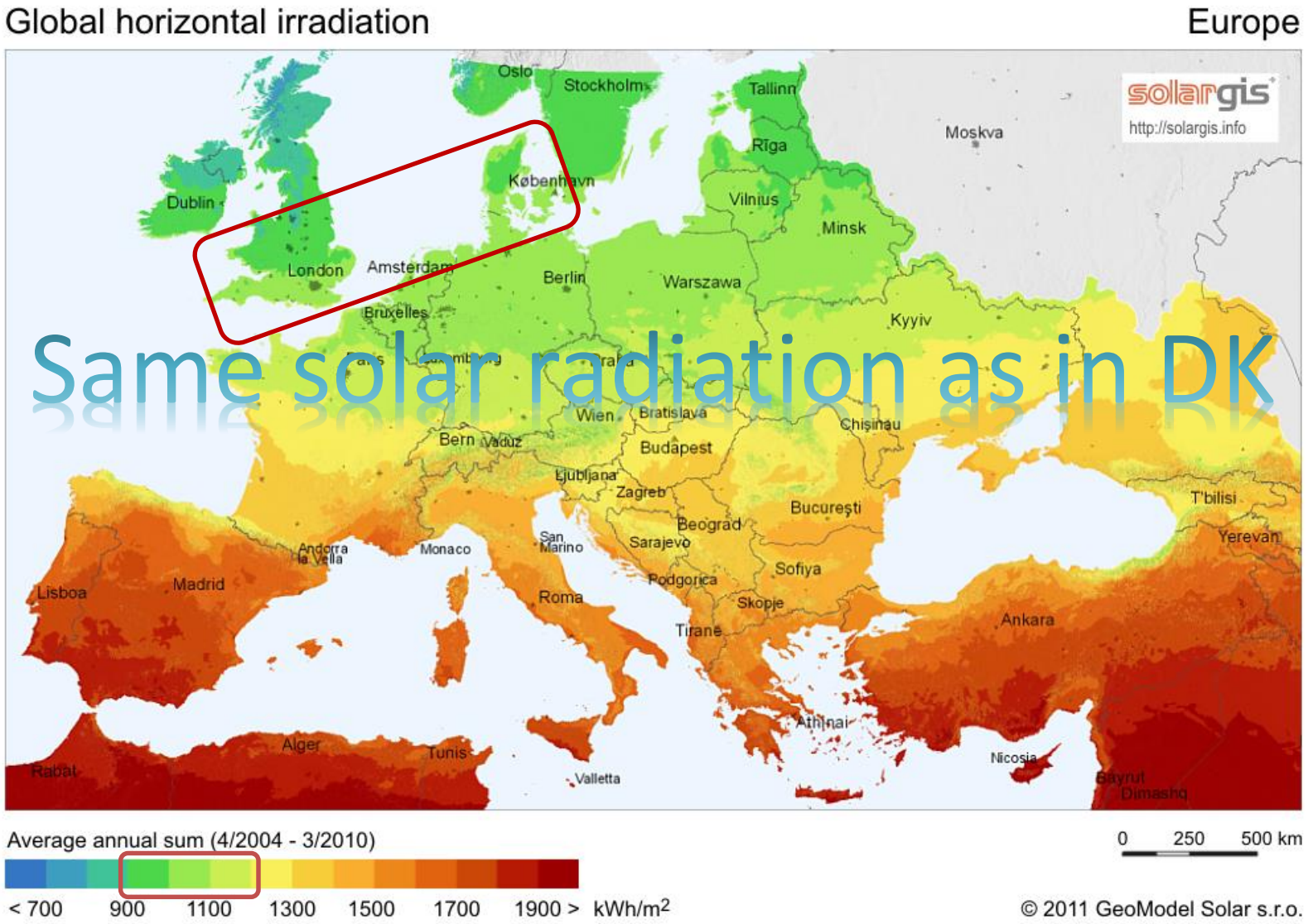
  → **heat cost: 62 €/MWh**



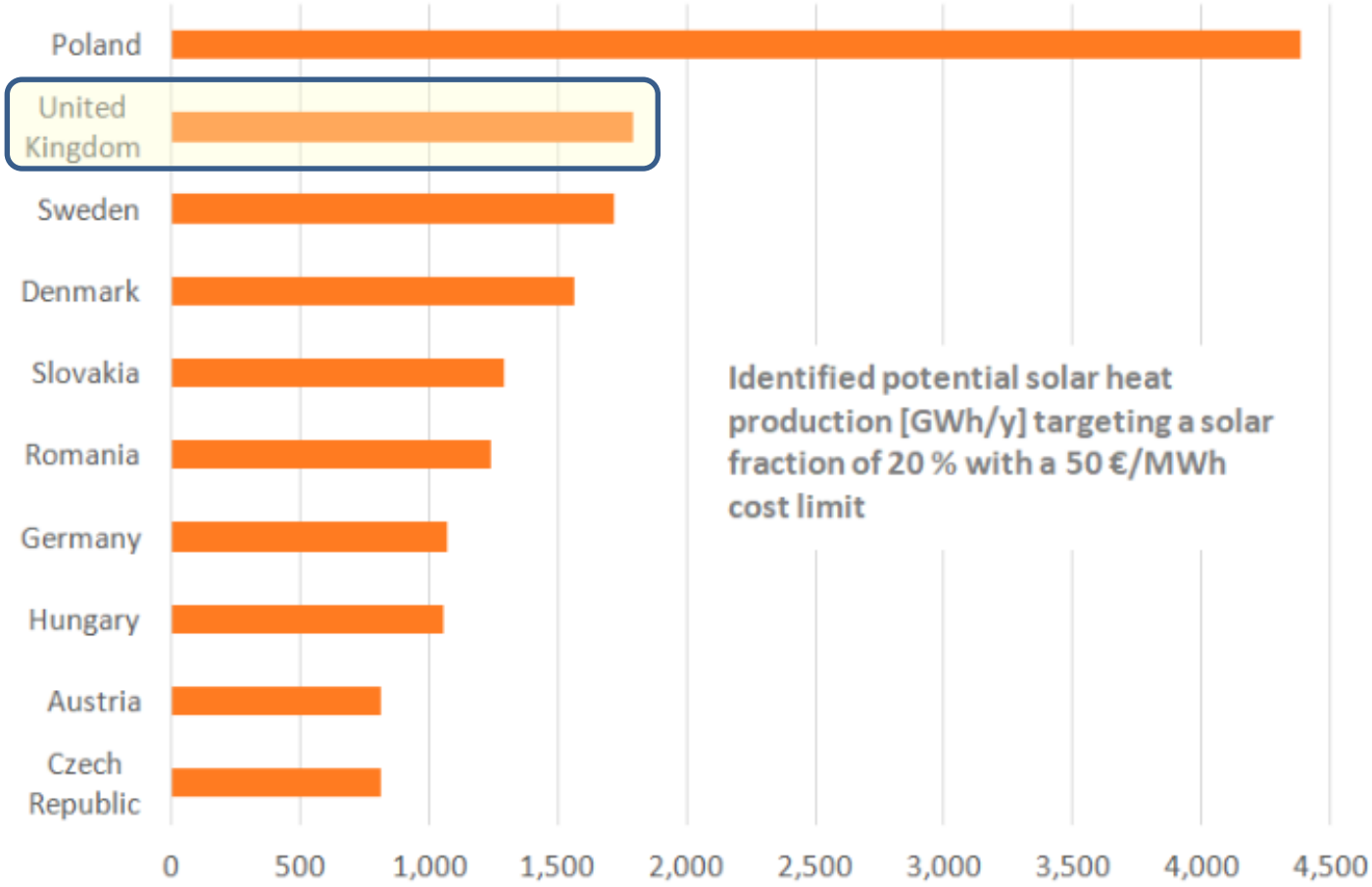
Conclusions

- Integration of solar thermal into DH is well-known, reliable, CO_2 free energy supply solution. This can help stabilise heat costs since the source is independent of fuel provider and the market (demand).
- Technical solutions and know-how are already mature.
- There is a need for the right boundary conditions:
  - Long-term energy planning is key! – Set common goals and include all relevant stakeholders in the process.
  - Phase out fossil fuels (end dates) – Ambitions are not enough.
  - Feasibility must be shifted in favour of RE – Taxation on polluting sources, and support for sustainable solutions.
  - Demonstration (lighthouse projects) may need support to initiate a national market for large scale SDH.
- **Many of the conditions in Denmark can be replicated.**

What is UK's potential for SDH development?



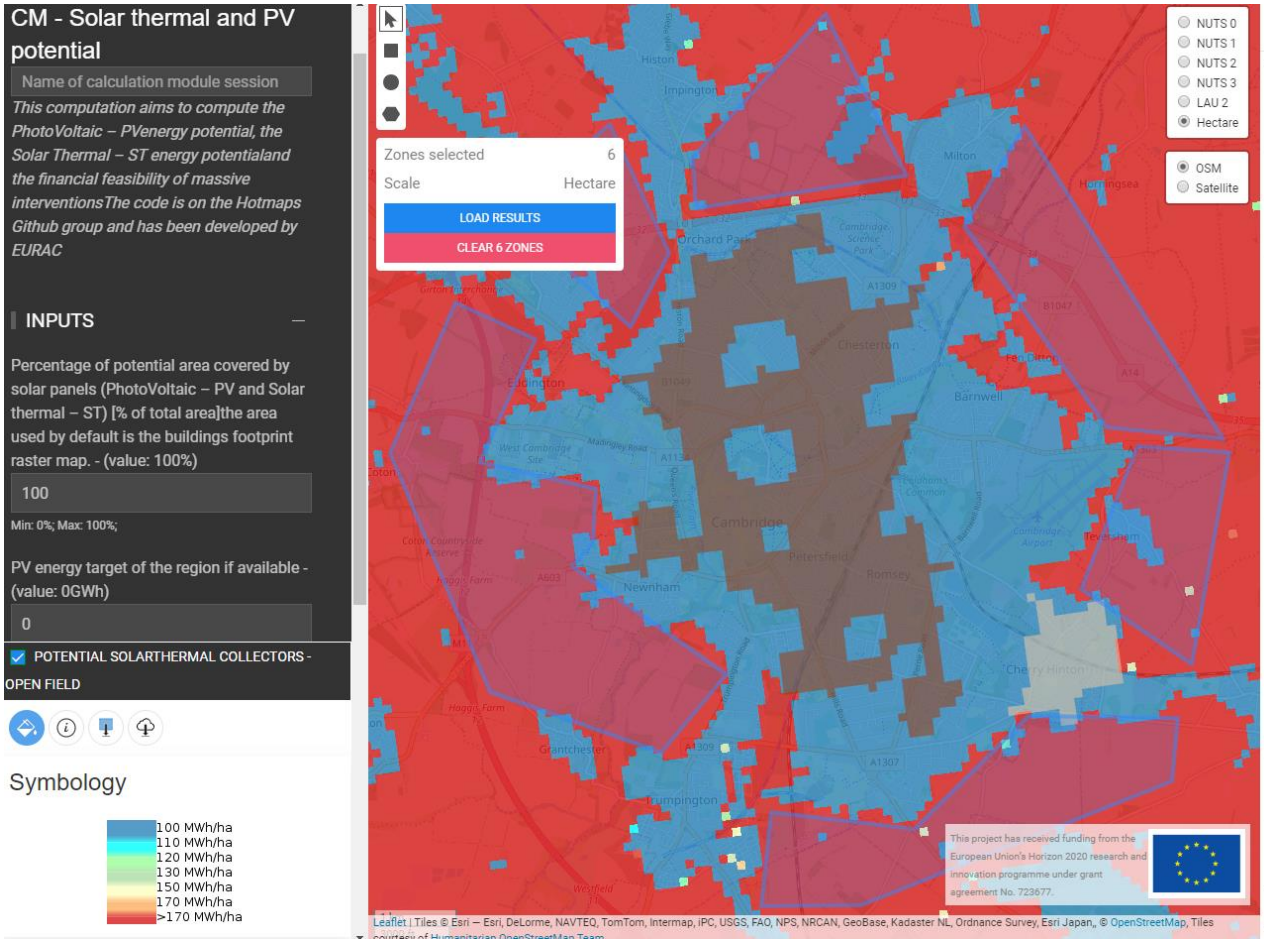
Potential annual solar heat production



Source: https://www.solarthermalworld.org/sites/default/files/news/file/2019-02-18/sdh-trends-and-possibilities-iea-shc-task52-planenergi-20180619.pdf

Toolbox for solar potential assessment

- Planenergi is a partner in developing the open source tool for mapping and planning of energy systems.



HOTMAPS

INDICATORS GRAPHICS

INFORMATION	VALUE
POTENTIAL SOLARTHERMAL COLLECTORS - OPEN FIELD	
Average solar radiation	1 052.84 MWh/(ha*yr)
Minimum solar radiation	9.29 MWh/(ha*yr)
Maximum solar radiation	1 099.03 MWh/(ha*yr)
Counted cells	3 528 cells
Restricted solar thermal potential - open field	3 714.43 GWh/yr
CM - SOLAR THERMAL AND PV POTENTIAL	
PV total energy production	6.1 GWh/year
PV total setup costs	13 Million of €
Number of installed PV Systems	2 130 -
Levelized Cost of PV Energy	0.17 €/kWh
ST total energy production	149.38 GWh/year
ST total setup costs	31 Million of €
Number of installed ST Systems	31 284 -
Levelized Cost of ST Energy	0.02 €/kWh

EXPORT INDICATOR

Source: http://hotmaps-project.eu



SW&W-Cartoon: Michael Hüter

Graph: Birgit Tanck



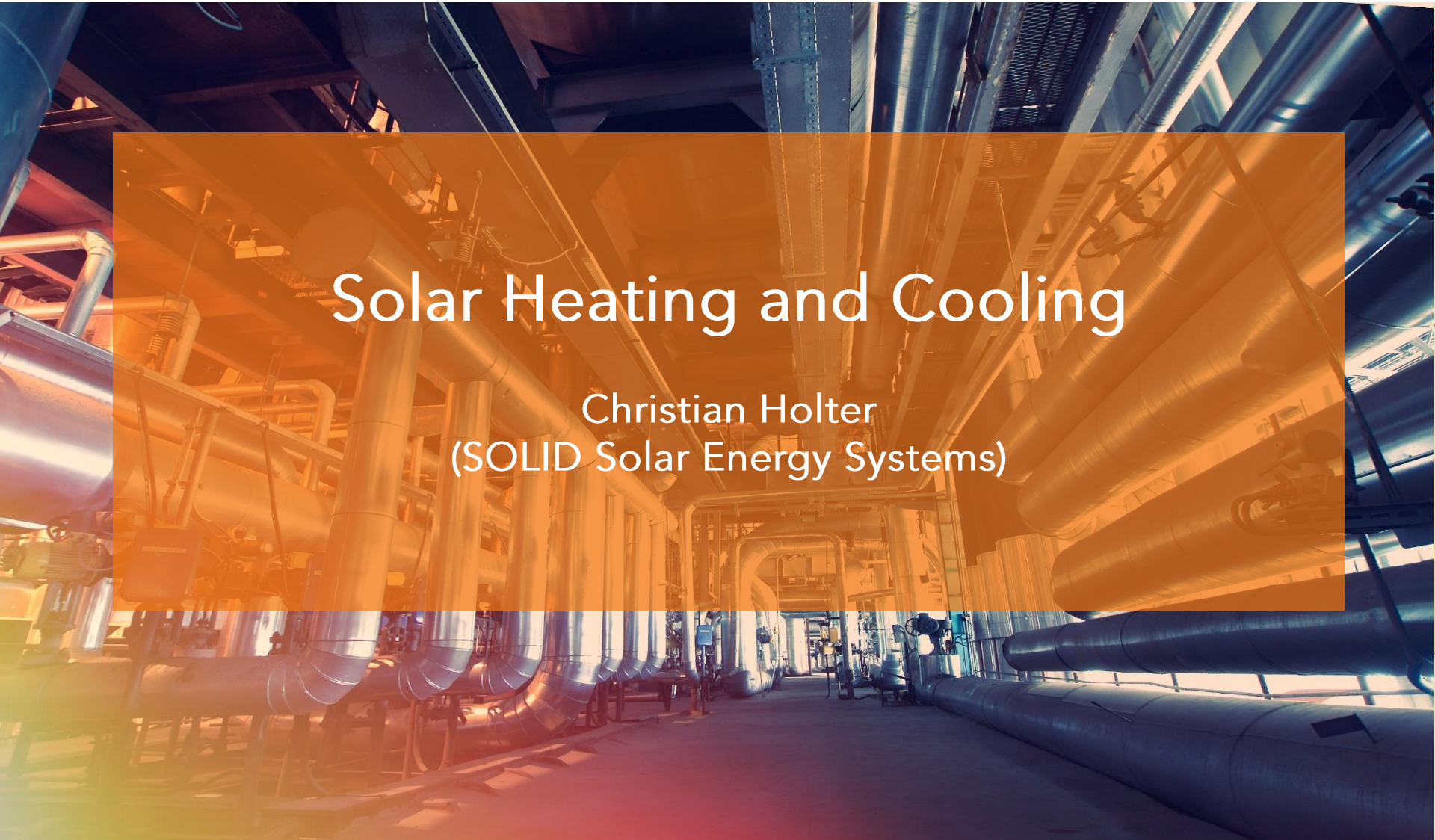
More information:

Magda Kowalska

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www.planenergi.dk

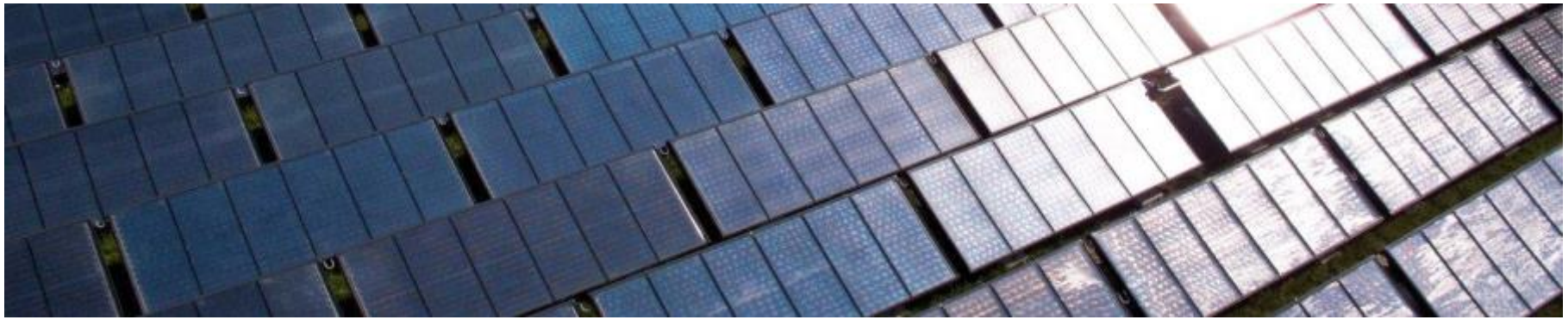
Triple Point
HEAT NETWORKS
INVESTMENT MANAGEMENT



Solar Heating and Cooling

Christian Holter
(SOLID Solar Energy Systems)

Energy transformation of the heat sector



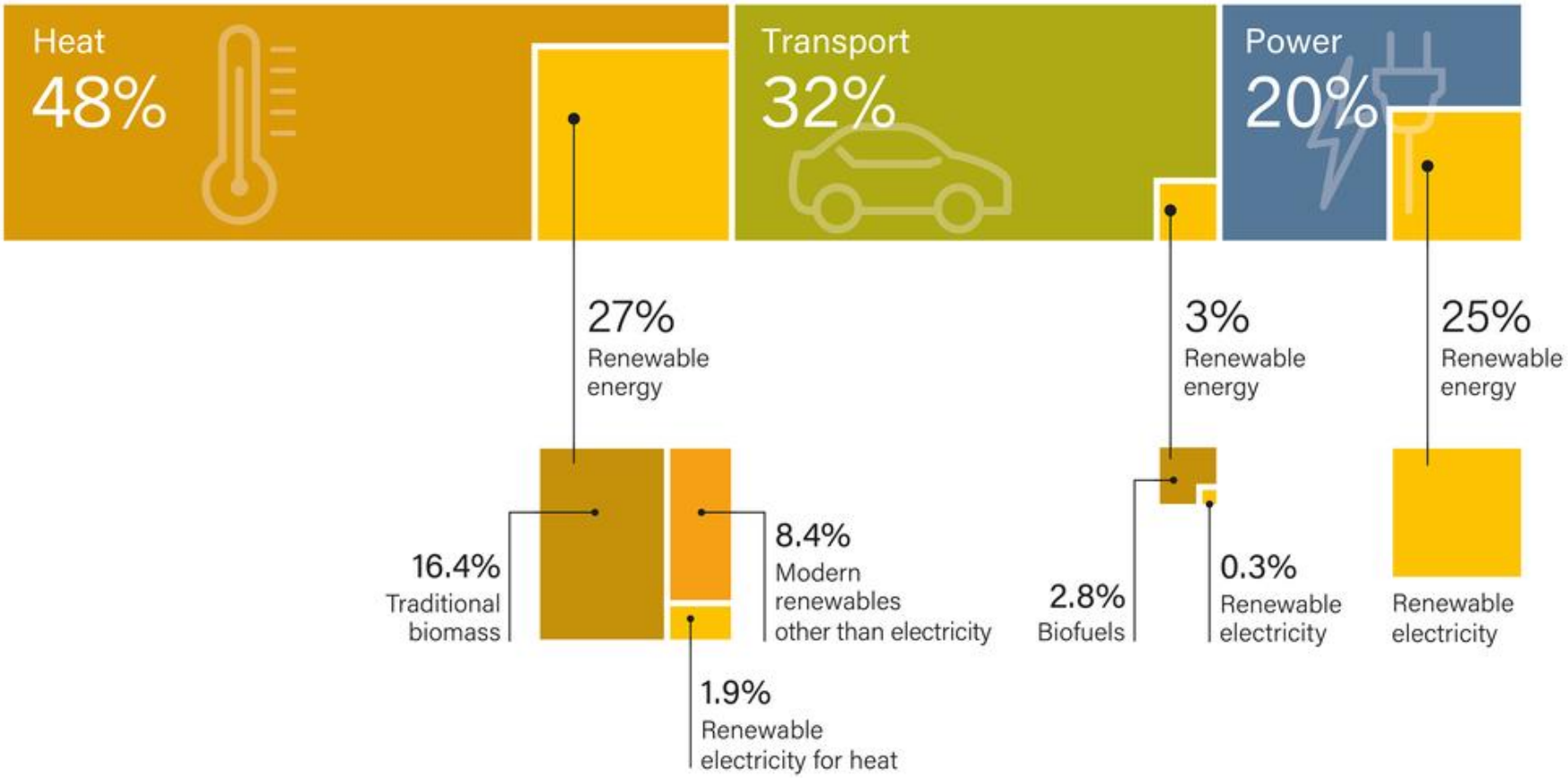
SOLID since 1992

Christian Holter +43 316 292840-0

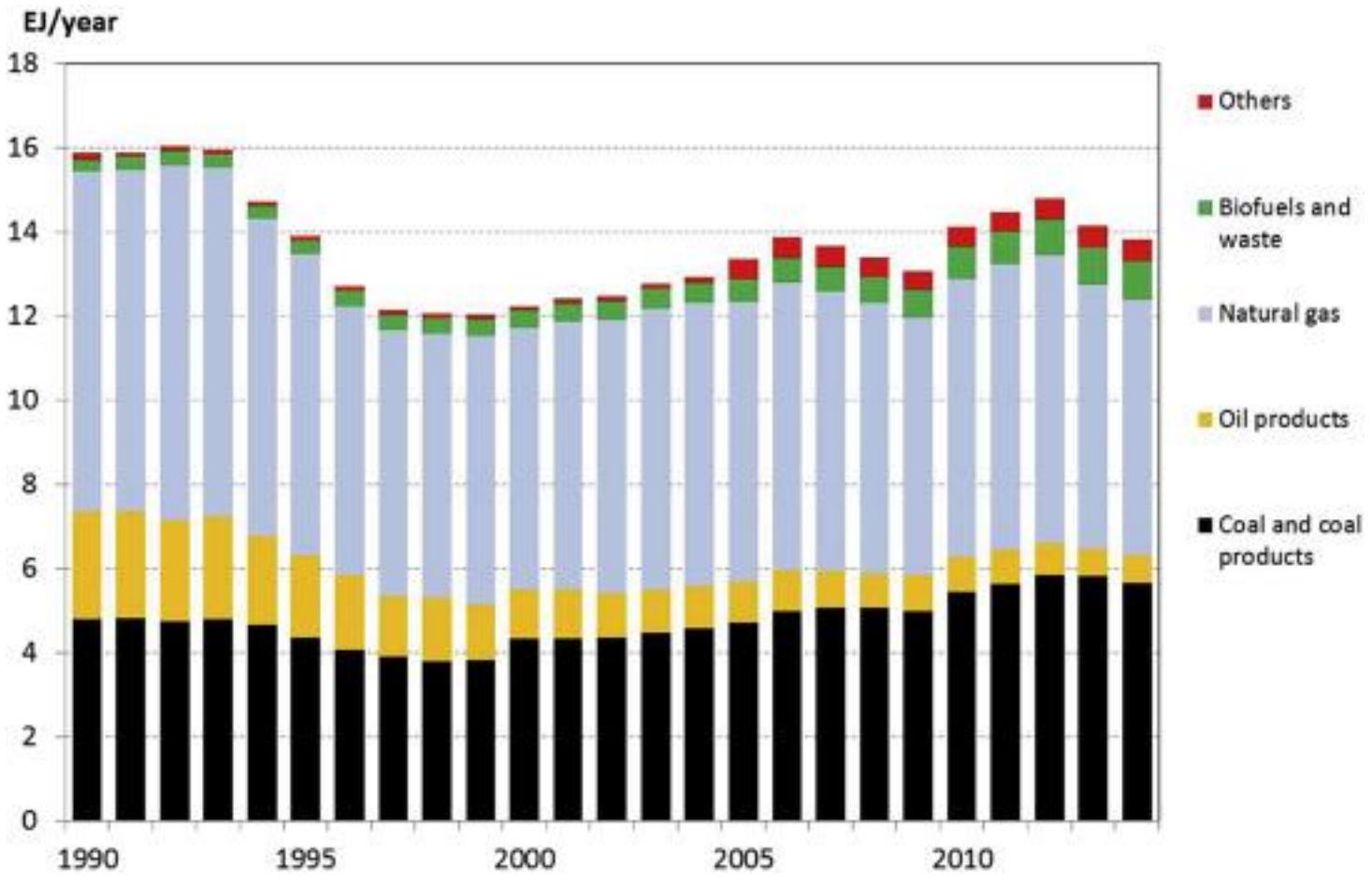
Puchstraße 85, A-8020 Graz, www.solid.at, office@solid.at

Heat- Mobility- Electricity

FIGURE 3. Renewable Energy in Total Final Energy Consumption, by Sector, 2015



Heat supply for DH systems worldwide



Science Direct:/www.sciencedirect.com
https://doi.org/10.1016/j.energy.2017.04.045

Energy Mix of the Future

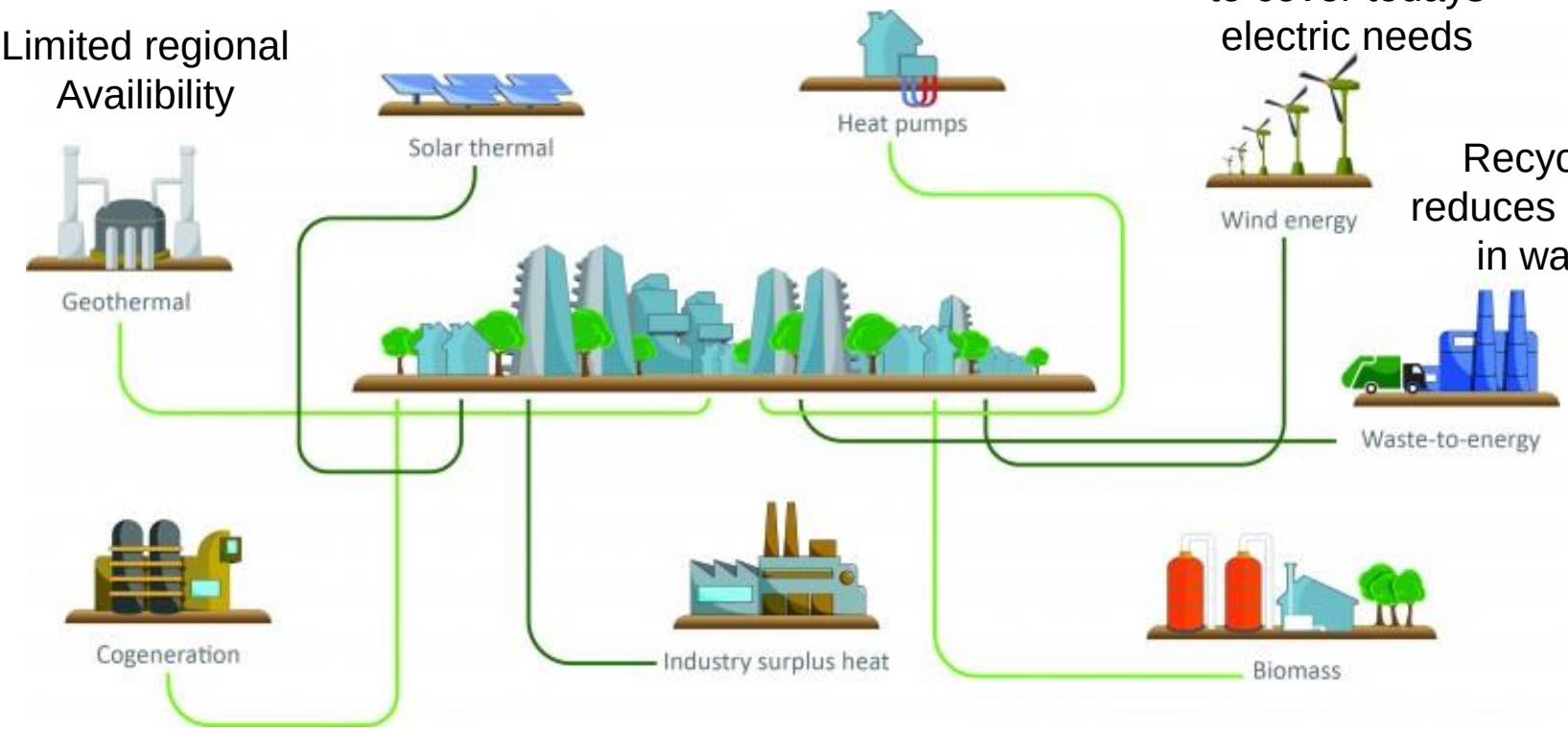
Limited regional Availibility

Seasonal mismatch

Limited renewable electricty

We need more wind to cover todays electric needs

Recycling reduces energy in waste



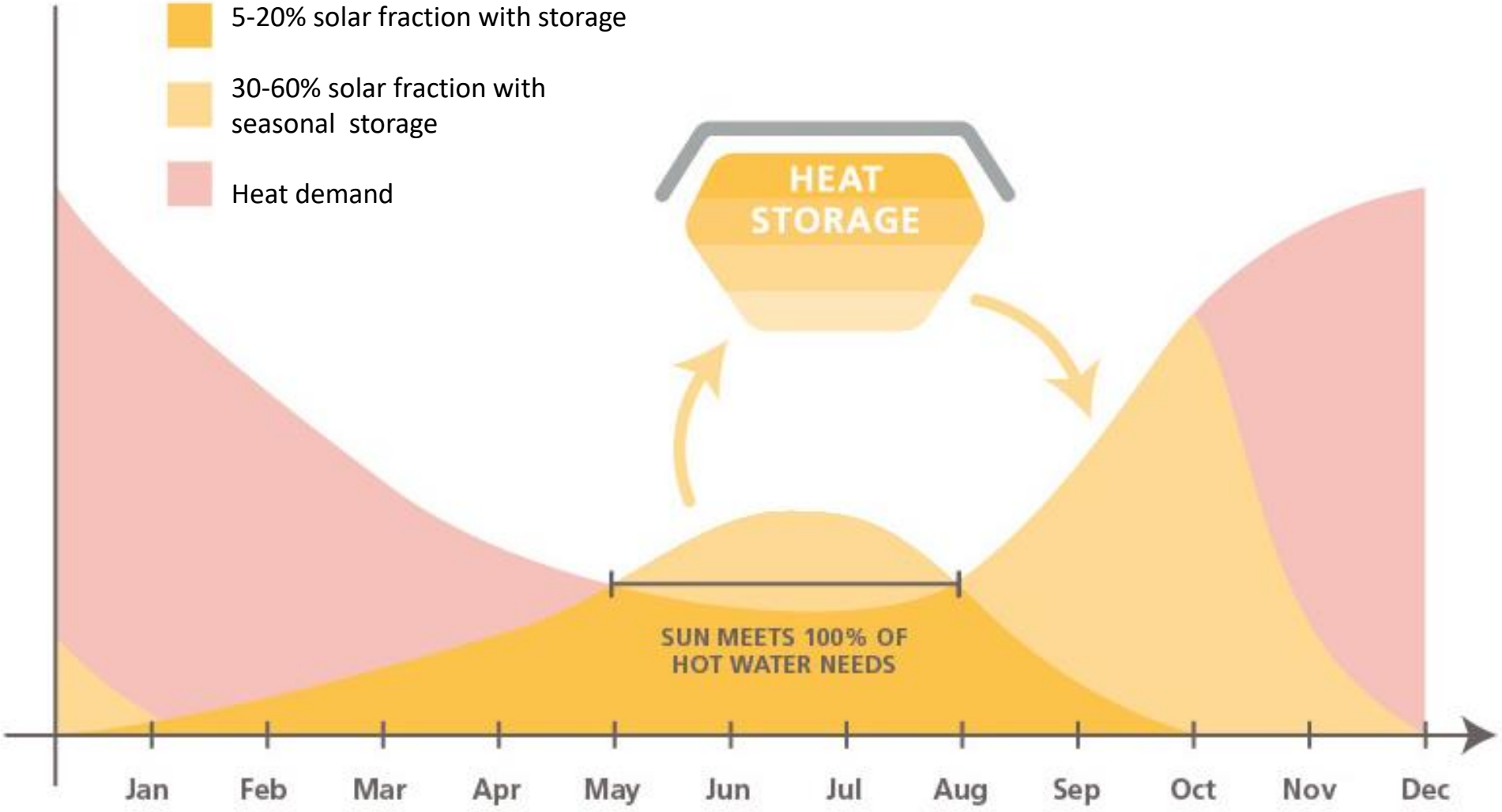
Operation according to electricty needs doesnot match heat profile

Industry tries to reduce waste heat

Limited Biomass Availibility

Source: Euroheat & Power

Storing summer sun for winter heating



Storage



Status of Big Solar today

- Several Projects in operation in small Danish/Chinese cities < 10.000 inh.
- Several projects under development in cities 30- 300.000 inh. in multiple countries

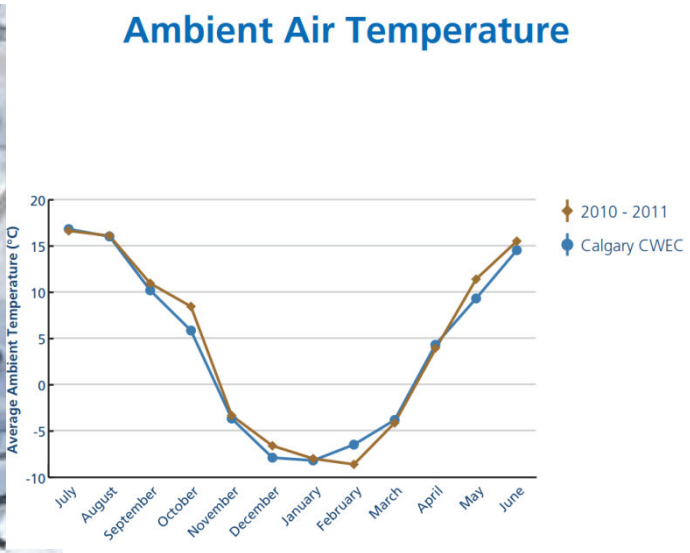
- Development ongoing to adapt storages to regional geology and improve invesmtent/cost ratio

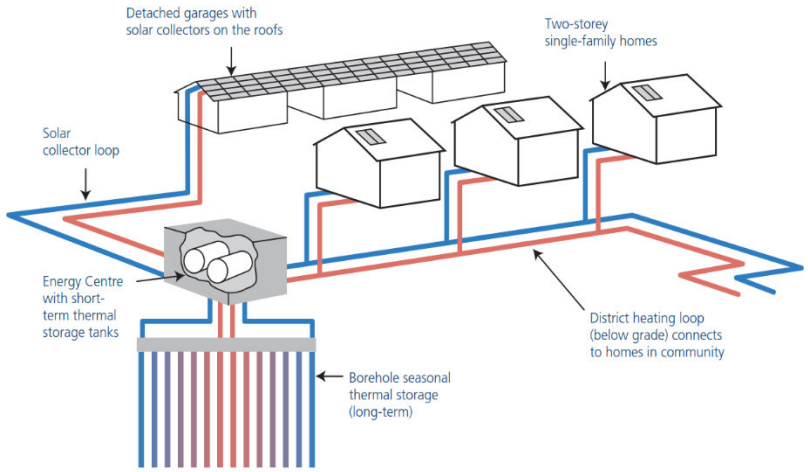
Existing and future Examples



Drake Landing, Canada





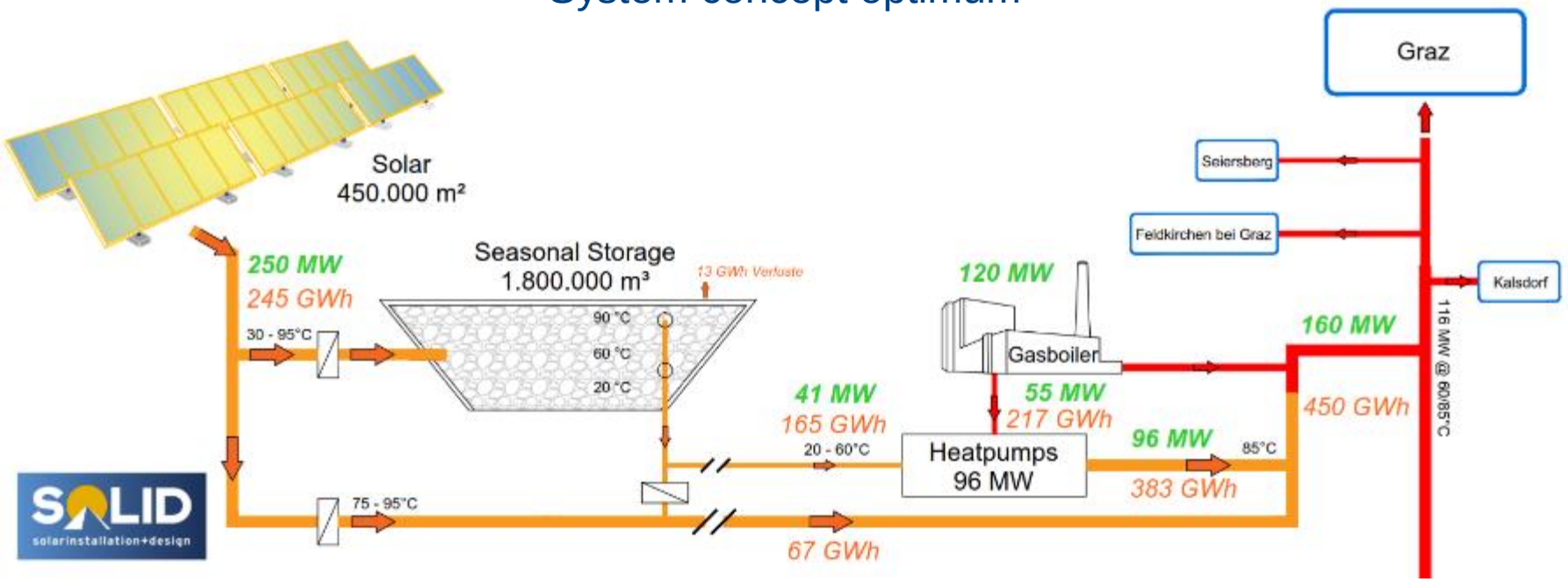


- 798 solar collector modules (2293 m² gross area)
- 240 m³ of water for short-term heat storage
- 34,000 m³ of earth for seasonal heat storage (144 – 35 m boreholes)

We can cover >90 % with solar in a best practice village scale DH net

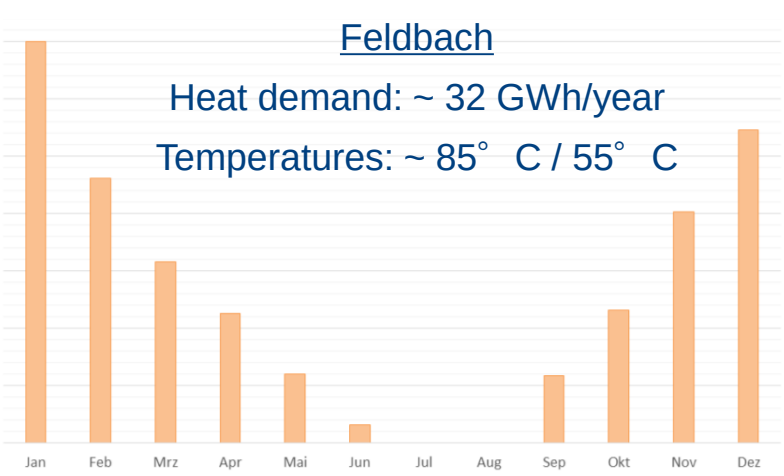
Case study BIG Solar Graz

System concept optimum

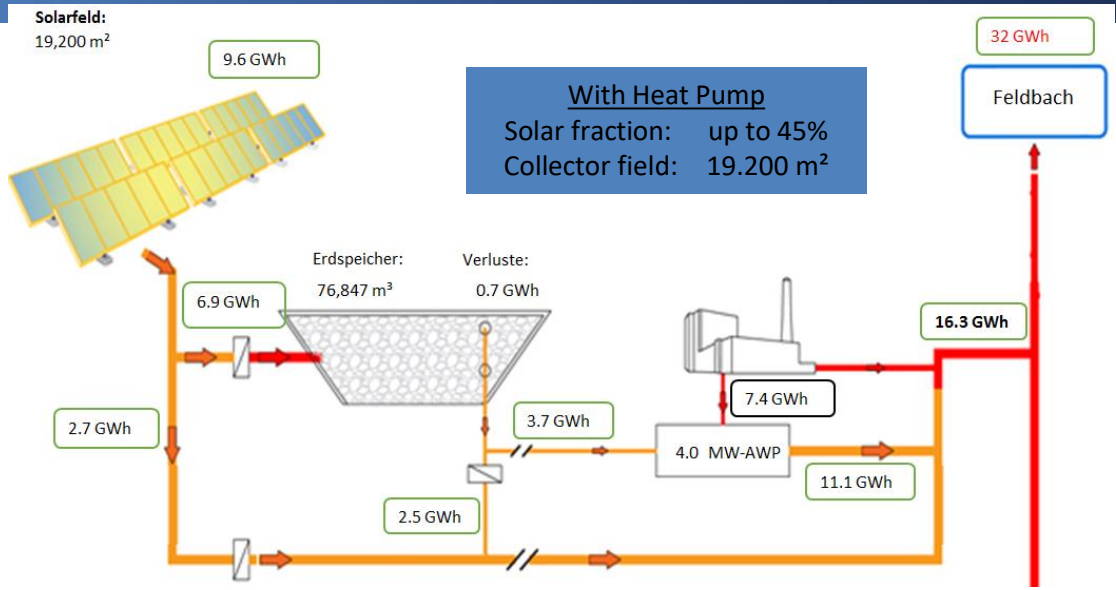


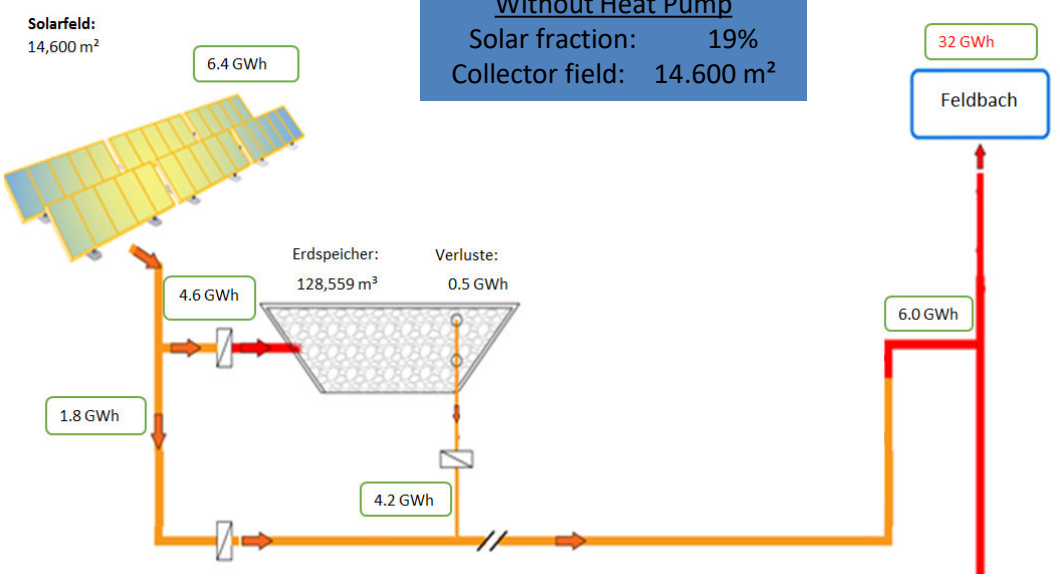
- 25% of city's district heating supply by solar
- Collector field : 450,000 m²,
- Total capital expenditures: ~200 Mio. EUR
- Feasibility study 2015
- Heat Price compareable to Natural Gas

Feasibility Feldbach (example with 54.000 m² used space)



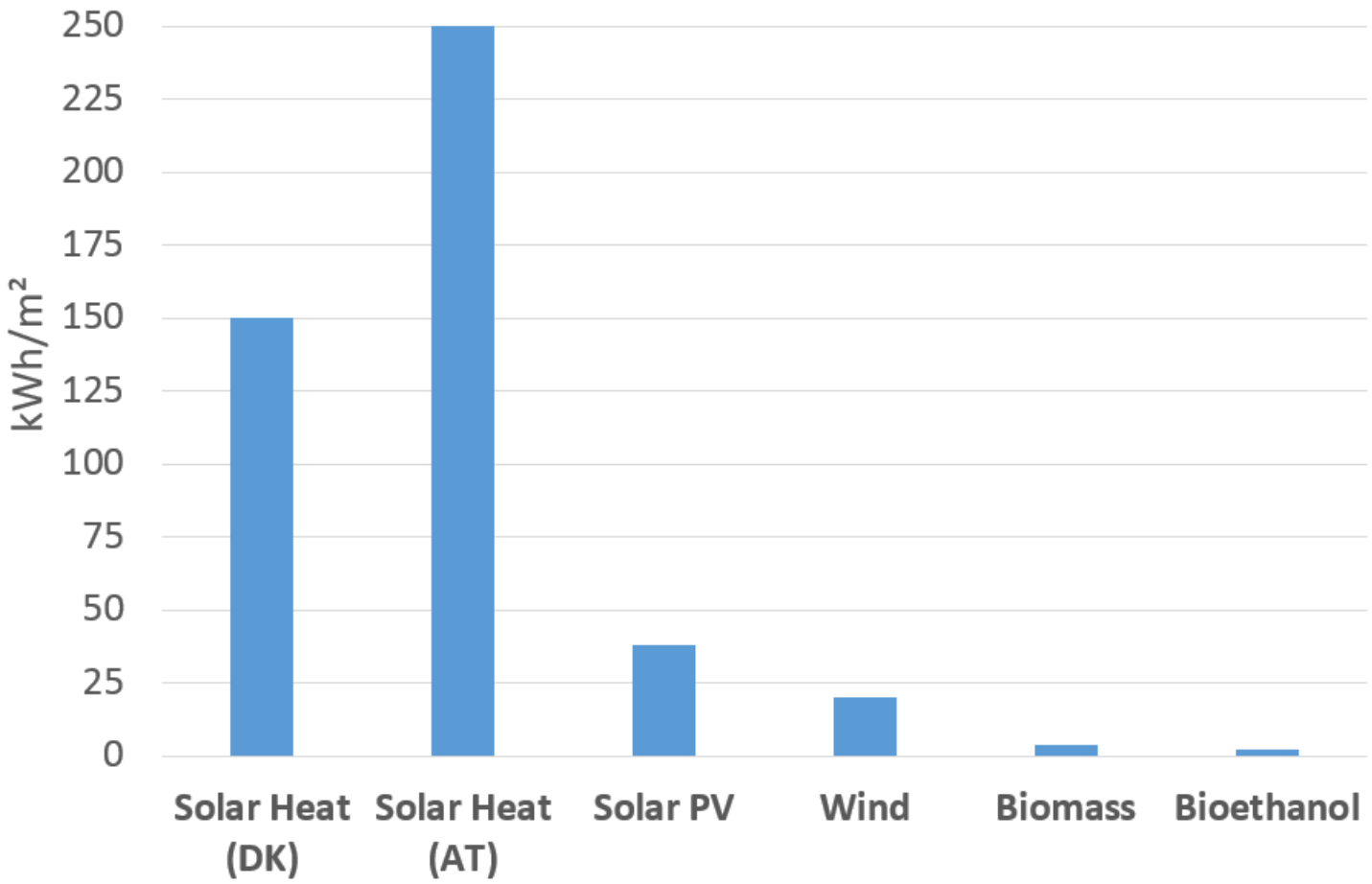






Required Space

Energy gain/m² ground



Required space: Big Solar Graz



required solar system area
< 0,8 % of the city area

comparison to other infrastructure areas in Graz

Big Solar concept	~ 100 ha
Airport Graz	~ 300 ha
Motorw. junc. Graz West	~ 40 ha
Generation plant Mellach	~ 110 ha

Areas for renewable energy need to become a part of urban planning!

Success Factors

- Modern district heating system with low supply/return temperatures
- Use of areas with restricted possibilities for collectors (former land fill, side areas of traffic, water protection area, …)
- Full integration in DH- system with multivalent use of storage
- Replacing fossil fuels for summer operation
-

Project Phases

Pre-Feasibility	Detailed Feasibility	Engineering & Construction	Monitoring & Controlling
Data collection	Technical and financial solution	Detailed Engineering	Tele-monitoring
Analyse energy and maintenance cost	Definition of revenues and savings	Procurment and Construction	Controlling
Estimation of savings potential	Financing offer (optional)	Optimisation	Maintenance
Project Concept	Energy Service Contract	Maintenance concept	Proof of energy services

Summary

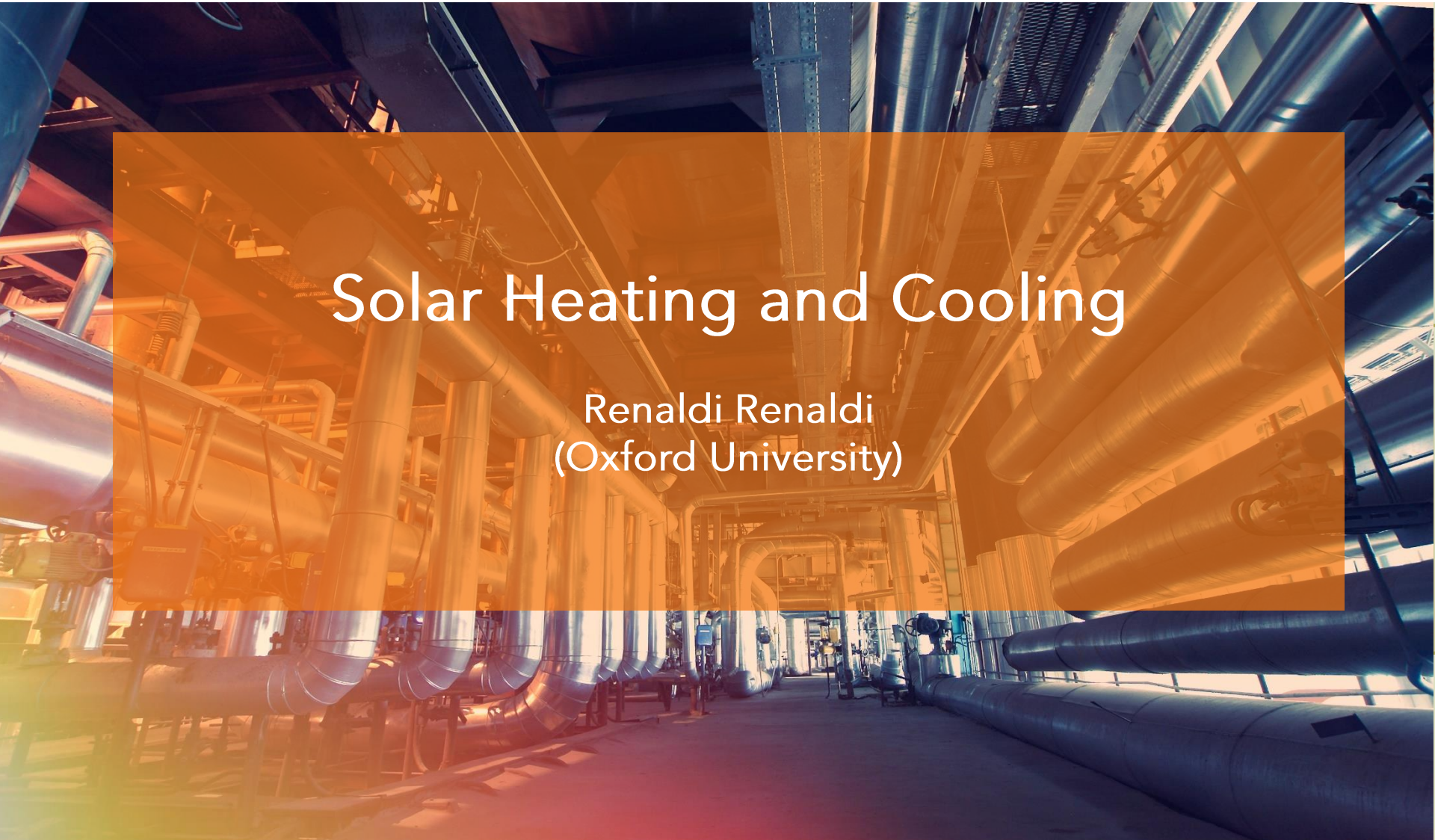
- Big Solar has a huge potential and can contribute to decarbonizing District Heating significantly
  - ca. 50% of DH can be supplied by solar economically
- Scaling is realistic compared both to potential capacity of solar industry, space demand and investment size
- Technology is ready to go but will improve still in the next years

Thank you for your attention!



SOLID Solar Energy Solutions
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Fax: +43 316 292840-28
Email: office@solid.at
http://www.solid.at

Triple Point
HEAT NETWORKS
INVESTMENT MANAGEMENT



Solar Heating and Cooling

Renaldi Renaldi
(Oxford University)

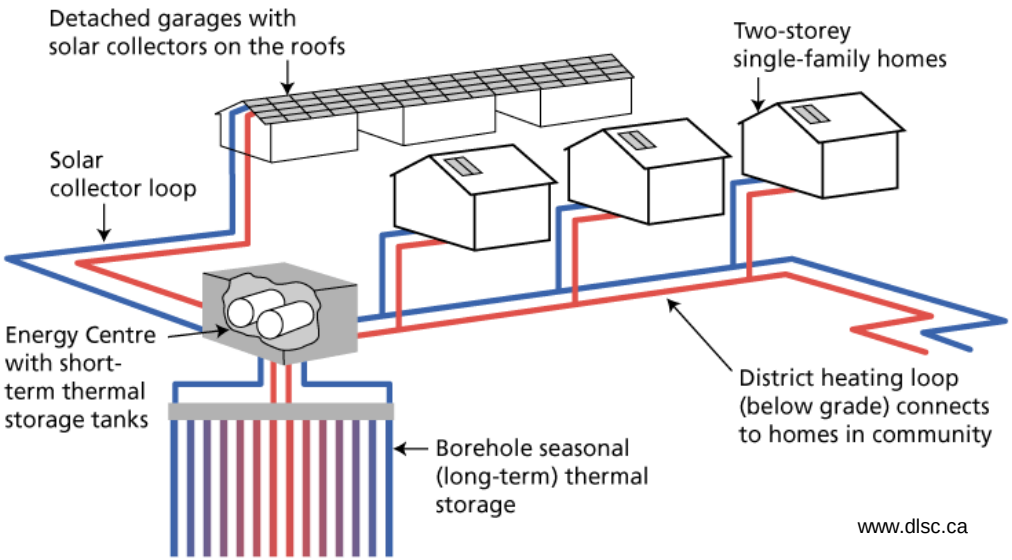
Case study: A 100% solar fraction system

Renewable Heat for Heat Networks Conference

London, 4 December 2019

Renaldi Renaldi
Research Associate
Energy and Power Group
Department of Engineering Science
University of Oxford

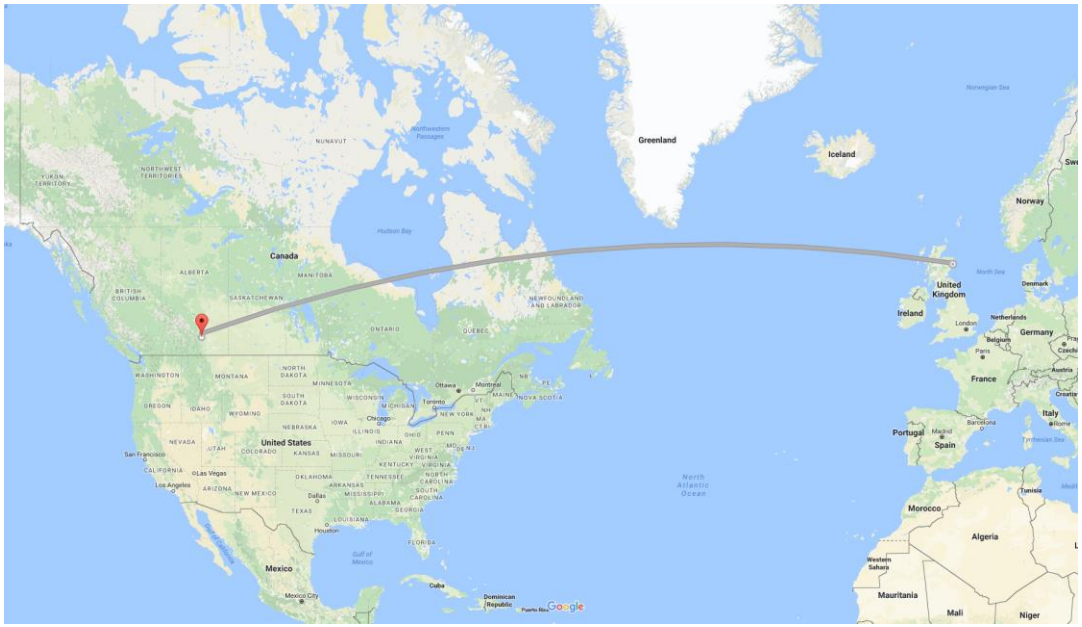
Drake Landing Solar Community





Location: Okotoks, Alberta, Canada

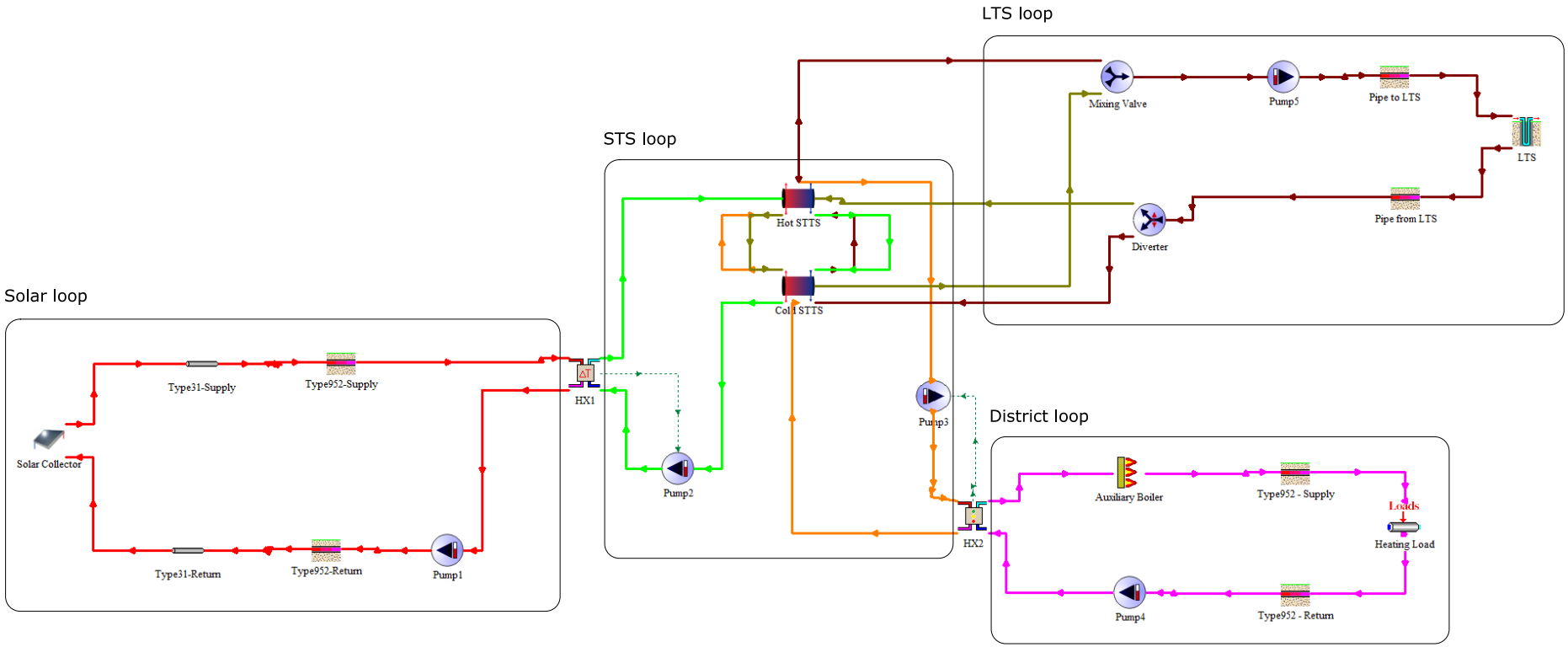
Operational: 2007 - present

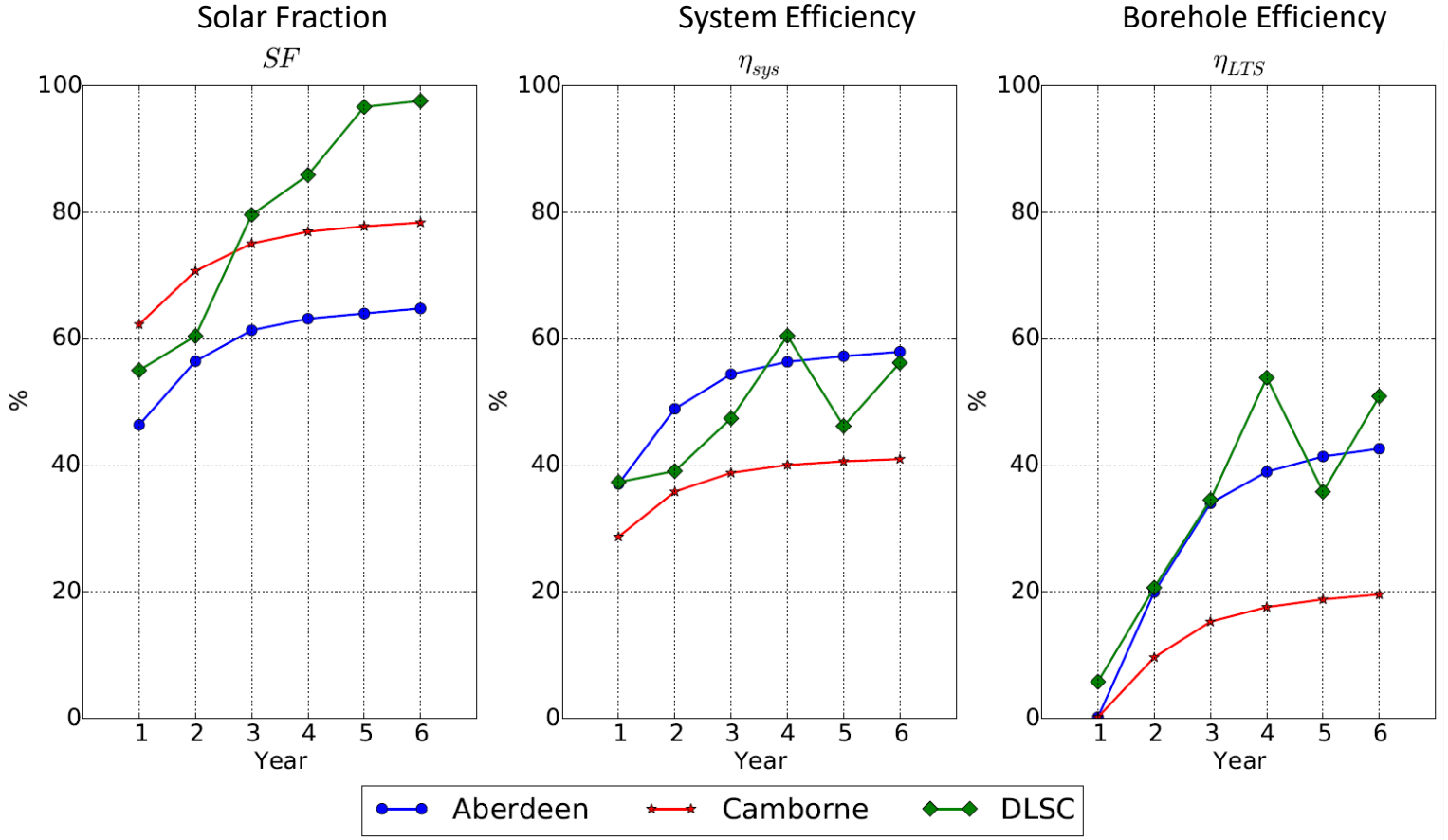




- Solar fraction
- System efficiency
- LCOE

Simulation model: TRNSYS

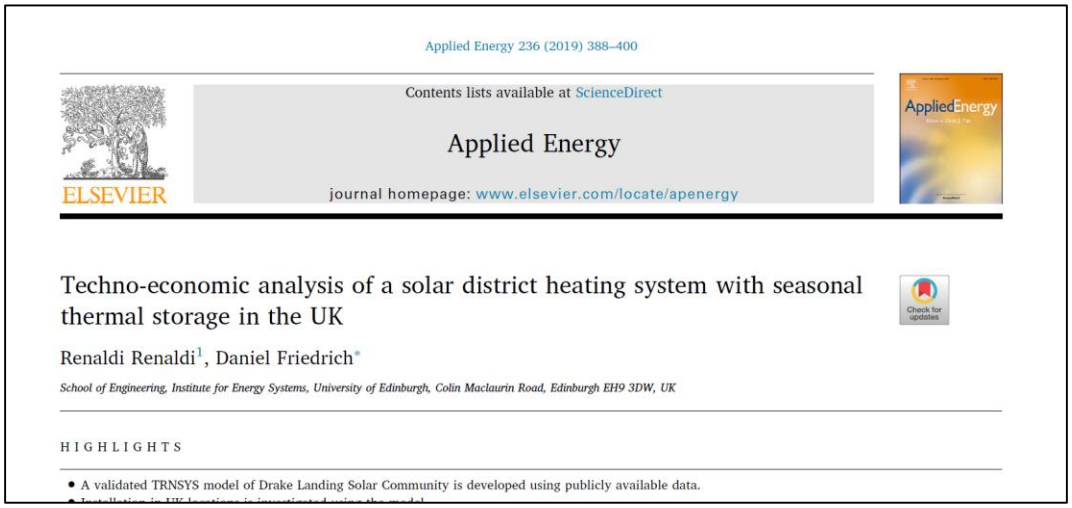




LCOE (£/kWh)
Aberdeen: 0.22
Camborne: 0.30

$LCOE_{ST}$ (£/kWh)
Aberdeen: 0.34
Camborne: 0.39

For more details



Applied Energy 236 (2019) 388–400

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

Techno-economic analysis of a solar district heating system with seasonal thermal storage in the UK

Renaldi Renaldi[1], Daniel Friedrich*

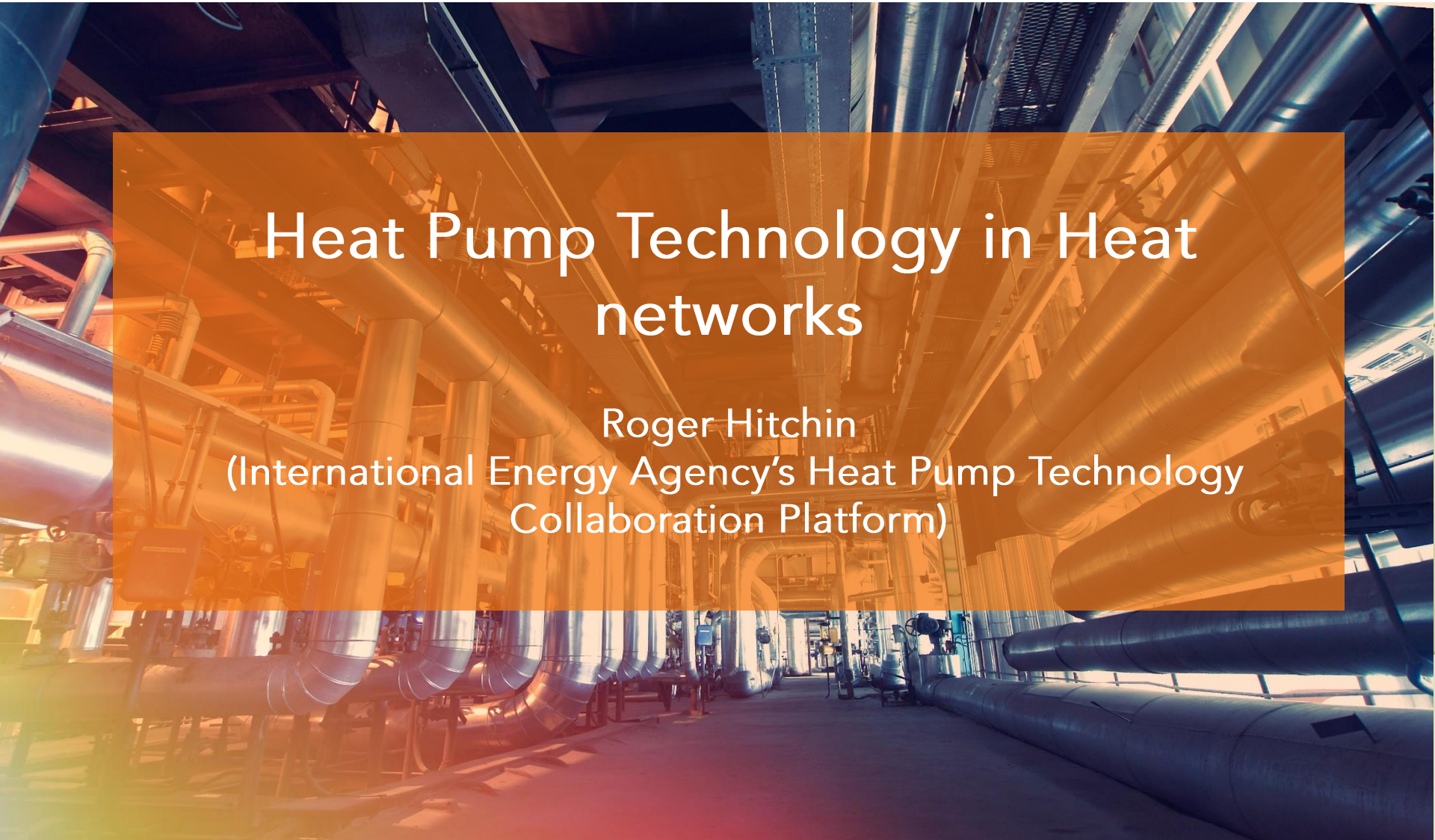
School of Engineering, Institute for Energy Systems, University of Edinburgh, Colin Maclaurin Road, Edinburgh EH9 3DW, UK

HIGHLIGHTS

- A validated TRNSYS model of Drake Landing Solar Community is developed using publicly available data.

renaldi.renaldi@eng.ox.ac.uk

Triple Point
HEAT NETWORKS
INVESTMENT MANAGEMENT



Heat Pump Technology in Heat networks

Roger Hitchin
(International Energy Agency's Heat Pump Technology Collaboration Platform)

HEAT PUMPS AND HEAT NETWORKS

The IEA Heat Pump Technology Programme

CONTENT

- Outline of the IEA "*Heat Pumping Technology*" Technical Collaborative Programme
- Heat Pumps and Heat Networks
  - As heat sources to networks
  - Distributed systems
- Proposed New Project: *"Flexibility by implementation of heat pumps in multi-vector energy systems and thermal networks"*

WHAT DOES THE HPT PROGRAMME DO?

- **Research Annexes** – Participants provide own funding/research. One country appoints an operating agent to manage the project. 55 Annexes to date, 9 currently active. (17 countries)

- **Newsletter** - A quarterly newsletter/journal. Presents heat pump technology, markets and market development, and information from annexes in the Programme.

- **Conference** -Every three years the IEA Heat Pump Programme stages an international IEA Heat Pump Conference. The next will be held in 2020 in South Korea.

- For more information:
- http://heatpumpingtechnologies.org/-Heat Pump Centre
- http://hpc2020.org/-202 Conference

THE UK "HPT NATIONAL TEAM"

- Each country is required to have a "National Team"
  - a means of interacting with industry and researchers

- In the UK its main activity is an annual one-day seminar
  - Most recently September 2019
  - About 90 attendees from across the industry
  - Presentations and discussions on Programme activities and other UK and International projects
  - Several expressions of interest in new projects

RECENT AND CURRENT ANNEXES WITH UK PARTICIPANTS

- Annex 43 Fuel Driven Heat Pumps : UK Participants: Warwick University.
- Annex 45 Hybrid Heat Pumps: UK Participants: BEIS, Glen Dimplex, PassivSystems, Mitsubishi Electric.
- **Annex 47 Heat Pumps in District Heating: UK Participants: BEIS, Glen Dimplex, Cardiff University, Leeds University**.
- ***Annex 46 Domestic Hot Water Heat Pumps: UK Participants: University of Ulster, Cardiff University, Glen Dimplex, BRE, Mitsubishi Electric, BSRIA.***
- ***Annex 48 Industrial Heat Pumps: UK Participants: University of Ulster, Cardiff University, Mitsubishi Electric***
- Annex 52 Long-term performance monitoring of commercial GSHPs: UK Participants: Leeds University, British Geological Survey, GSHPA, HPA, BEAMA.

OTHER RECENT AND NEW ANNEXES

Ongoing – no UK participants

- Annex 49 Design and integration of heat pumps for nZEB – Operating Agent Switzerland.
- ***Annex 50 Heat Pumps in Multi-Family Buildings for space heating and DHW - Operating Agent Germany***.
- Annex 51 Acoustic Signature of Heat Pumps - Operating Agent Germany.

New Annexes - open for participation

- Annex 53 Advanced Cooling and Refrigeration – Operating Agent USA
- Annex 54 Heat pump systems with low GWP refrigerants - Operating Agent USA
- Annex 55 Heat Pumps and Storage ("Comfort Climate Box") – Operating Agent NL
- Digitalization and IoT for Heat Pumps –Operating Agent Austria

HEAT PUMPS AS SOURCES FOR DISTRICT HEATING

- Increased temperatures from “low-grade” heat sources
  - In particular from large, low-carbon waste or renewable sources, remote from demand
  - Can use refrigerants that provide high temperatures but would be problematic in buildings *(eg Ammonia)*
- Can be added to existing networks
- Centralised plant can have better operation, monitoring and maintenance regimes than decentralised heating

2050 POTENTIAL: H2020 HEAT ROADMAP PROJECT

- Cited by Annex 47: includes country report for UK (2050)
  - Economic modelling with geographical market constraints
  - Some questionable assumptions and methods (in my view)
- 56% of space heating provided by individual heat pumps
- Heat networks provide (most of) the rest:
  - 45% industrial and petrochemical waste heat
  - 37% cogeneration
    - Heat deemed to be secondary product that is carbon-free
    - Fuel mix: 50% natural gas, 50% biomass
  - 28% large heat pumps (low temperature waste heat)

UK DISTRICT HEATING NETWORKS AND HEAT PUMPS

- About 2,000 district heating systems in the UK
  - Supplying about 1% of building heat demand
  - Heat Roadmap project: potentially 35% or more by 2050
- Annex 47 estimated that
  - 1% of UK DH sources are heat pumps currently
  - Heat Roadmap project: could increase to 2% to 25% by 2050.
- Heat Network Project Pipeline (2019 Q2): of 80 projects, 9 have heat pumps: 2 Ground Source, 1 Minewater, 6 other Water Sources

HEAT FROM SEWAGE: UK EXAMPLE

- Scottish Borders College

- 2 X 400 kW heat pumps using sewage as heat source
- Typical sewage water temperature between 20-25°C in summer and 10-15°C in winter
- Provides nearly all heat needed on campus via 5 plant rooms
- SCOP (23 months) 3.8



Infintatas Design

HEAT PUMPS IN LOW TEMPERATURE HEAT NETWORKS

- Large low temperature district heating / cooling network

OR

- Communal heating (or cooling) network within a building
  - About 12,000 systems in the UK, supplying 1% of building heat demand
  - *Heat pump* heating/cooling systems used since at least 1964 (Versatemp)
    - Can redistribute reject heat from cooled spaces to those with a heat demand (and vice versa)
    - Within individual buildings the savings are quite low
  - In multi-family dwellings, reduces heat loss from distribution pipes in communal spaces which aggravate overheating

EXAMPLE: SWEDEN

E.ON “Ectogrid”



Medicon village

- Redeveloped industrial site – single owner
- Will eventually connect 15 commercial and residential buildings with different heating and cooling needs.
- System includes storage.

TWO-STAGE SYSTEMS

- In principle, a two-stage system is more efficient than single stage
  - But that depends on distribution and other losses
- Relative to stand-alone heat pump:
  - For heating, the network needs to be at above-ambient temperature
    - And below the desired supply temperature
  - For cooling, the network needs to be at below-ambient temperature
    - And above the desired supply temperature
- Efficiency per se does not affect carbon savings if heat source and electricity are is zero-carbon
  - Still important for cost and capacity

CHALLENGES FOR NEAR-AMBIENT NETWORKS

- Heat recovery requires overlapping and reliable cooling and heating demands from multiple users
  - May need thermal storage
  - Additional barriers from landlord/tenant agreements
- Heat supplier is (probably) responsible for in-house equipment
- Magnitude of carbon savings compared to independent heat pumps?
- Hot water provision needs either higher temperature HP or back-up
  - Heat pumps typically provide 60 C, but higher temperatures are possible.

PROPOSED NEW ANNEX ON HEAT PUMPS AND THERMAL NETWORKS

"Flexibility by implementation of heat pumps in multi-vector energy systems and thermal networks"

- Focus "how heat pumps, in combination with thermal grids, can support the *electrical network* locally, regionally, and nationally"
- Follows on from Annex 47 "**Heat Pumps in District Heating and Cooling Systems"**
- Supported by, and will work with, the **DHC** "**Hybrid Energy Networks"** project
- Potentially interacts with SHC Annex 55: "**Towards the Integration of Large SHC Systems into DHC Networks"** and DHC Annex TS5"**Integration of Renewable Energy Sources into existing District Heating and Cooling Systems (RES DHC)**

PROPOSED STRUCTURE (SIMPLIFIED)

- Task1: **Energy market analysis** – Future developments and sector coupling
  - **Define** “flexibility and sector coupling” and clarify which requirements are to be taken into consideration
  - **Analyse** different electricity markets and assess how heat pumps and networks can interact with them.
- Task 2: Identification and description of **existing projects**
- Task3: Development of representative and **promising concepts**
- Task 4: Assessment and analysis of **identified options**
- Task 5: Development and evaluation of **business models**
- Task 6: Dissemination - summary report for **policy makers**

PROVISIONAL TIMESCALE

- Three-year project
- Danish Operating Agent
- Probably starting in 2020
  - Workshop to flesh out priorities at IEA Heat Pump Conference in Korea, May 2020
  - Likely to be formally approved at ExCo in Korea

SUMMARY

- Heat pumps can provide low-carbon heat to heat networks
  - Established technology
- Distributed heat pumps in low-temperature systems offer potential advantages
  - Limited experience at network scale
- Heat pumps in heat networks could provide flexibility at scale to electricity generation systems
  - Needs assessment and demonstration

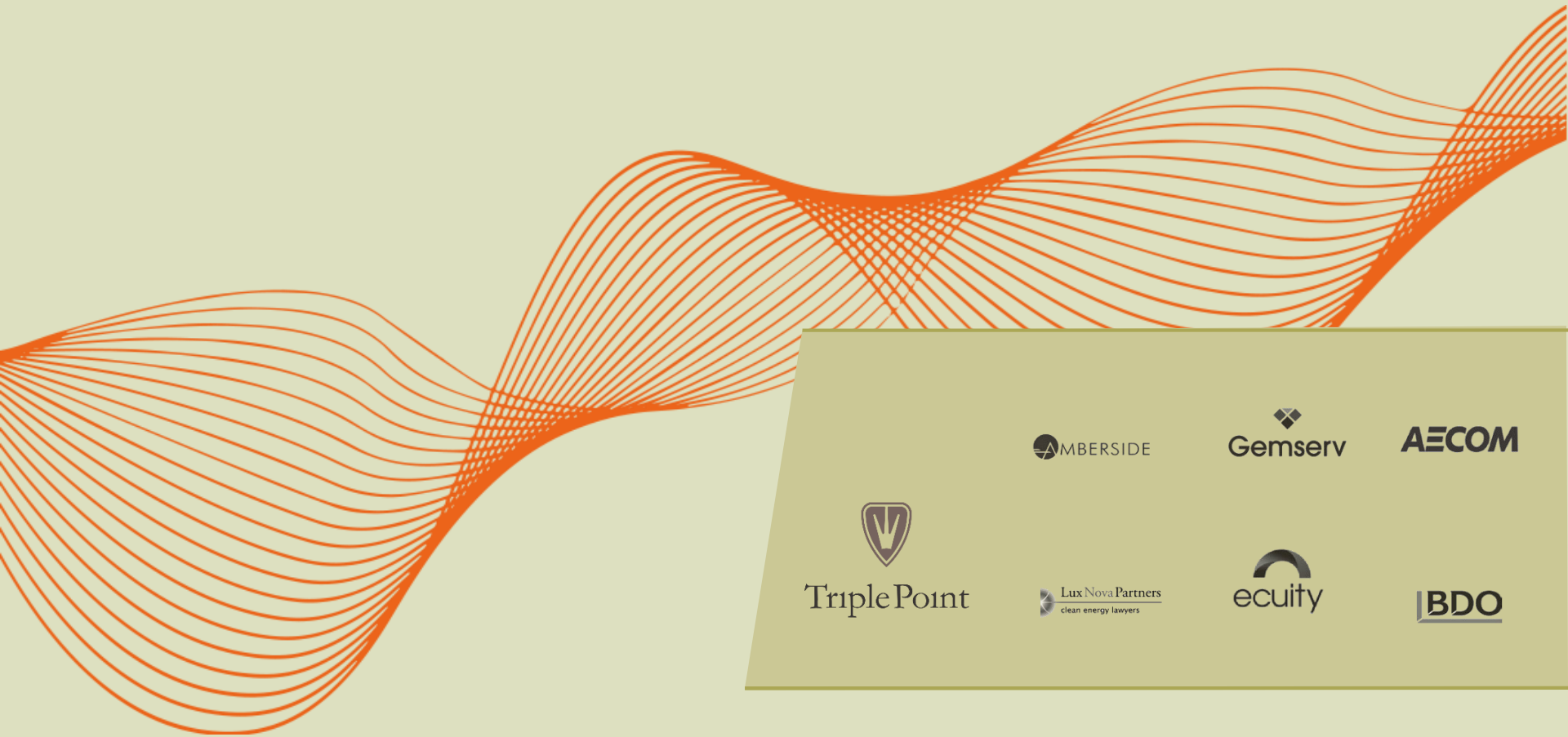
THANKS FOR LISTENING

- More information
  - Annexes and programme generally: https://heatpumpingtechnologies.org/about/heat-pump-centre/

  - UK representatives
    - oliver.sutton@beis.gov.uk
    - roger.hitchin@blueyonder.co.uk

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Panel discussion



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Refreshment break

Please return at 11:10

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HNIP Heat Decarbonisation Assessment Overview

Dr Andrew Cripps
(Triple Point Heat Networks Investment Mangement)

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Dr Andrew Cripps, AECOM

- Technical lead for TP team
- 30 years in construction consultancy and research
- Leads team in St Albans office
  - DH design studies
  - Renewables
  - Assessments and planning support, LCA
  - Post occupancy evaluation
  - Research

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Contents

- Key scheme features for renewables
- Engagement to date
- Observations on technologies

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HNIP main features

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Eligibility, Scoring and Decisions

Projects must be **eligible** to be assessed

Four **scored** elements combined into one total score

Ranking list and funding **decision** process

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Eligibility – Heat network

Eligibility

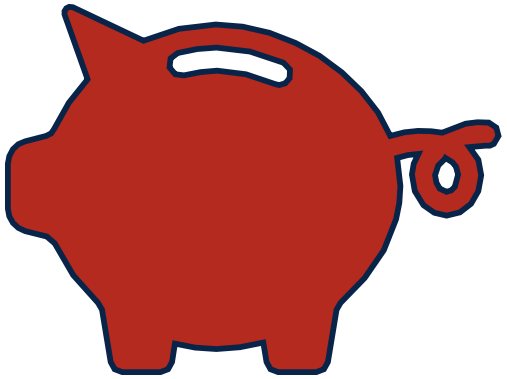
- Must meet the definition of a heat network
- Scheme size > 2GWh per year
- Potential to expand and decarbonise
- Delivers carbon savings
- Low carbon heat source
  - >75% of heat if gas CHP, [Good quality]
  - >50% of heat if renewable

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Eligibility – Funding rules

- Project does not exceed State Aid limits

- This matters because RHI is also State Aid
- Costs for e.g. heat pump will not be eligible
  - But other costs generally are



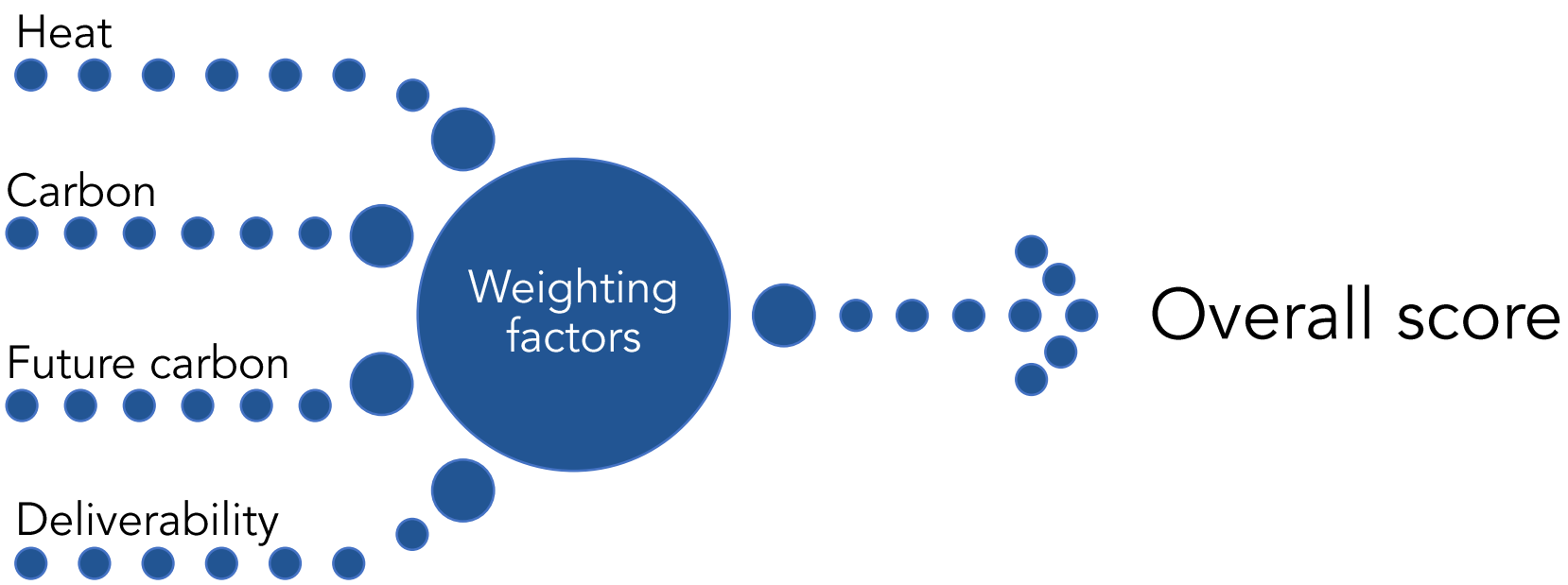
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Scoring

- Projects are scored on:
  - Volume of heat delivered (GWh)
  - Project carbon savings (TCO_2E)
  - Future decarbonisation (TCO_2E)
  - Deliverability

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Overall score



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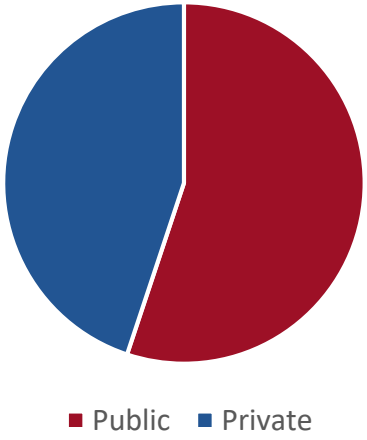
Key Themes So Far

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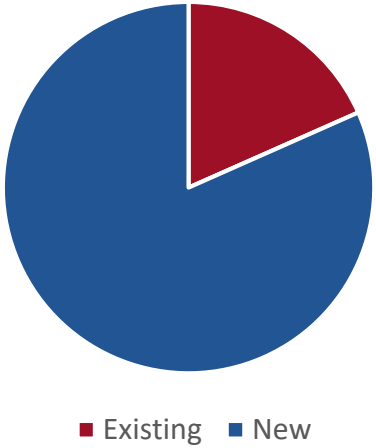
Statistics Summary

We are pleased with the number of applications and the range of projects represented.

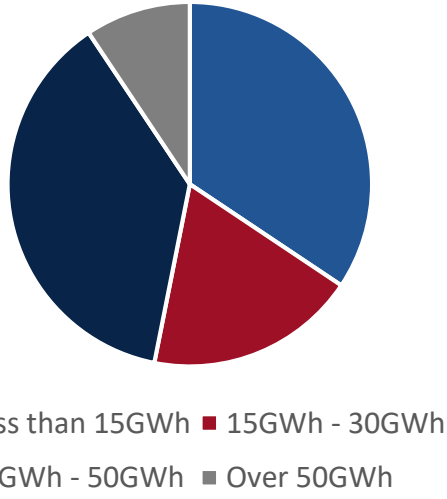
50+ pre applications submitted



Both new and existing schemes

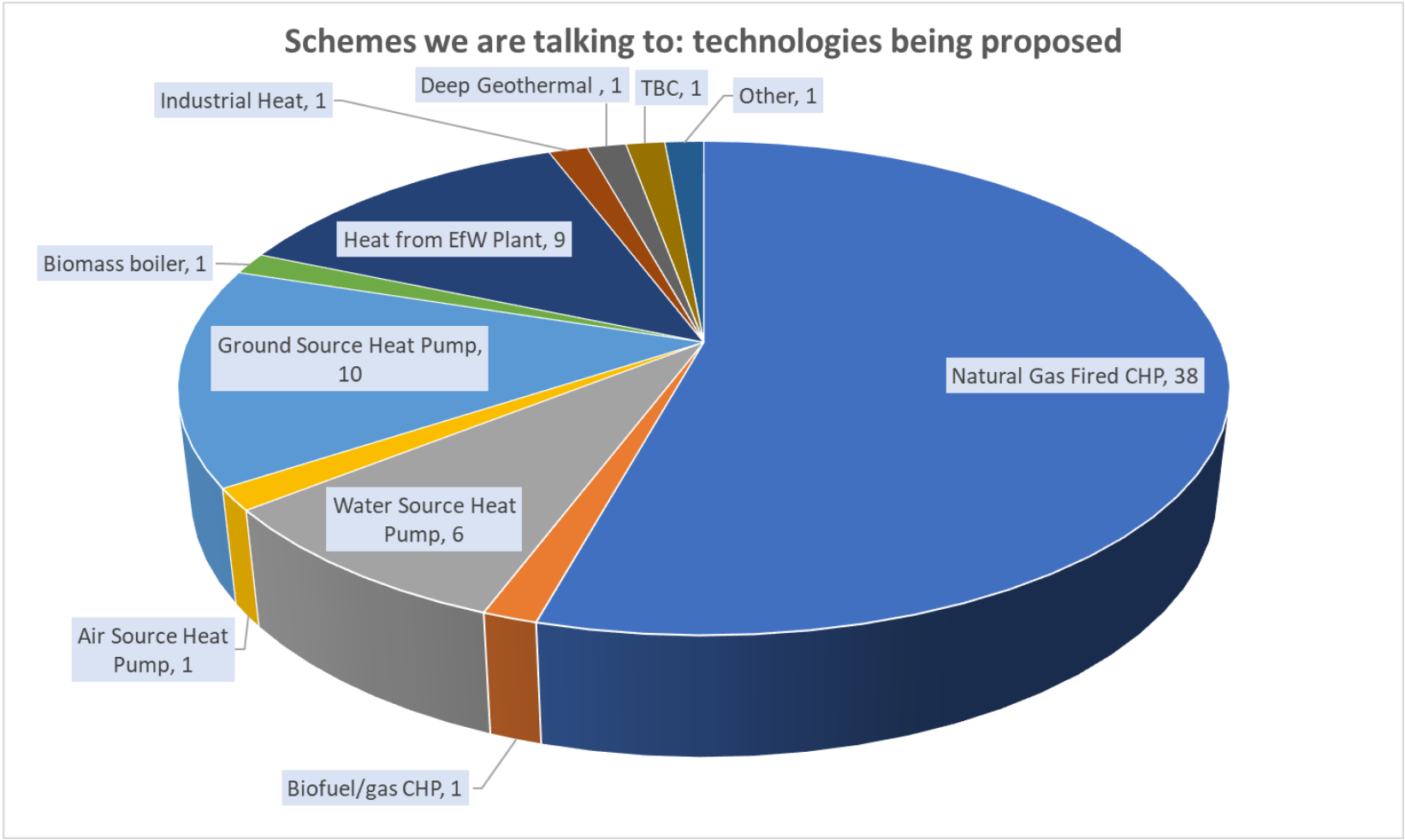


GWh delivered per year (exc. Network losses)



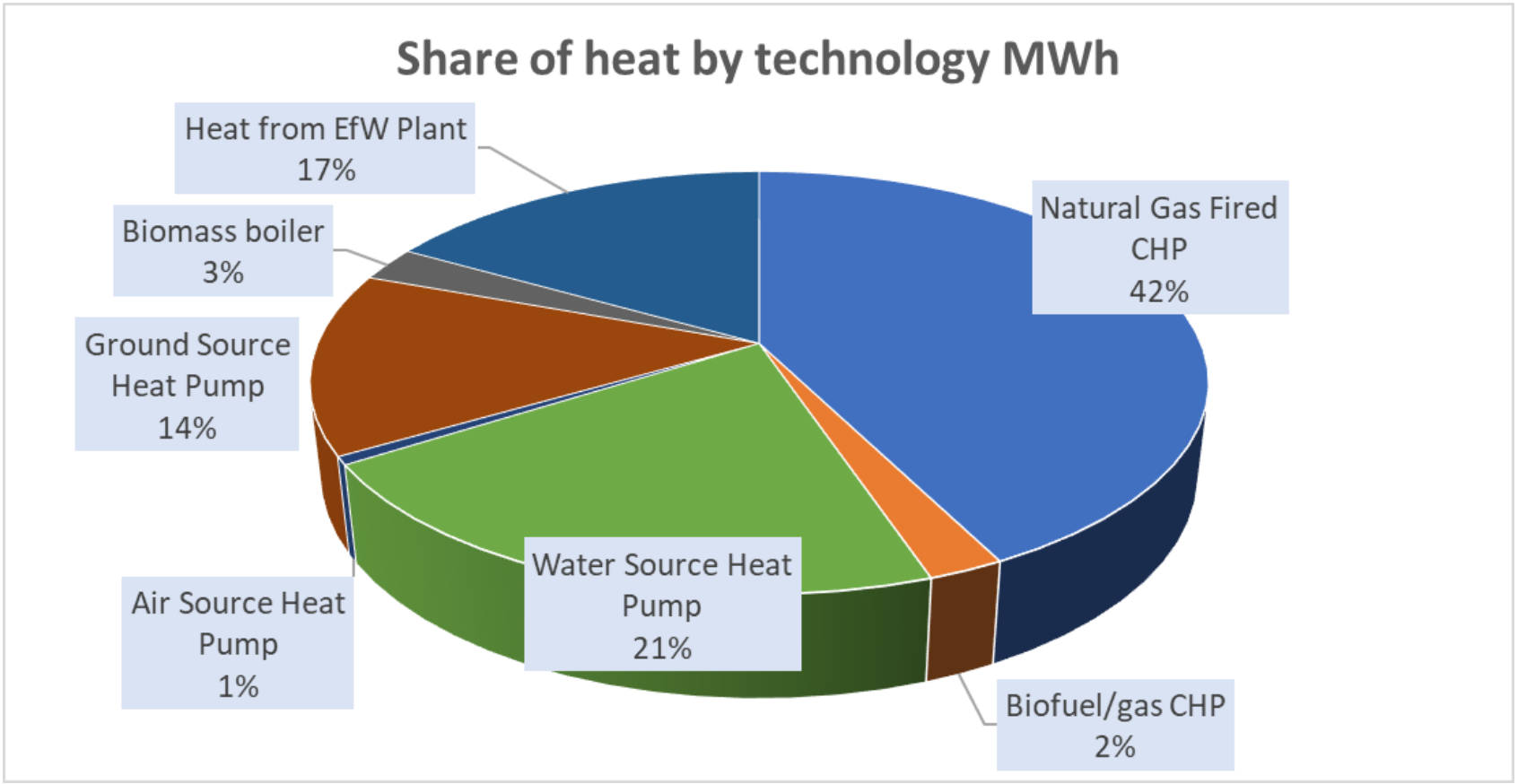
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Technologies being considered



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But scheme sizes vary…



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Thoughts on technologies

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Gas CHP

- Not renewable…
- But can be an important first step
- Challenge of operating temperatures when we switch away from this
- Is Hydrogen CHP the answer?

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Heat pumps

- Capital costs are high
- Limited / no operational saving compared to counterfactual
- Will RHI continue?
- Is performance good enough?
- How to integrate with existing networks?

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Energy from waste

- Is it renewable? [partly]
- Is it sustainable?
- But if it exists we should not waste the heat….

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'Other'

- Industrial 'waste' heat – typically not really renewable but can be good
- Biomass / Anaerobic digestion – not seeing many
- No solar thermal yet
- No renewable Hydrogen through fuel cells
- No nuclear CHP yet – not renewable but should be low carbon

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Headlines for HNIP

- Main focus is investing in heat networks
  - The clue is in the name!
- Carbon saving as an important by-product

  this is not a renewables support scheme

  but we do want schemes with renewables
- If fossil gas CHP to start must have a future decarbonisation plan
- Gap funding only
- Consider State Aid

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District Heating Technology

Robin Wiltshire
(International Energy Agency's District Heating Technology Collaboration Platform)

IEA Technology Collaboration Programme on District Heating & Cooling (IEA-DHC)

4 December 2019

Robin Wiltshire

What is the IEA District Heating & Cooling TCP?

- IEA-DHC was established in 1983
- Established as a cost-shared TCP that carries out research projects in three-year ‘annexes’ which comprise 4 – 6 projects
- Also initiated task-sharing in 2011
- Current members are: Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, Korea, Norway, Sweden, UK, USA.

IEA-DHC: what it does

- Cost-shared projects carried out in three-year ‘annexes’ which comprise 4 – 6 projects chosen by competitive bidding
- Task-shared projects emerging alongside the cost-share programme: participants identify their own funding
- Approximately 80% of projects are technically focused’; 20% policy focused
- Research topics cover all aspects of DHC technology focusing on reducing cost and improving performance: eg pipe materials, installation techniques, system optimisation, pro-active maintenance, thermal storage, integrating renewables
- Reports are produced for all projects and are available at the website: www.iea-dhc.org

Annex XII (2017-20) – current projects

- Effects of Loads on Asset Management of the 4th Generation District Heating Networks

  4GDH networks: to facilitate waste (secondary) and renewable heat sources
- MEMPHIS - Methodology to evaluate and map the potential of waste heat from industry, service sector and sewage water by using internationally available open data

  Waste (secondary) heat sources are as important as renewables
- Integrated Cost-effective Large-scale Thermal Energy Storage for Smart District Heating and Cooling
- Stepwise transition strategy and impact assessment for future district heating systems.

Ongoing Task Sharing Initiatives

Practical realisation of low temperature district heating systems

Contact kristina.lygnerud@hh.se Nottingham workshop presentations can be found at www.iea-dhc.org

UK participation: Nottingham Trent University, University of Leeds, DESMI, Carbon Alternatives

The key motive for this work is to be able to make more use of available sources of waste (secondary) heat sources and renewable heat sources, paving the way for a post-fossil future.

Practical realisation of low temperature district heating (LTDH) systems

The purpose of Annex TS2 is to facilitate the implementation of LTDH:

- Key topics for increased LTDH implementation will be explored. These topics enable the identification of critical hurdles to overcome for efficient LTDH implementation. A systems approach will be taken with focus on the following areas:
- (1) the indoor heating systems of buildings
- (2) the district heating systems
- (3) new demonstrations
- (4) the competitiveness of the LTDH business
- (5) compile knowledge into guidebook for LTDH implementation.

Ongoing Task Sharing Initiatives

Hybrid Energy Networks – DHC networks in an integrated energy system

Contact: Ralf-Roman.Schmidt@ait.ac.at

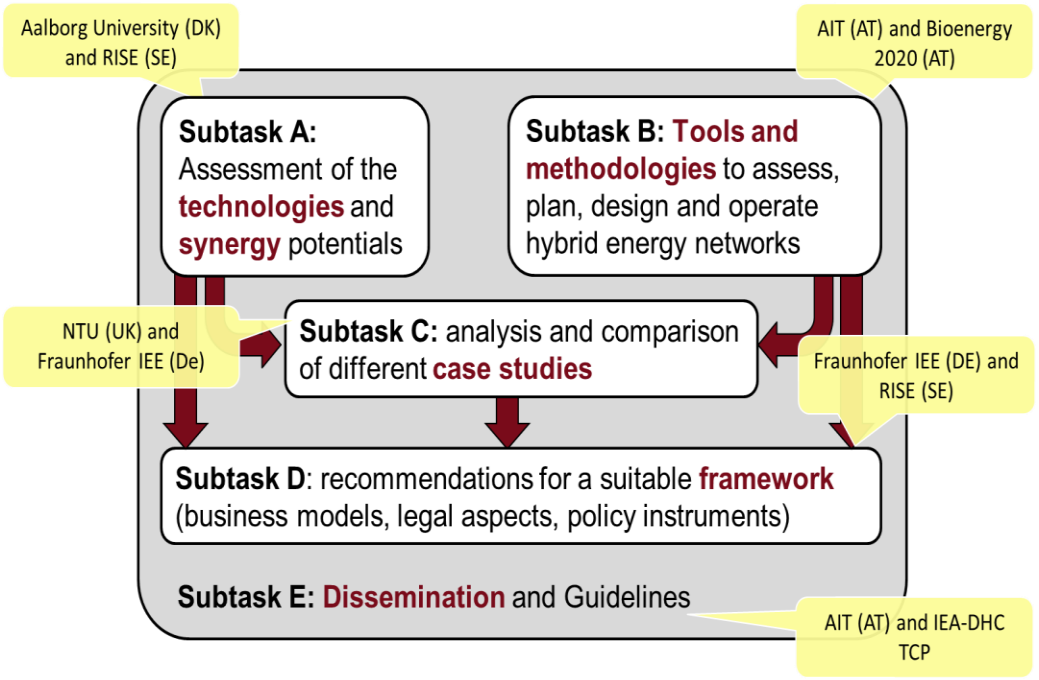
UK participation: Nottingham Trent University

Sector coupling is one of the key developments for decarbornising the energy system; it can trigger important synergies that cannot be achieved by each sector individually.

.

Hybrid Energy Networks - aim and structure

- Aim: to **promote the opportunities and to overcome the challenges** for DHC networks in an integrated energy system context.
- provides a **holistic approach** for assessing, planning and operation,
- considers **technical** aspects (system configuration, operational strategy) and **strategic** aspects (business model, regulatory frame).



Task Sharing Initiatives in planning

Digitalisation of DHC: Optimised Operation & Maintenance of DHC via Digital Process Management

Contact: Dietrich Schmidt *dietrich.Schmidt@iee.fraunhofer.de*

This work is important in enabling the integration of fluctuating heat sources (renewables).

Background: Digitalisation of DHC

- District heating and cooling networks are **traditionally** operated with a limited number of controls.
- A wider implementation of information and communication technologies, as in many other industries, opens up opportunities for better network management based on real time data.
- **Opportunities**:
  - offering flexibility by integrating digital processes and demand side management (peak shaving)
  - enabling the integration of fluctuating heat sources (renewables)
  - new business models for district heating providers.

Task Sharing Initiatives in planning

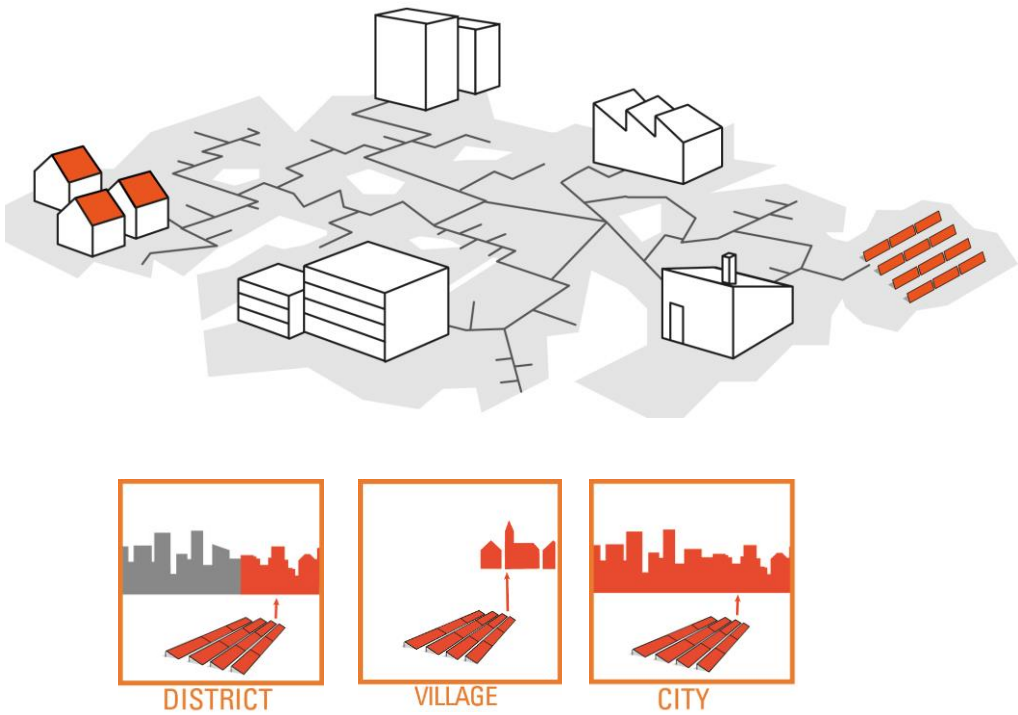
Integration of Renewable Energy Sources (RES) into existing DHC Systems

Contact: Thomas Pauschinger pauschinger@solites.de & Heiko Huther h.huther@agfw.de

Service life analysis and life-time prediction of buried pre-insulated bonded DHC pipes

Presented to ExCo and approved for development

Integration of RES into DHC networks



- biomass
  (heat plants, CHP)
- solar thermal
- geothermal
- CHP
- industry surplus heat
- power-to-heat from RES
  (electric boilers, heat pumps)
- thermal energy storage

Integration of RES into DHC networks: potential subtasks (tbc)

Approach: R&D activities will address heat network integration.

Subtask A: Integration of RES heat plants into DHC systems; large heat stores in combination with CHP and surplus heat

Subtask B: Decentral integration of RES heat into DHC systems: technical solutions for substations, effects on network operation, prosumer models

Subtask C: Non-technical aspects: economics, life cycle analyses, legal framework, business models, area availability for RES

Subtask D: Dissemination and knowledge transfer

Integration of RES into DHC networks: target audiences

- Heat suppliers and DHC network operators (as knowledge receptors, owners and investors of demo cases)
- Technology suppliers, planners and service providers of the DHC sector
- National and regional Authorities (legal framework, support instruments) and local authorities
- Citizens and DHC-end users.

Call for Proposals: (cost-share) Annex XIII

- Full details now at website www.iea-dhc.org
- Short (2 pages) project outlines to be submitted by 28 February 2020
- Outlines that are approved will be invited to submit full proposals by 15 May 2020
- Work on the basis of $100k - $220k; total budget about $1.2m
- Projects approved will be notified by mid-July 2020
- Aim for a duration up to a maximum 30 months
- Project teams should comprise at least 2 countries; more than 4 countries in a project team is not recommended.

Topics for cost –share Annex XIII

1. Decarbonisation and temperature reduction in District Heating Networks

1.1 Cost-effective system transformation - *pathways towards low-carbon energy solutions; for DHNs, innovative low-carbon and low-temperature technology combinations promising cost reduction*

1.3. Flexibility and thermal storage - *balance between heating & cooling sources and demand profiles; simulation models; integration of alternative materials/technologies; time-scale hours to seasonal*

1.4. Demand side – *solutions that allow demand side to contribute to more sustainable DH systems; improved sub-stations eg that enable return temperatures to be minimised while remaining cost-effective.*

Topics for cost –share Annex XIII

2. Improving the business case of DHC including the integration of prosumers

2.1. Better economic viability - *cost-reduction strategies for network piping and building connection; design, construction and installation; trenchless technologies; optimised design for systems integrating multiple heat sources; maintenance improvement*

2.2. Bringing together the investment world and the DHC world – *making low-carbon DHC fundable at a large scale; identify barriers that deter investment and how to overcome them, including risk management and decision support strategies*

2.3. Market development to allow the integration of prosumers – *synergies with electricity markets; development of realistic market regulations that aloe DHC to thrive.*

including electricity markets

Topics for cost –share Annex XIII

3. Digitalisation for DHC in the era of big data

3.1. Improving planning, operation and maintenance of network, storage and demand – *digital twins; monitoring schemes; overall system and city level (ie energy use and potential mapping) to help design and control DHC systems; tools for decision support*

3.2. Collection, management and application of data for overall DHC optimisation and maintenance – *market surveys; actions needed to achieve 3.1; smart tariffs: adapting price based on network data; data security*

3.3. Smart controls and Internet of things in DHC networks – *data gathering systems for DHC; integration of sensors into DHC elements; automated, self-regulated sub-systems.*

Further information

For more about the IEA-DHC TCP, contact:

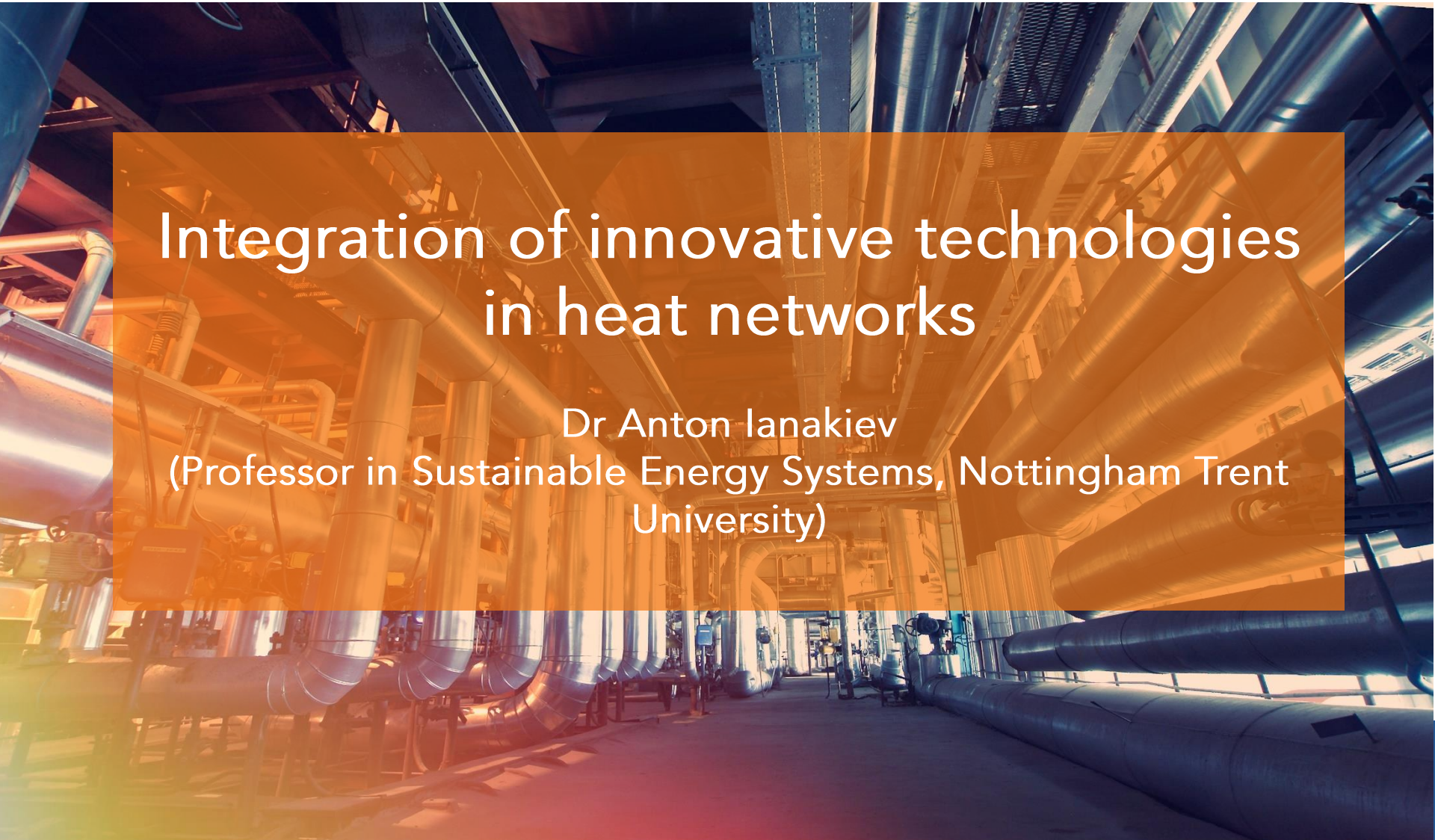
Robin Wiltshire (Chair)

Robin.Wiltshire@bre.co.uk

Andrej Jentsch, AGFW (Operating Agent)

IEA-DHC@agfw.de

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INVESTMENT MANAGEMENT



Integration of innovative technologies in heat networks

Dr Anton Ianakiev
(Professor in Sustainable Energy Systems, Nottingham Trent University)

Integration of innovative technologies in heat networks

(LTDH and 2050 homes in Nottingham supported by EU H2020 REMOURBAN project)

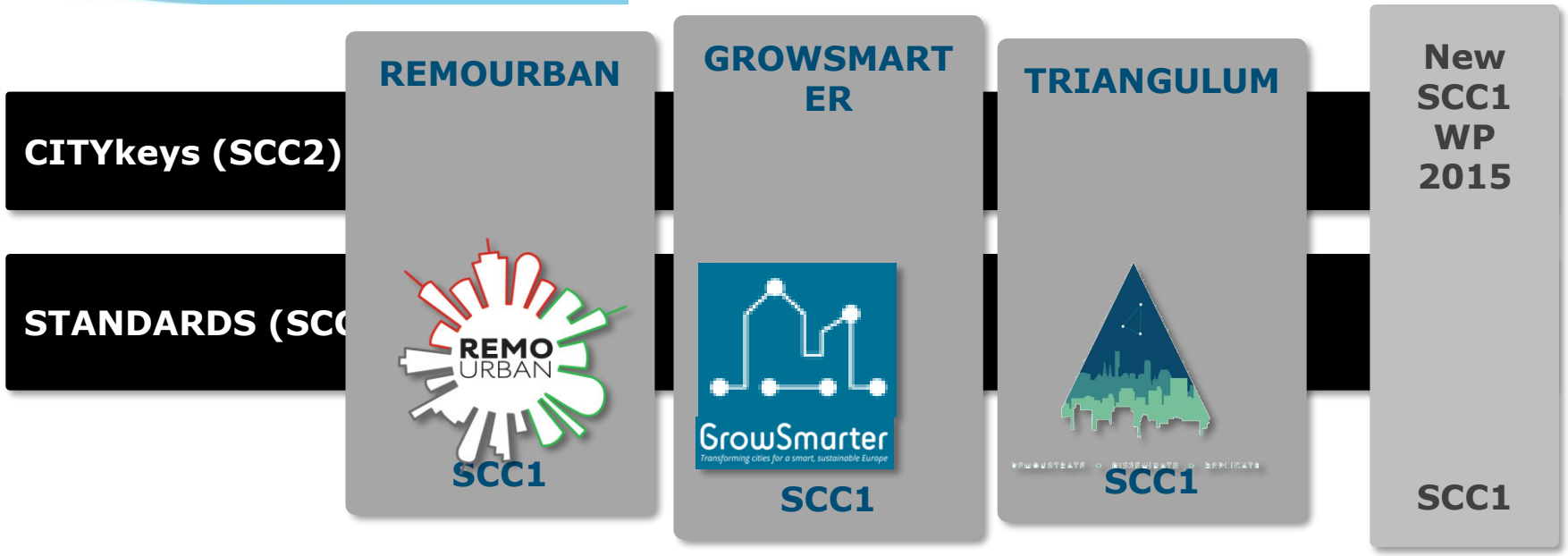
Nottingham Trent University

Dr Anton Ianakiev

LTDH and 2050 homes in Nottingham supported by EU H2020 REMOURBAN project

EUROPEAN INNOVATION PARTNERSHIP ON SMART CITIES AND COMMUNITIES

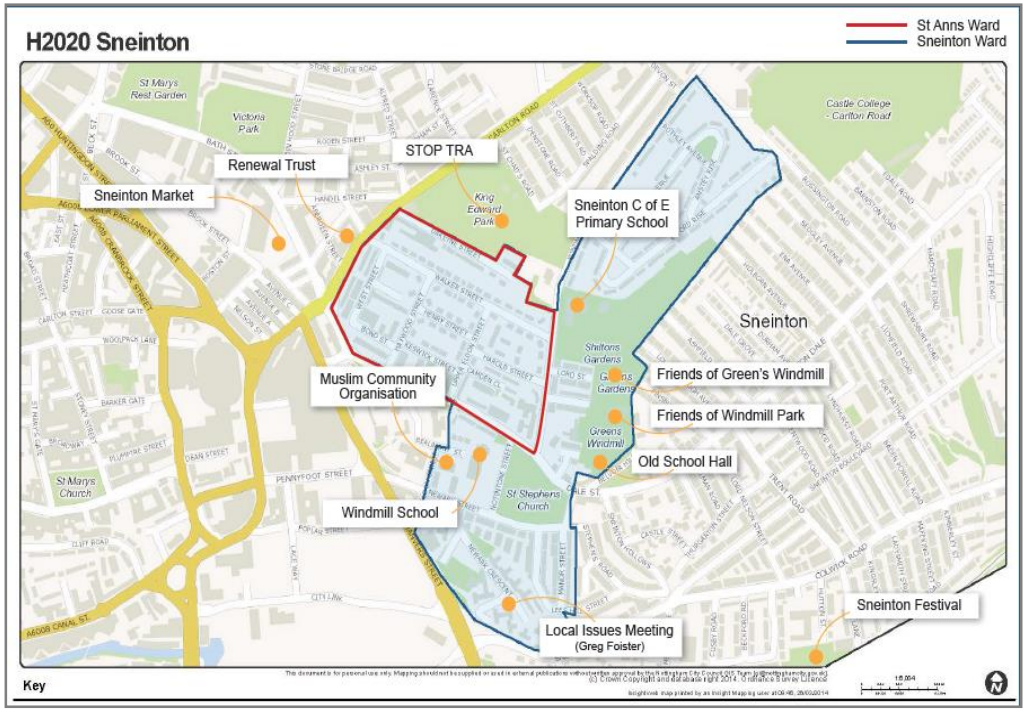




LTDH and 2050 homes in Nottingham supported by EU H2020 REMOURBAN project

REMOURBAN Project area





- The area around Sneinton Road, Sneinton, Nottingham is considered as the most appropriate for the development of the REMOURBAN (DEMO site).
- The site is very close to the existing district heating. The pipe line is reaching the Bio City which is very close to Sneinton Road (100 – 200m).
- A large number of the properties (65%) in the area are social housing, owned by Nottingham City Council (NCC) and managed on their behalf by Nottingham City Homes (NCH).

Nottingham District Heating network



Nottingham's existing extensive Energy-from-Waste (EfW) district heating network, currently supplying 4,900 homes close to the Demo site, means that there is an opportunity to supply the blocks with an efficient and low-carbon heating supply.

It is proposed that a branch emanating from the return pipe of the primary mains is created to use low temperature heating from the *return* the first time on this system and maybe in the UK.

Eastcroft incinerator





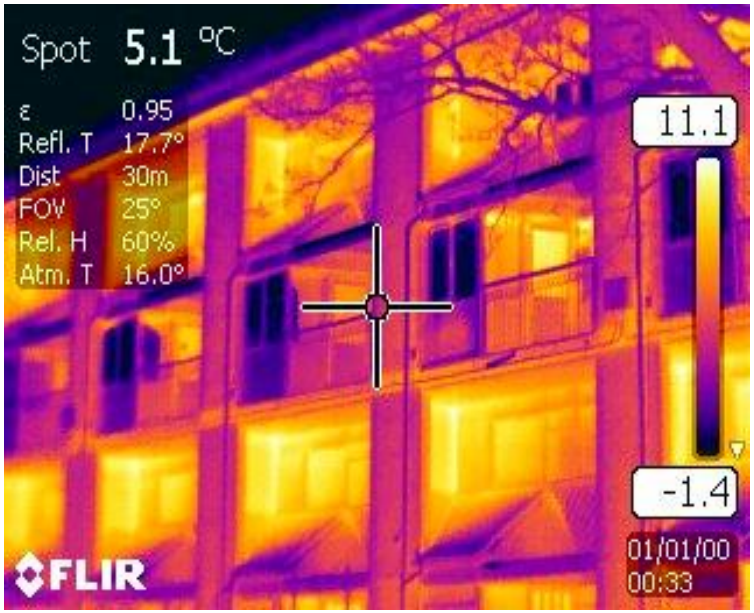
- The heat energy mainly comes from the annual incineration of around 170,000 tonnes of municipal waste at Eastcroft incinerator
- The Nottingham District Energy Network is comprised of approximately 68km of insulated pipework carrying pressurised hot water around Nottingham City Centre satisfy the heating and hot water requirements of circa 4,900 dwellings and over 100 commercial premises
- It is a Combined Heat and Power (CHP) Plant, the steam is also run through a generating turbine to produce 60,000MWh of electricity annually.

LTDH network planning map



Maisonettes at Morley Court





LTDH and 2050 homes in Nottingham supported by EU H2020 REMOURBAN project

LTDH – Citizen engagement









LTDH and 2050 homes in Nottingham supported by EU H2020 REMOURBAN project

Retrofitting the four Court buildings





LTDH and 2050 homes in Nottingham supported by EU H2020 REMOURBAN project

The Sneinton Courts – LTDH





Connection to the existing DH system





Connection to the existing DH system







LTDH and 2050 homes in Nottingham supported by EU H2020 REMOURBAN project

The Sneinton Courts – LTDH Monitoring and data collection



Tenants

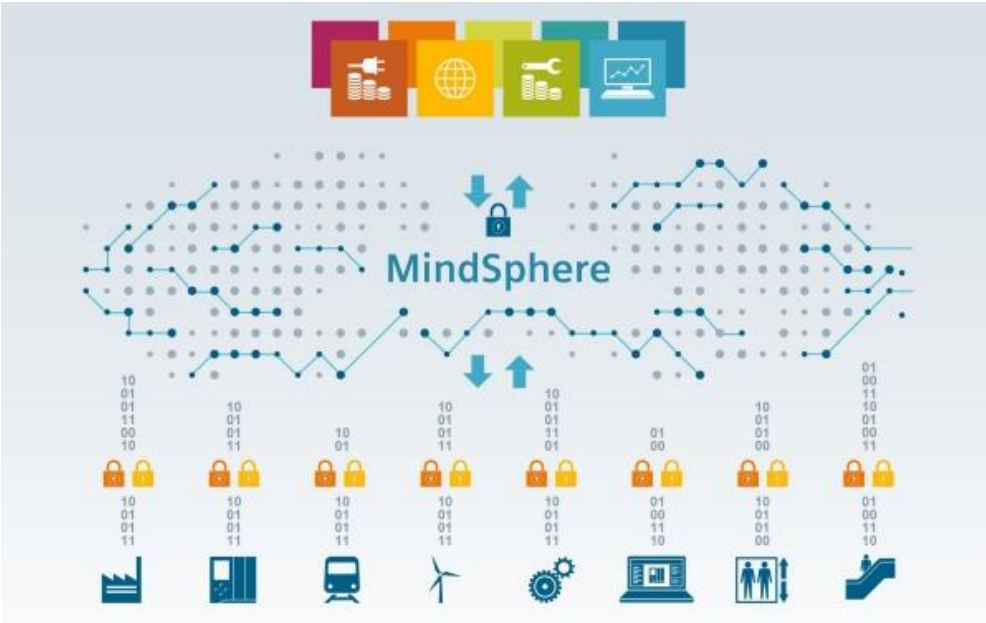
- Homes look better, more comfortable, neighbourhood improvement.
- Reduced energy bills down to *c.*£600 per year for all energy.
- Extends capacity for the NCC DH (important for 2028)
- Each flat has an NCH smart meter for electricity, and this meter also provides the comms for the heat,
- Ways to Pay
  - ✓ Web platform
  - ✓ Automatic from bank
  - ✓ At shop (cash)



Intelligent Control System (*Siemens MindSphere*)

The intelligent control system in each retrofitted property:

- optimise energy use and storage to suit predicted demand profiles
- allow provision of alerts and alarms for assisted living for vulnerable tenants
- energy consumption feedback for all tenants



LTDH and 2050 homes in Nottingham supported by EU H2020 REMOURBAN project

Retrofitting the four Courts buildings





Retrofitting innovation activities – 2050 Homes





As part of the retrofitting programme it is proposed to refurbish a terrace block of 9 three bedroom **William Moss Cross Wall** houses at West Walk, Sneinton to a high standard of energy efficiency, aiming to be as close as reasonably possible to the **EnerPHit** standard.

•The undercroft and major heat loss through the floors of the first floor of these properties.
•Significant temperature difference in the property
•Residents and surveyors report draughts can be felt coming through the walls, from behind skirting boards, as well as up the stairs from the garage.

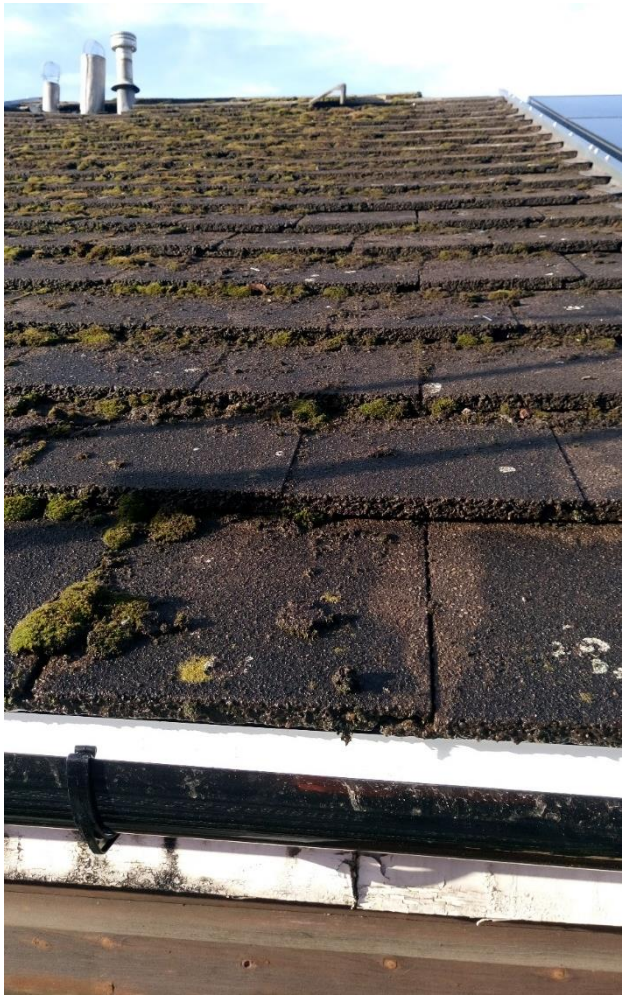
Passive house retrofitting innovation activities – 2050 Homes





2050 Homes in Nottingham
(REMOURBAN project)

Passive house retrofitting innovation activities – 2050 Homes





Passive house retrofitting innovation activities – 2050 Homes





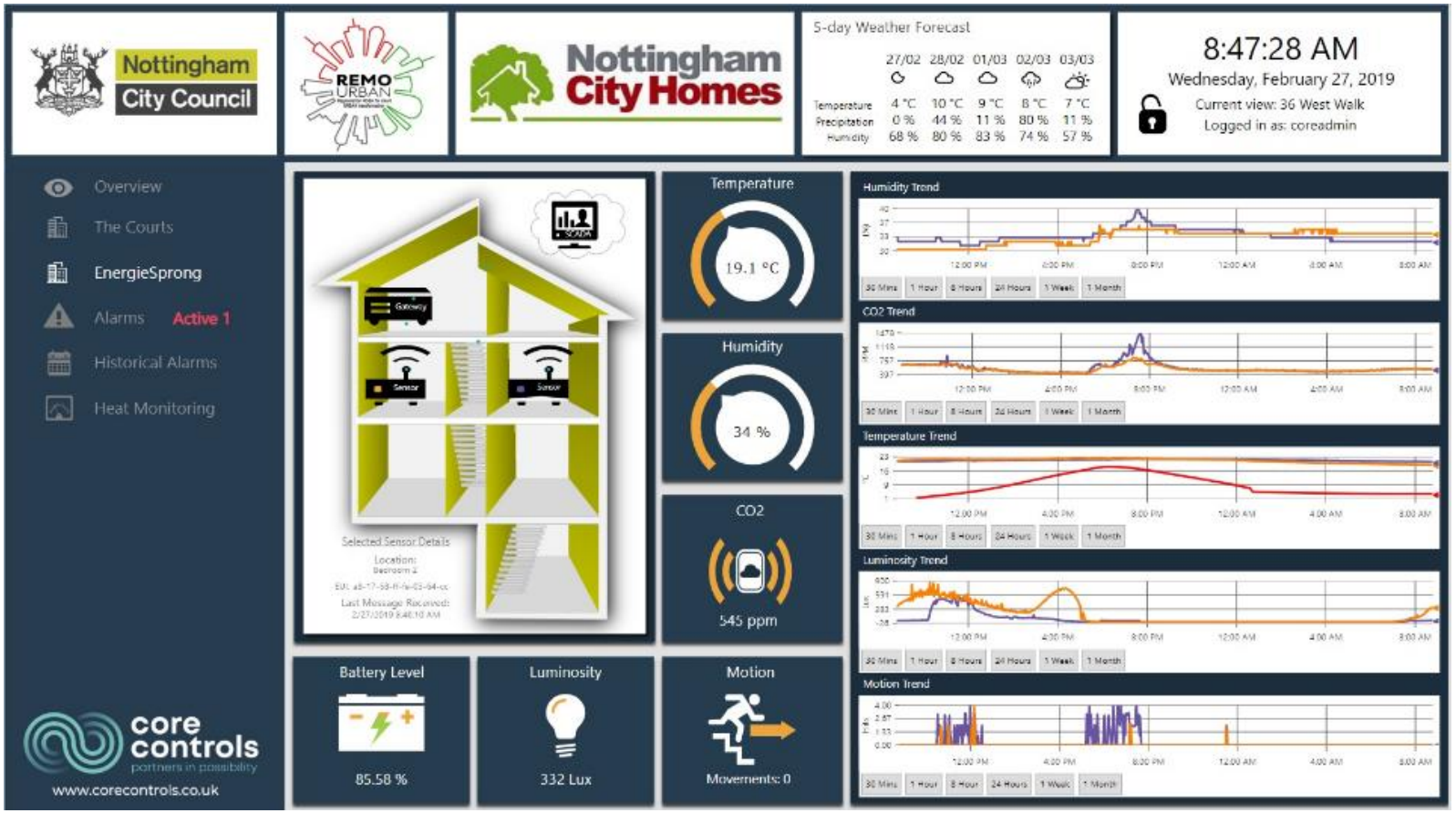
Energy Centre– 2050 homes



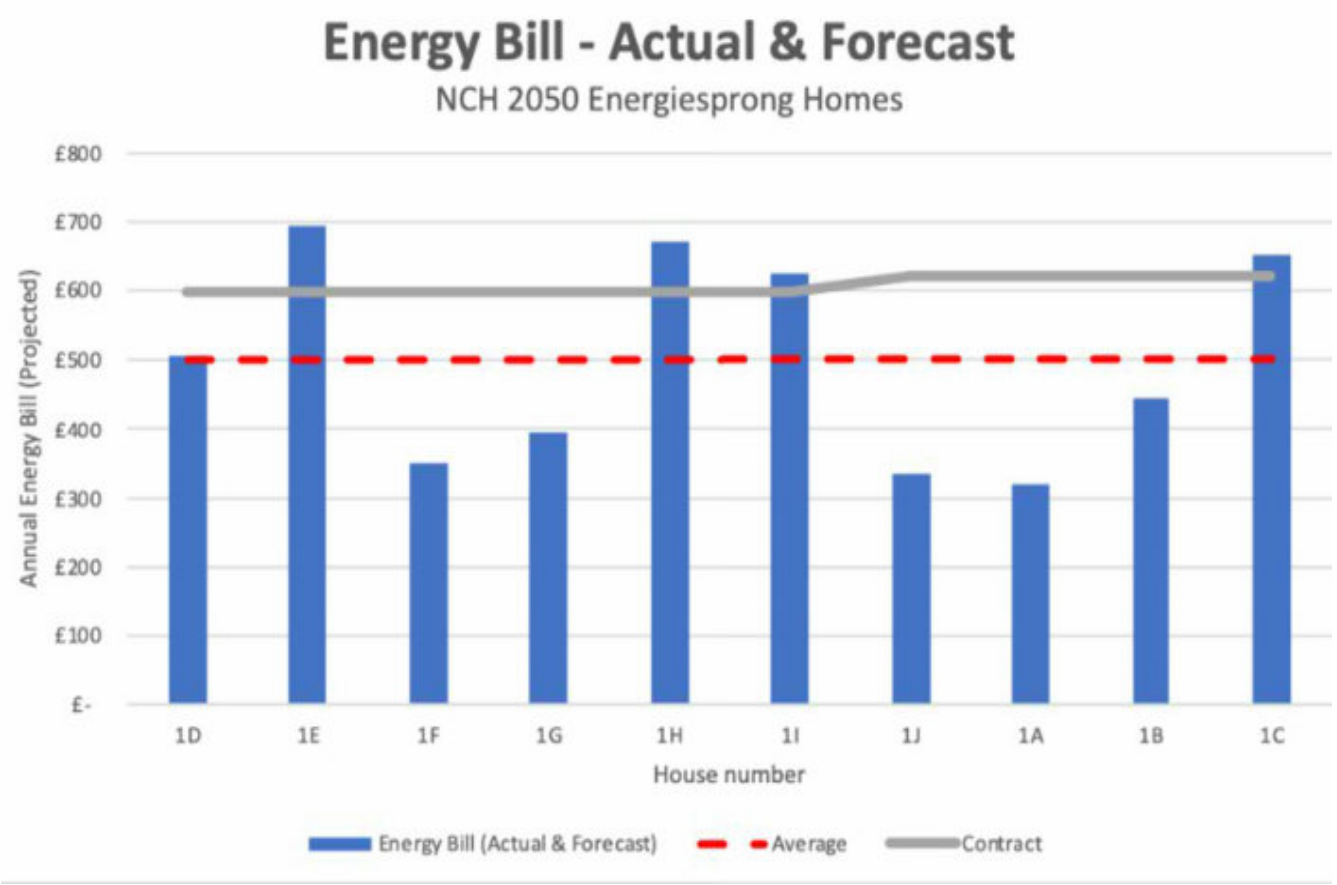


2050 homes 3 ground source heat pumps onto communal network, with 3 large thermal stores 12m3, and thermal stores in each property. Fully commissioned and operational. Used as part of strategy to take homes off grid at peak times. Home heating efficiency 74% improvement.

2050 Homes Monitoring Programme Definition



2050 Homes Monitoring Programme Definition



Retrofitting the district – 2050 homes

Before



After



Quote from Tenant

"Before the refit I had the gas heater and central heating on all day and central heating on all night. The house was freezing. Now I have the heating on only 1 and a half hours a day and it stays warm all night too.

***I'm much happier 'cause** I can wear less layers of clothing. **I don't have to wear a coat in the home anymore**"*



Thank you for your attention!

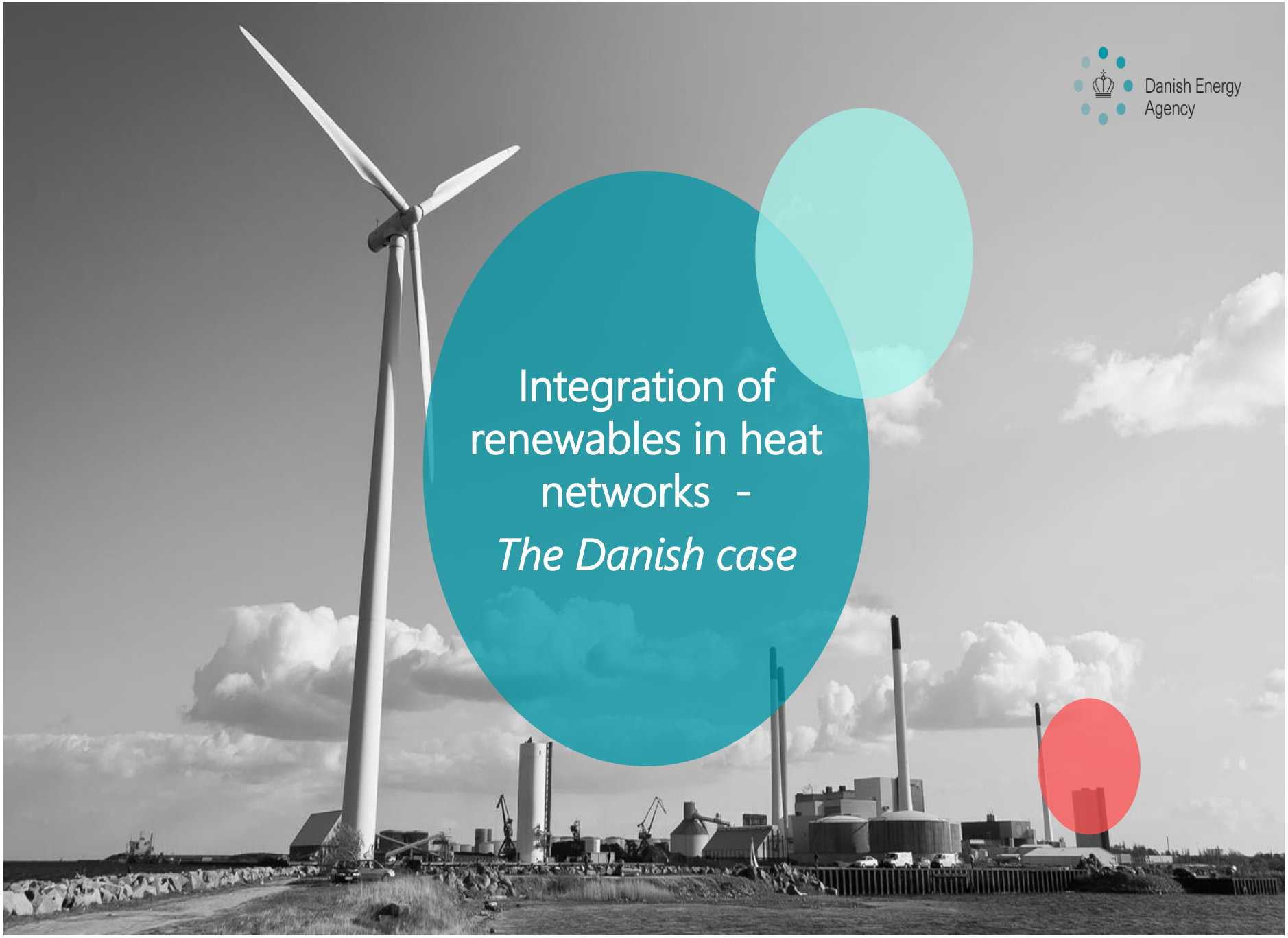
Dr Anton Ianakiev

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HEAT NETWORKS
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Lessons learned from Denmark - a multifaceted approach

Jacob Byskov Kristensen
(Danish Embassy)


Danish Energy Agency
Integration of renewables in heat networks -
The Danish case

Agenda

1. What is the Energy Governance Partnership programme?
2. Brief background on heat networks in Denmark
3. Variations across Danish heat networks
4. Applied technologies
5. Why heat networks are the answer



Danish Energy Agency

JACOB BYSKOV KRISTENSEN

ENERGY POLICY ADVISOR

ROYAL DANISH EMBASSY LONDON

JACKRI@UM.DK / +44 (0) 7917 800847

The Energy Governance Partnership (EGP)

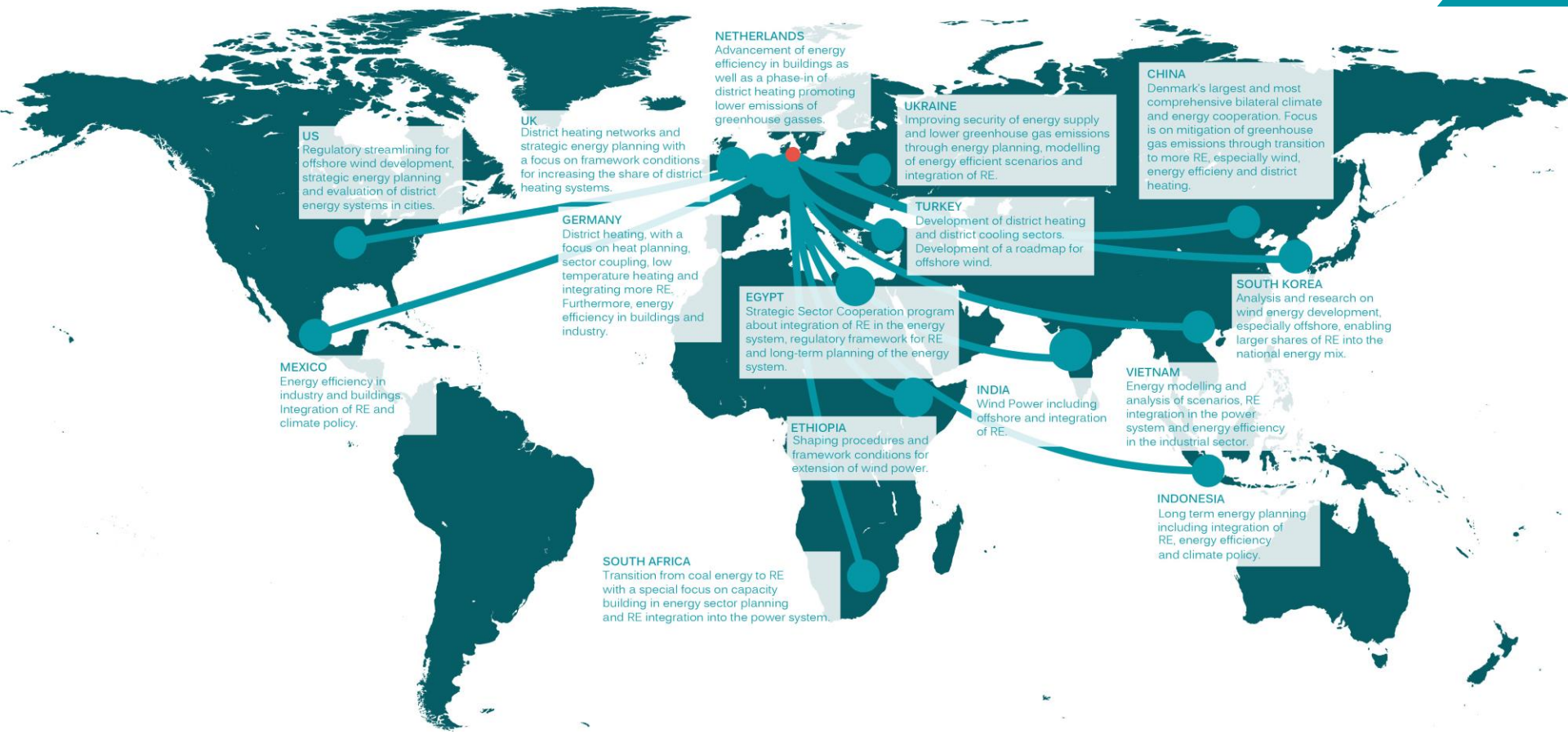
- 5 year program funded by Danish Government
- Support and knowledge exchange on policy making
- Focus: Heat networks and energy efficiency in buildings
- We provide a range of services – but government-to-government cooperation is the priority
- Based in London - supported by global task force

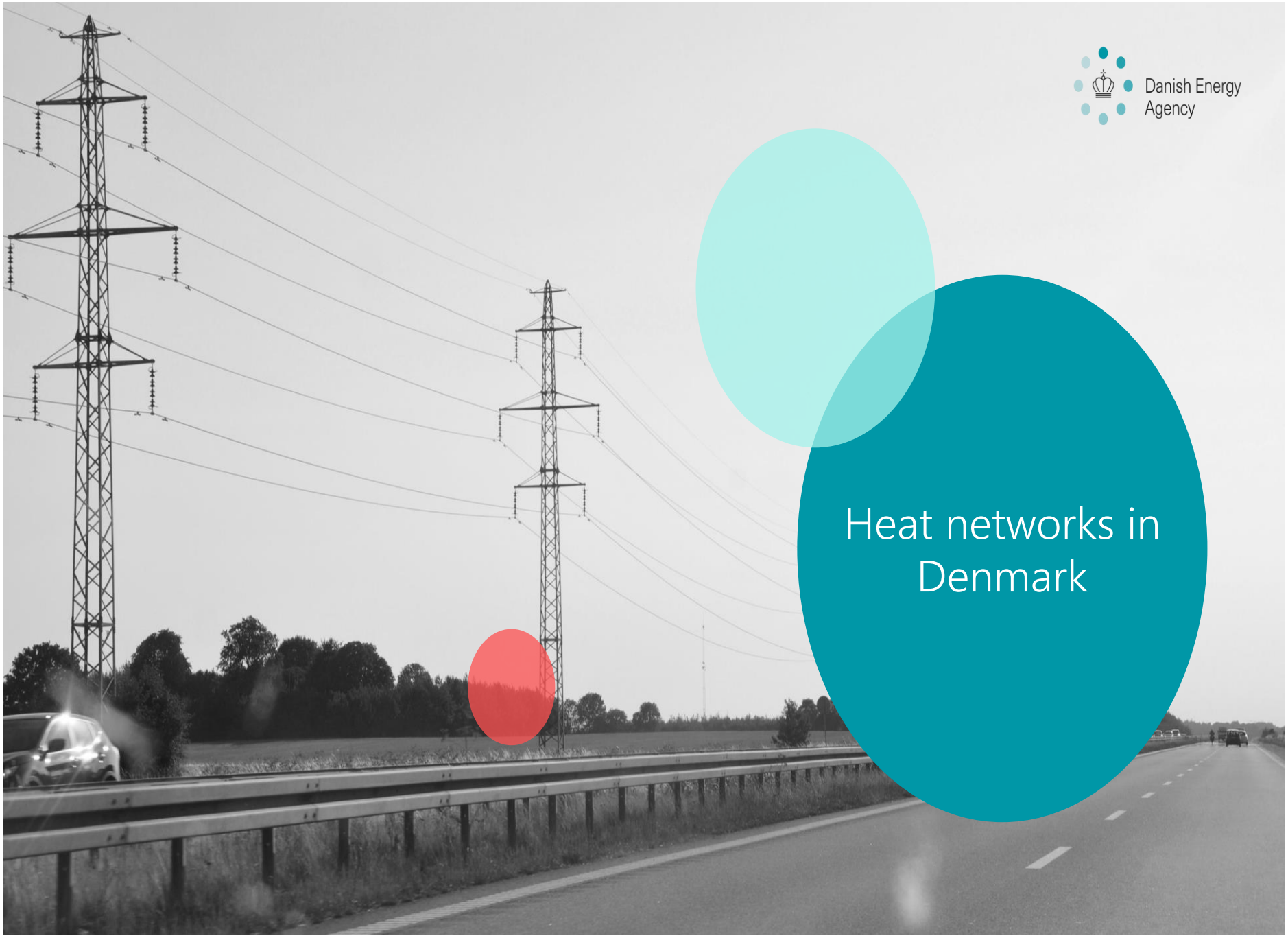
Danish Energy Agency

MINISTRY OF FOREIGN AFFAIRS OF DENMARK
The Trade Council

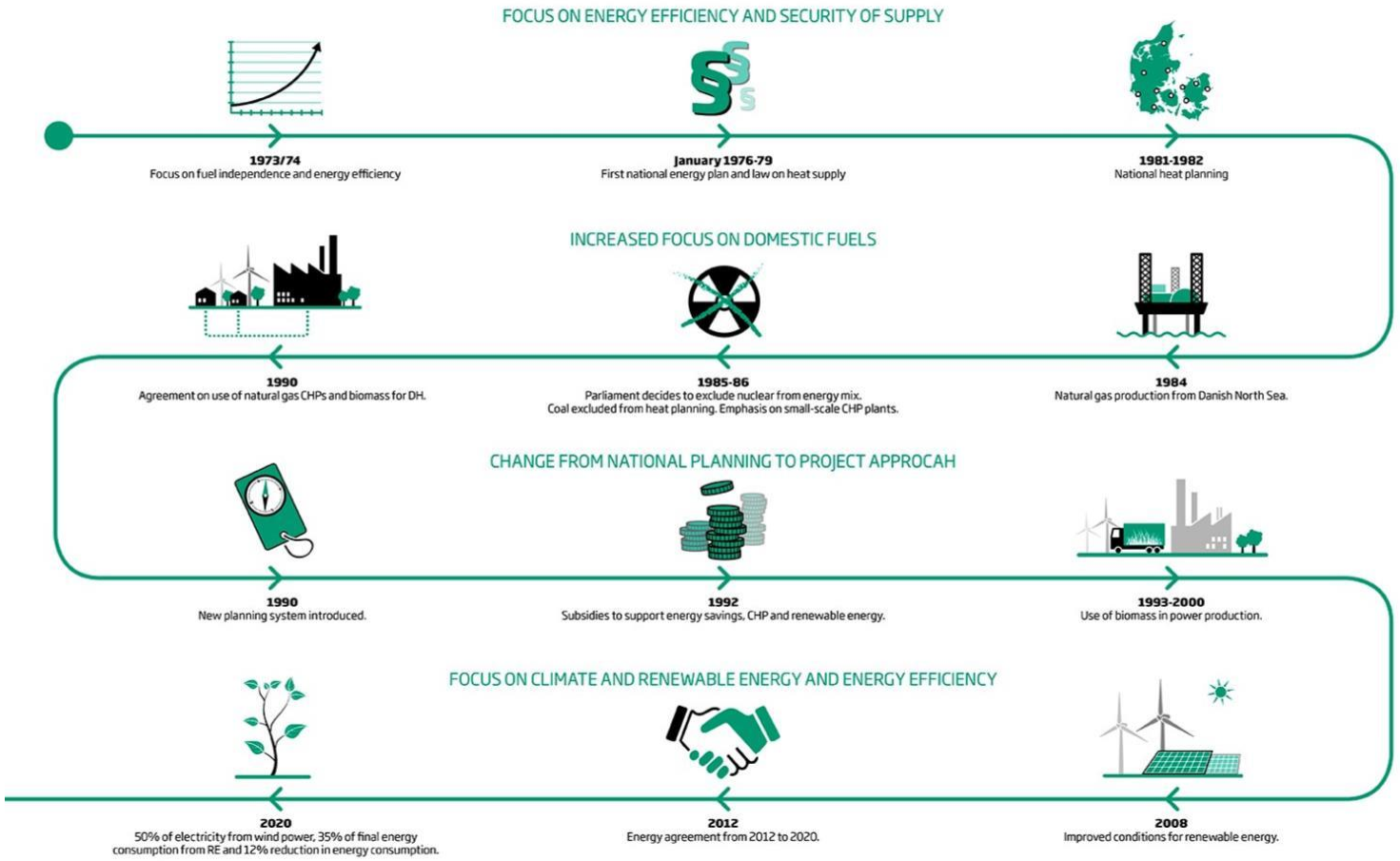
Motived by commitments from the Paris Agreement

Currently 15 partner countries



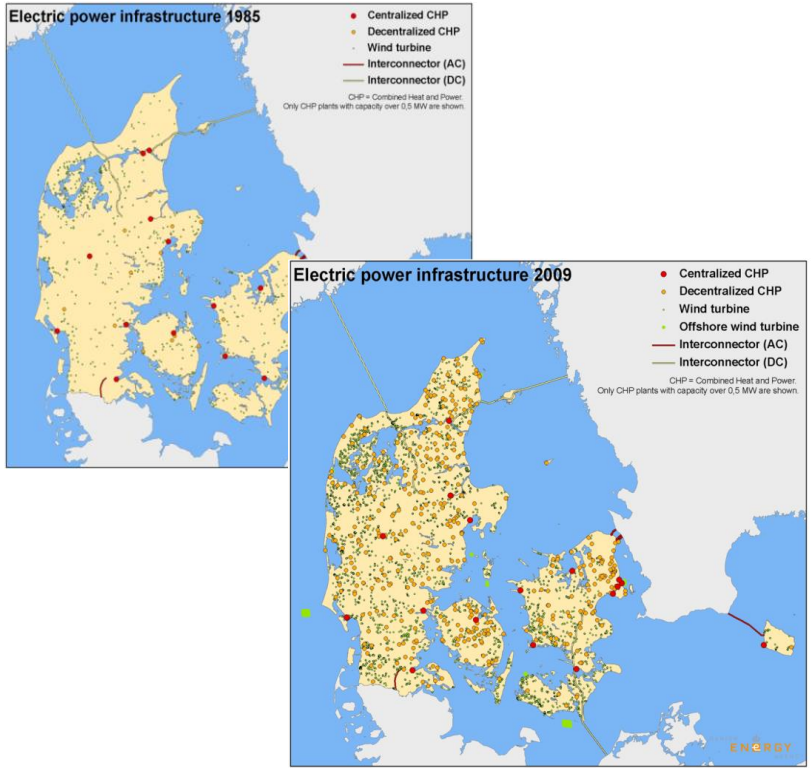

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Agency
Heat networks in
Denmark

HISTORICAL OVERVIEW OF DISTRICT ENERGY IN DENMARK



More than 40 years of HN policy history

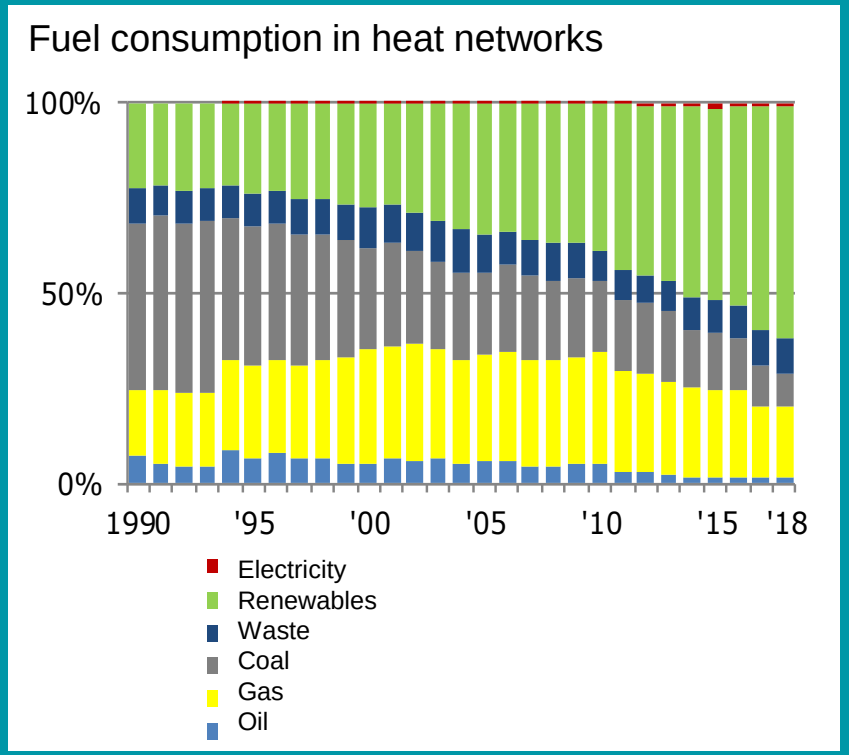
- Originally motivated by a need to <u>diversify</u> the general energy mix and use it more <u>efficiently</u>
- Over time the green agenda and subsequent policy incentives changed
- … so did the role but not the "need for" heat network
- Today one of the most important enablers of the green transition in Denmark



Heat networks in Denmark

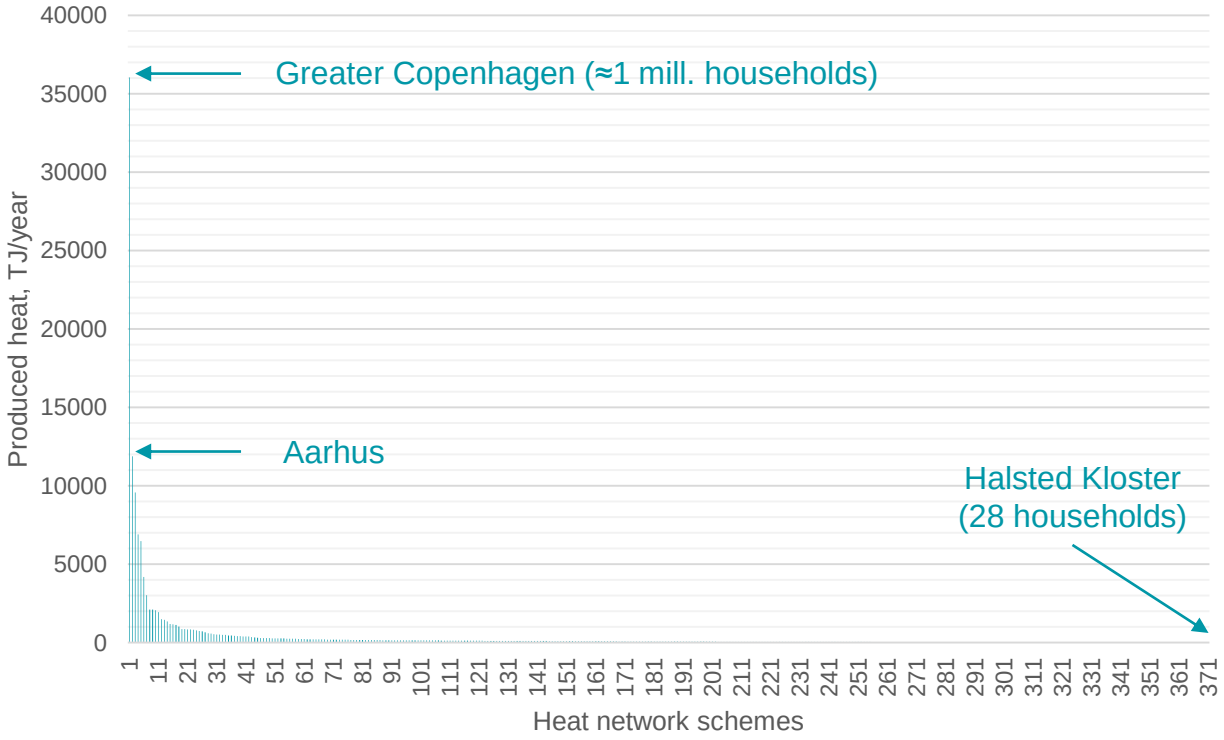
Quick stats (2018)

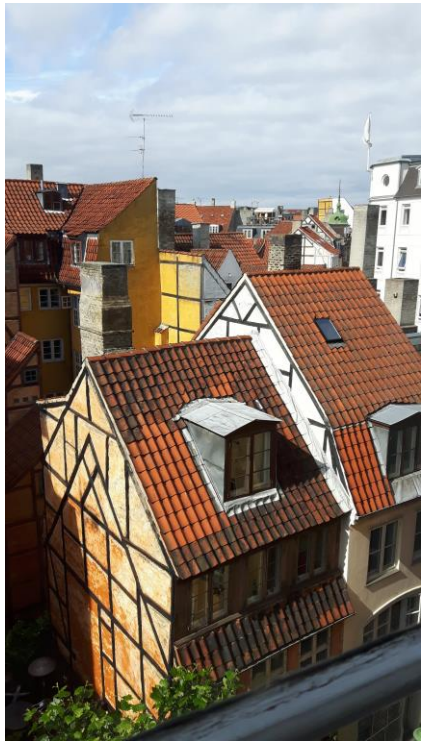
- ≈ 65% of total heat demand (15% gas)
- ≈ 375 individual networks
- ≈ 600 companies
- ≈ 76% renewable energy by 2023 (BAU)



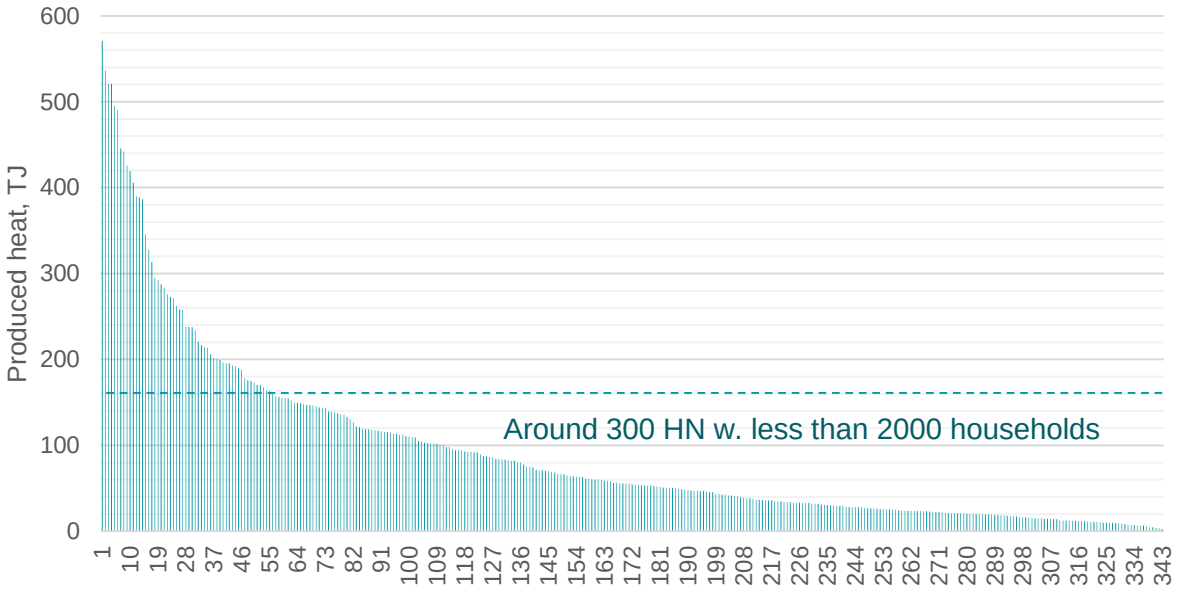
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Great variation in size





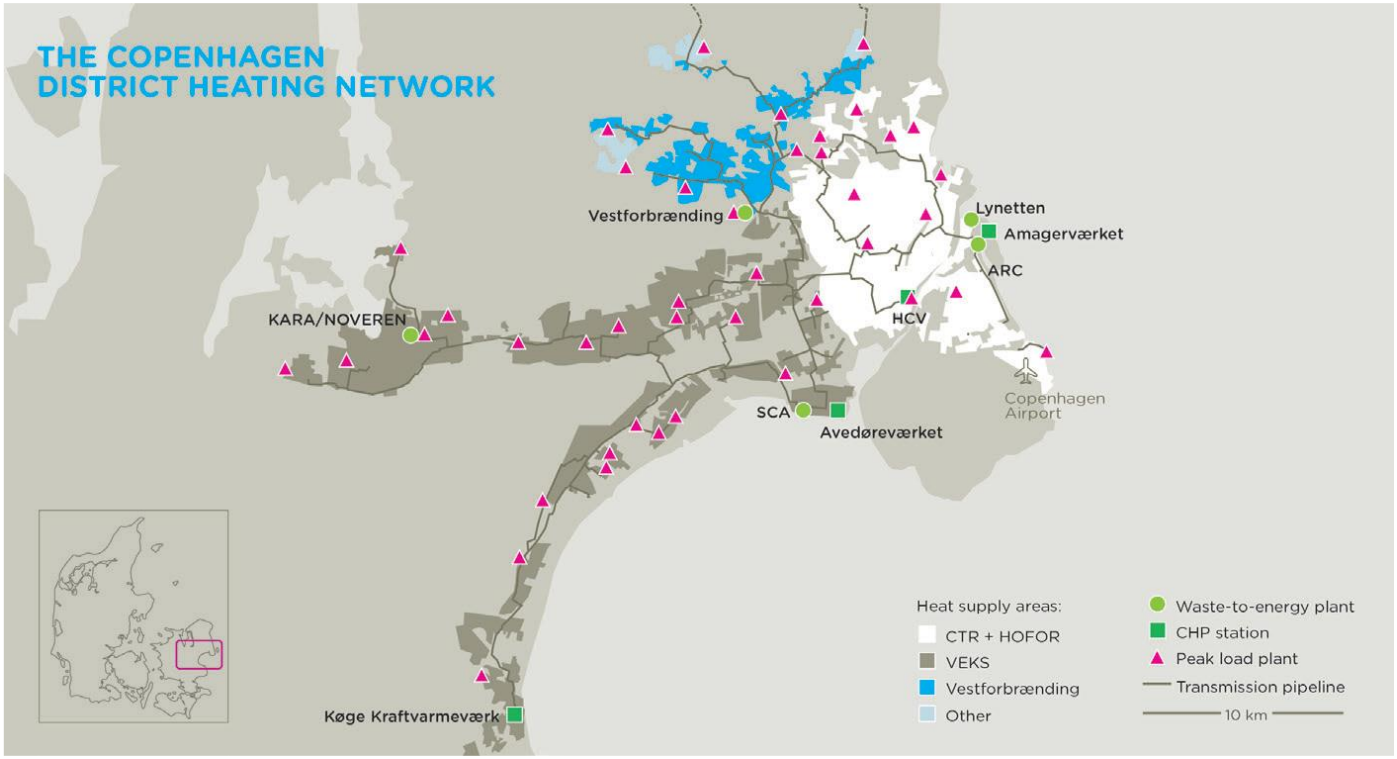
Zoom: 344 smallest heat network schemes






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Agency
The larger schemes

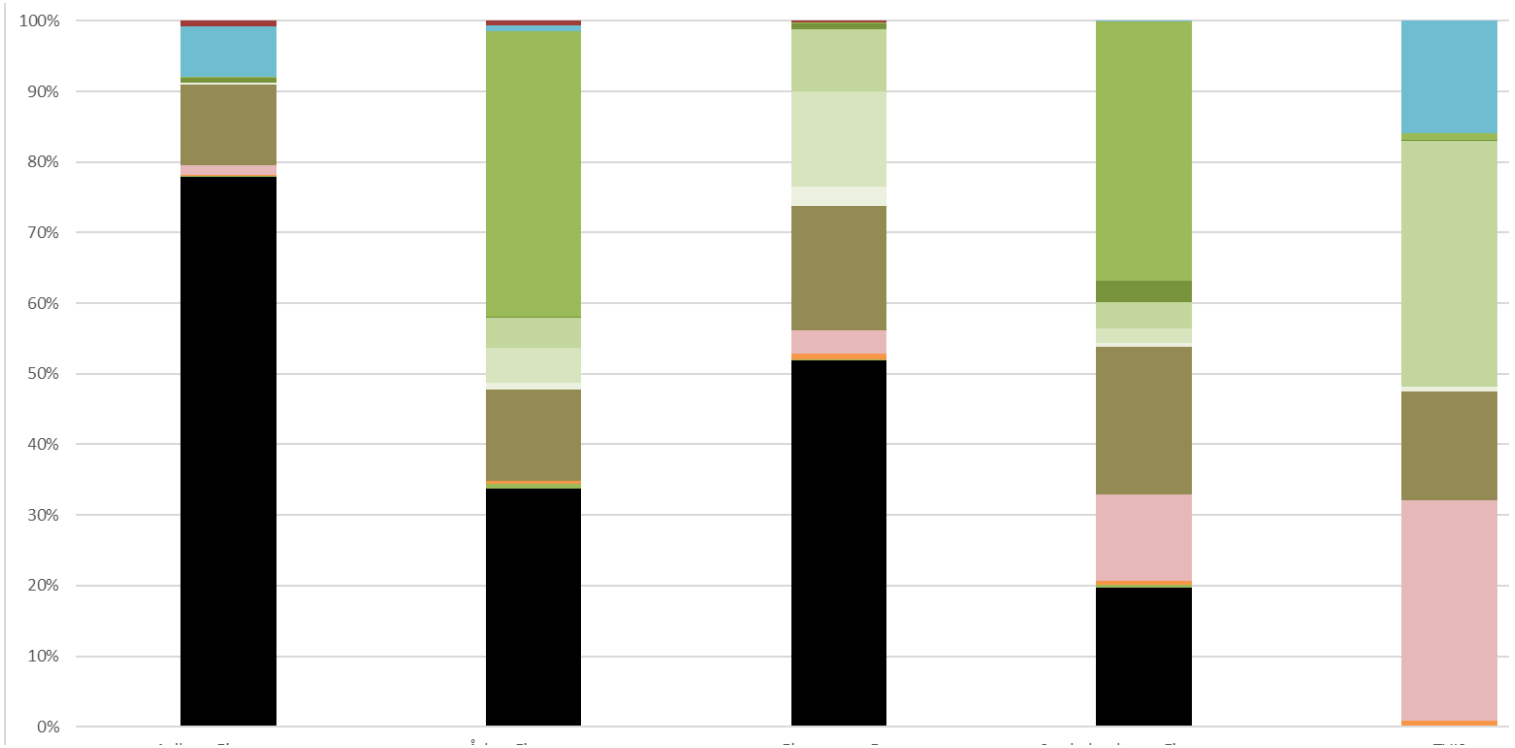
The Copenhagen network



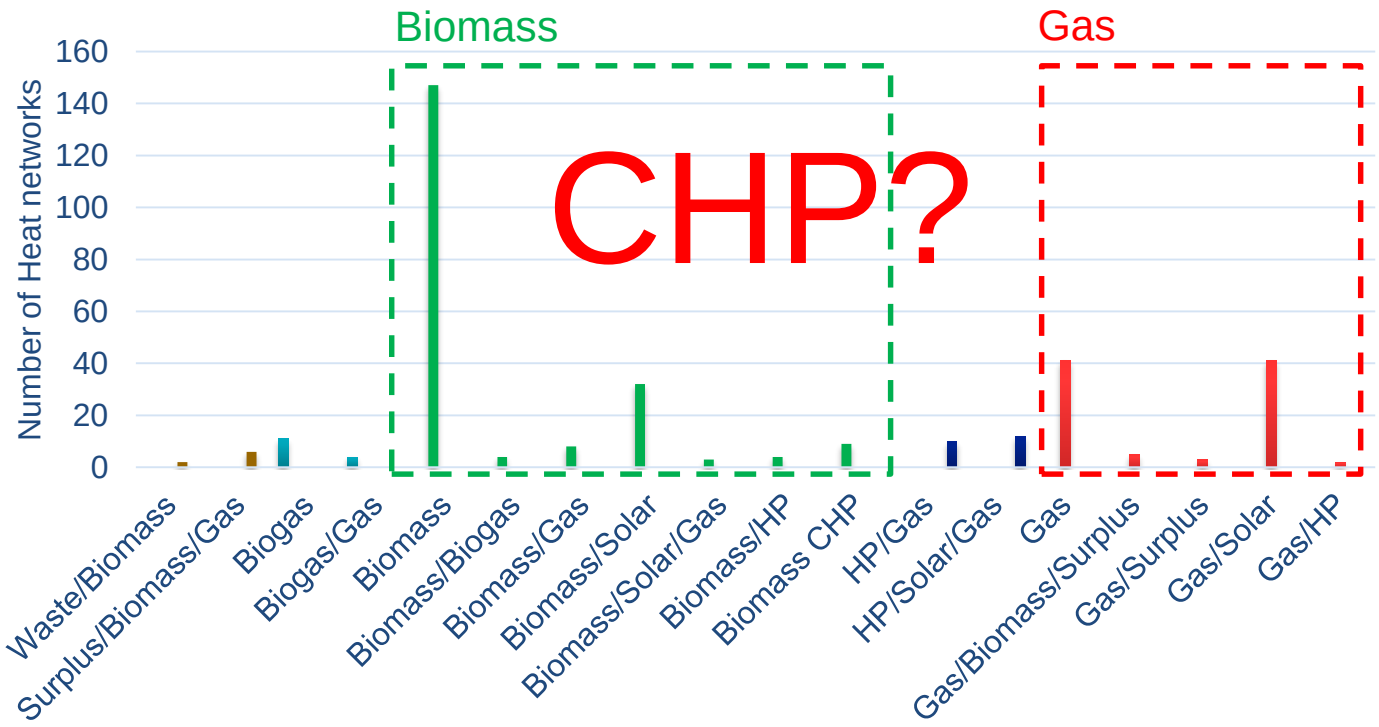
Source: State of Green, Think Denmark, District Energy (2018)

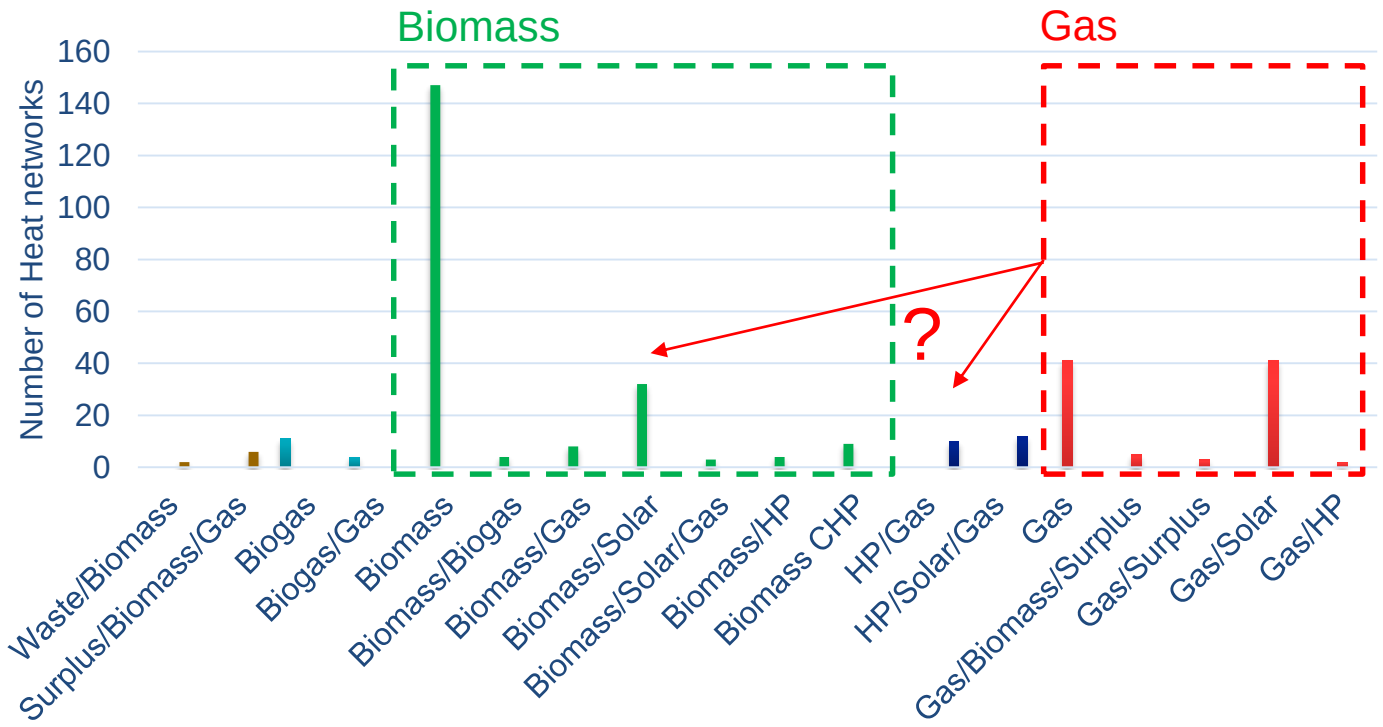
Fuel consumption in the five largest schemes

2018

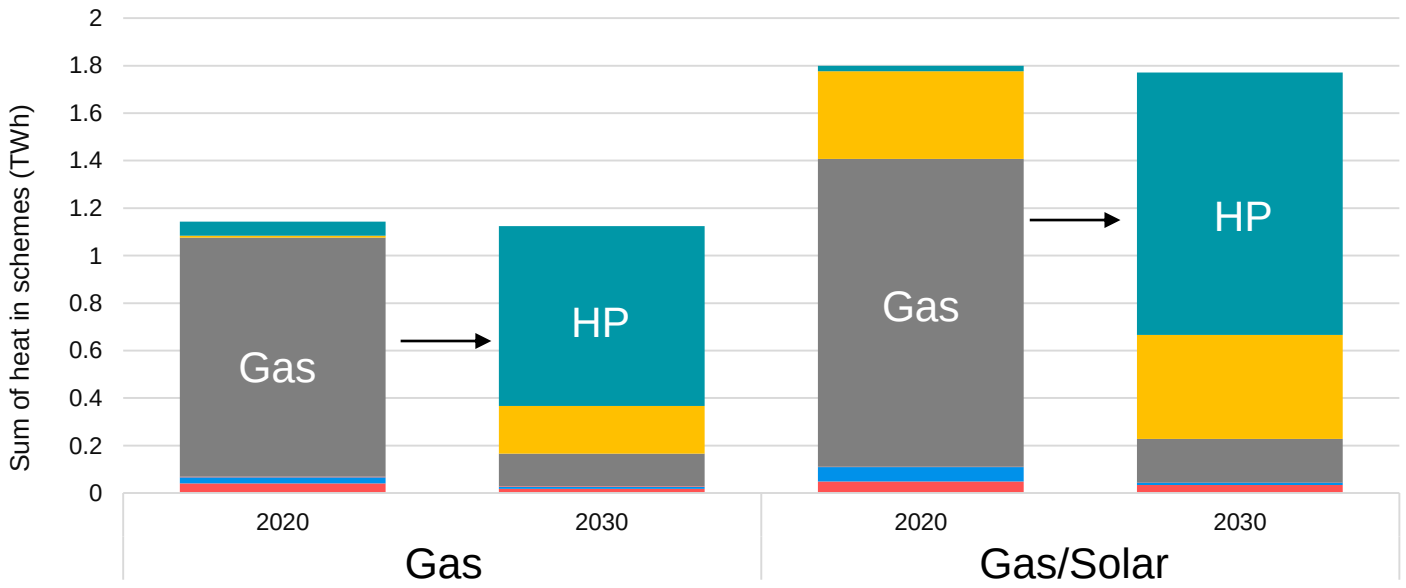



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The 344 other schemes


Biomass
Gas
CHP?
Number of Heat networks
160
140
120
100
80
60
40
20
0
Waste/Biomass
Surplus/Biomass/Gas
Biogas
Biogas/Gas
Biomass
Biomass/Biogas
Biomass/Gas
Biomass/Solar
Biomass/Solar/Gas
Biomass/HP
Biomass CHP
HP/Gas
HP/Solar/Gas
Gas
Gas/Biomass/Surplus
Gas/Surplus
Gas/Solar
Gas/HP

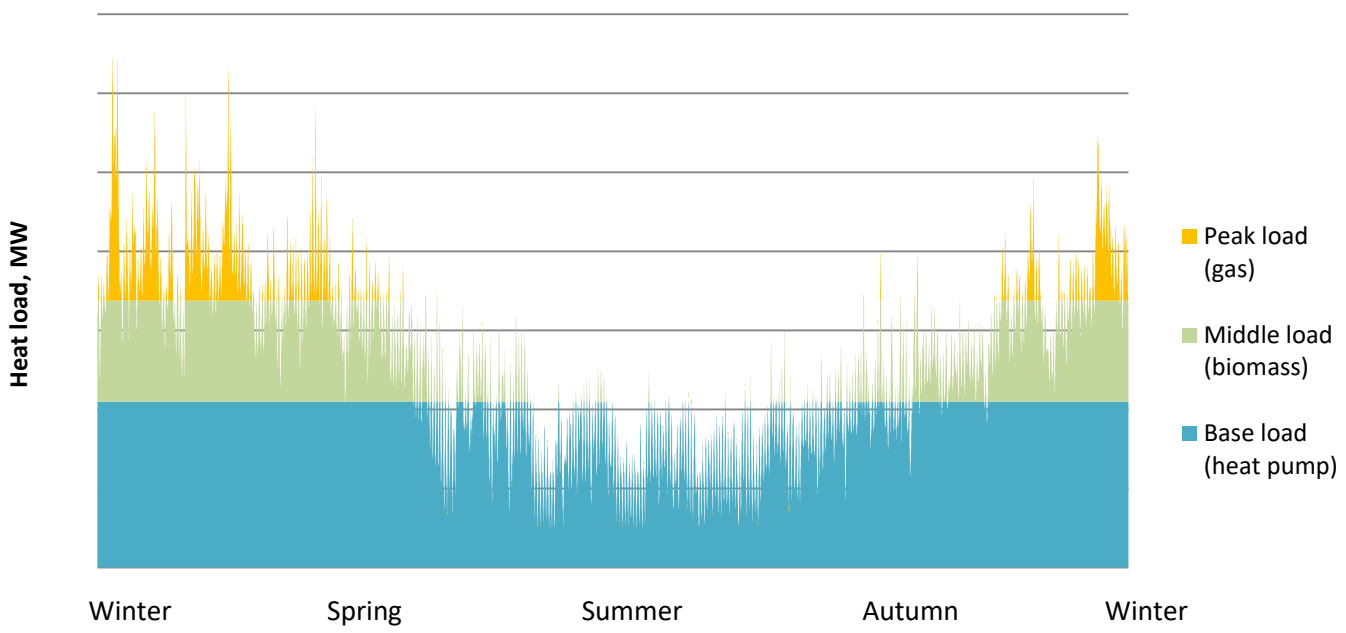

Biomass
Gas
Number of Heat networks
160
140
120
100
80
60
40
20
0
?
Waste/Biomass
Surplus/Biomass/Gas
Biogas
Biogas/Gas
Biomass
Biomass/Biogas
Biomass/Gas
Biomass/Solar
Biomass/Solar/Gas
Biomass/HP
Biomass CHP
HP/Gas
HP/Solar/Gas
Gas
Gas/Biomass/Surplus
Gas/Surplus
Gas/Solar
Gas/HP

Estimated future of remaining gas schemes

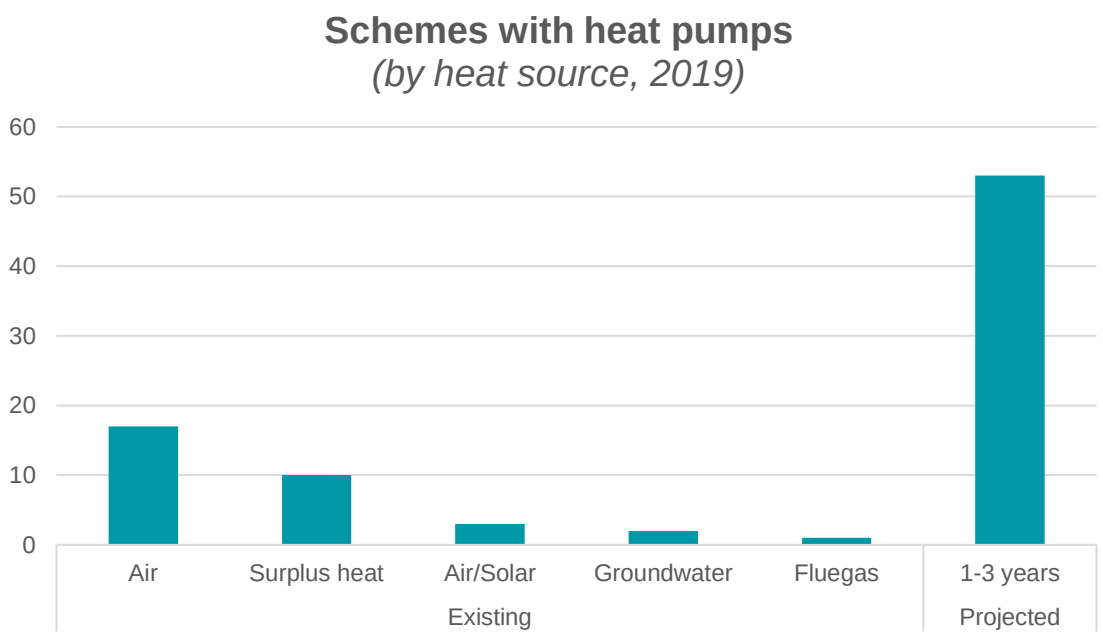


…but biomass still lurks around the corner

Example: Possible future combination of biomass and heat pumps



Heat pumps are making their entry



Today:

33 / 68MW

By 2022:

85 / 210 MW

Solar heating and seasonal heat storage

More than 25% of heat networks in Denmark use solar heating[1] – amounts to ≈75 % of the world's solar heating plants[2]. An important contributing factor is the focus on heat storage – including seasonal.



Installing the worlds largest (pit) heat storage in Vojens, Denmark (2015)



Arial foto of facility in Vojens (gas CHP+ HP+solar+storage)

[1]Planenergi, 2018: 100 networks with solar heating
[2]DTU referencing IEA, 2018: Measured in m²
Left: https://www.vojensfjernvarme.dk/profil/billedearkiv/solvarme-etape-2/, Right: https://stateofgreen.com/en/partners/ramboll/solutions/world-largest-thermal-pit-storage-in-vojens/

In conclusion

The Danish case shows that heat networks are:

- An effective and cheap way of decarbonizing heat
- Technology agnostic
- Future proof enabler

And…

- Consumers: Cheap, reliable and hassle free

So no reason to hold back: **HN are low/no-regret**



Thanks for listening



JACOB BYSKOV KRISTENSEN
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Danish Energy Agency

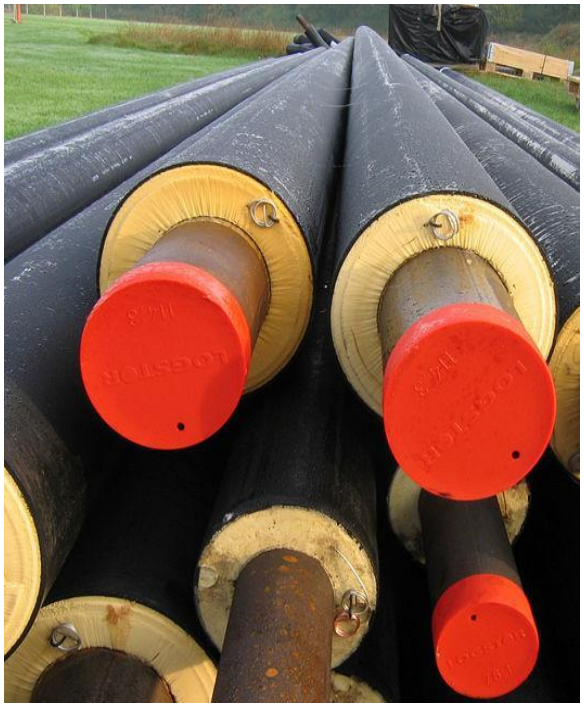
Extra slides



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General points on the Danish case

- Central authorities provide regulation framework and clear guidelines to municipalities to plan and approve local implementation of heat projects
- High share of consumer based ownership
- Non-profit principle
- Local entrepreneurs in place
- Cheap finance available
- Variety of technical solutions
- Focus on LCOE
- The regulatory and organisational setup in Denmark have encouraged a competent and experienced industry within design, engineering, construction and operational management of DH



Danish heat regulation

Main principles of the heat supply act:

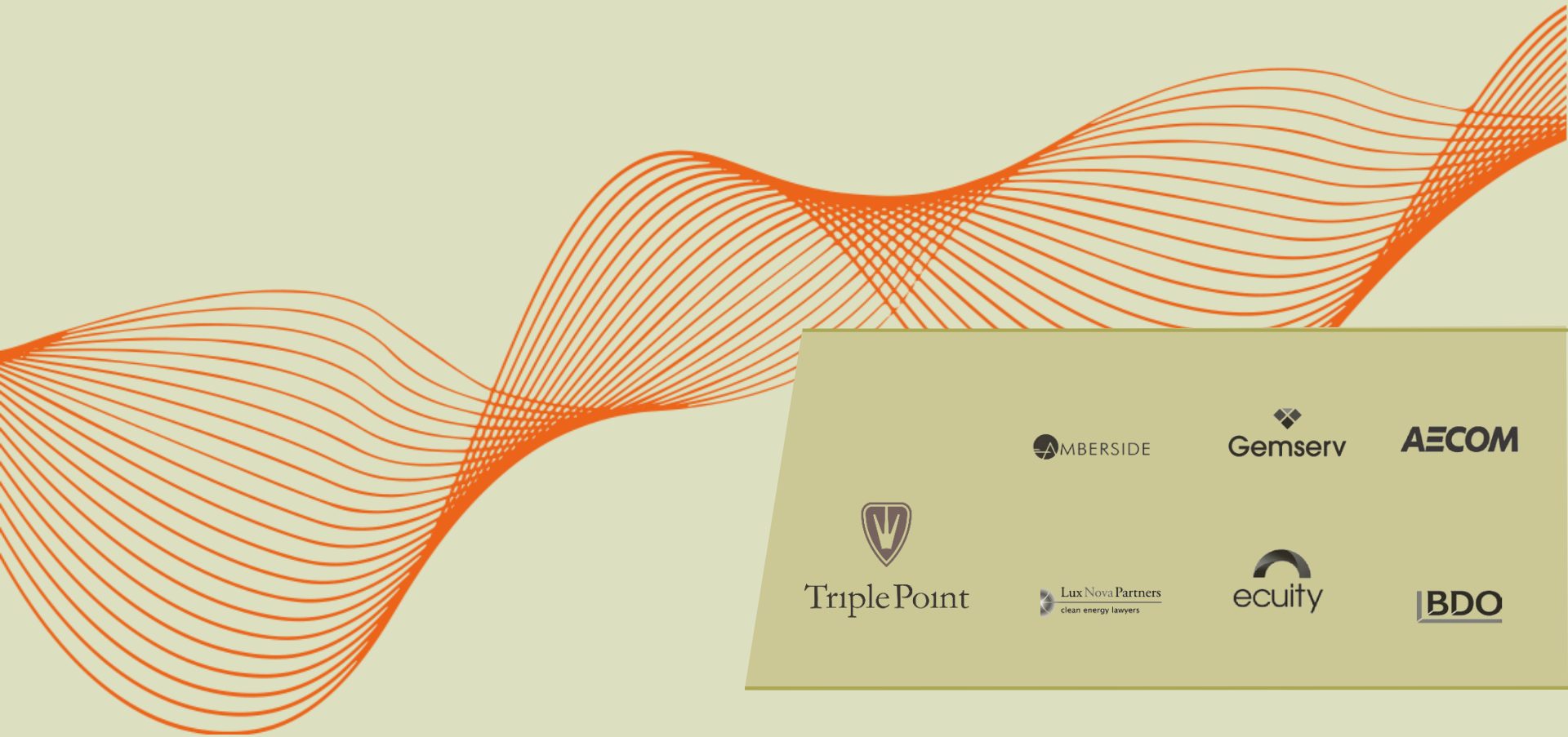
- Local authorities are responsible for the approval of new heat supply projects and make sure that projects with the most socioeconomic benefits are chosen.
- Production of heat must, if possible, be produced as combined heat and power.
- The collective heat supply price must offer consumer prices based on the exact “necessary costs”, meaning that the heat price should not be higher or lower than the actual heat production costs.

Denmark 1990: Secondary act for project approval

- Municipal obligations, and socioeconomic calculation principles.
- Municipalities can ask utilities to propose supply plans for specific areas

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Panel discussion



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Closing remarks

Ken Hunnisett
(Tripe Point Heat Networks Investment Management)

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Timeline



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Support throughout the application process



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Business Development Managers and online support

Ken Hunnisett



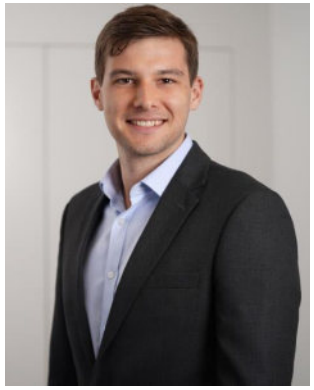
Lauren Bright

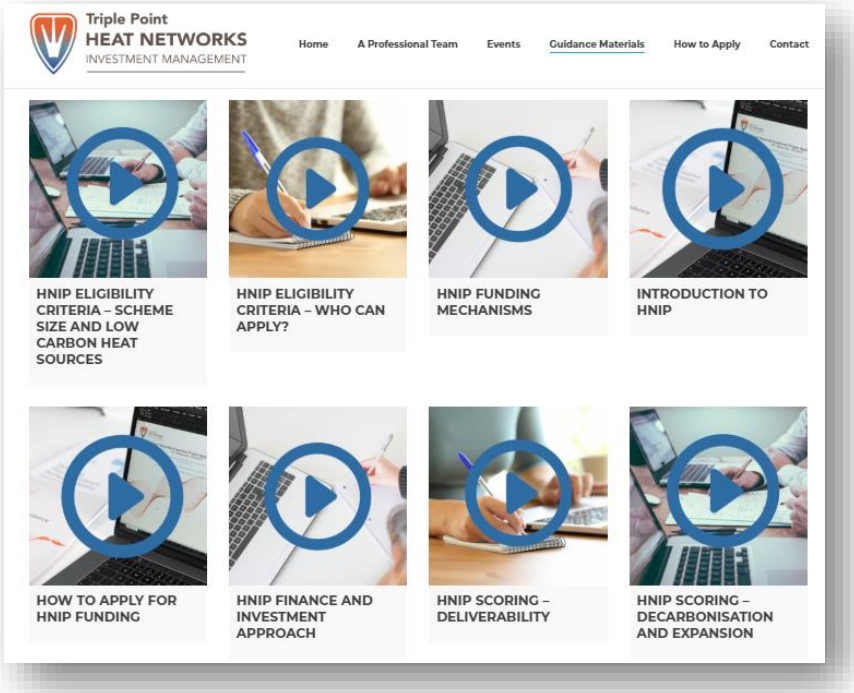


Amy Fry



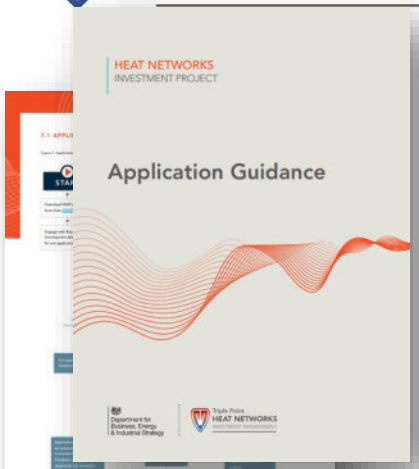
Nick Good

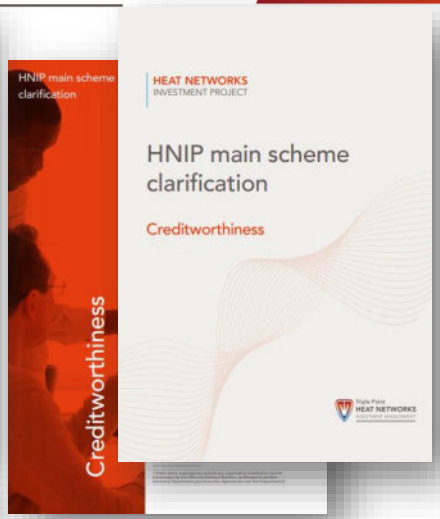


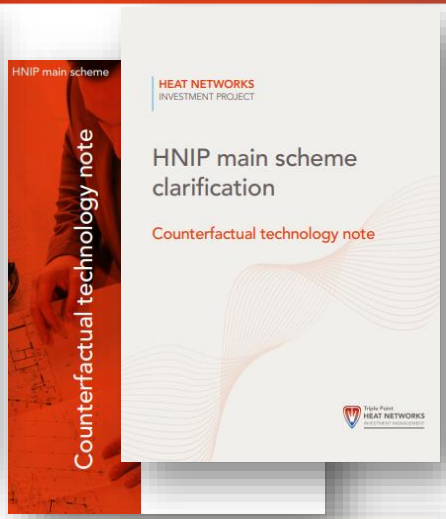


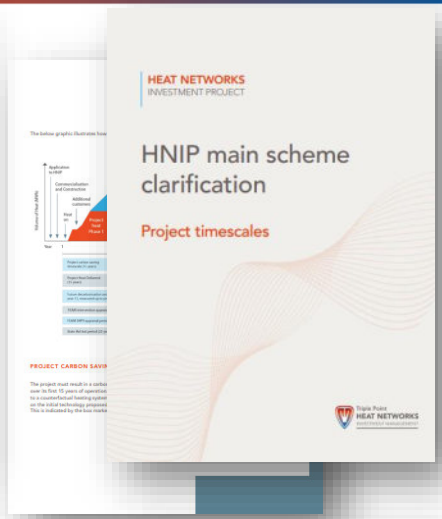
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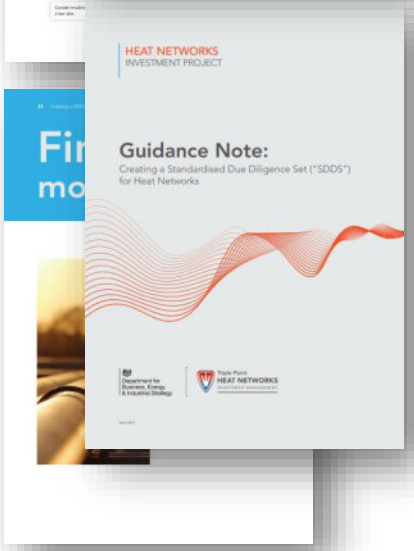
Publications

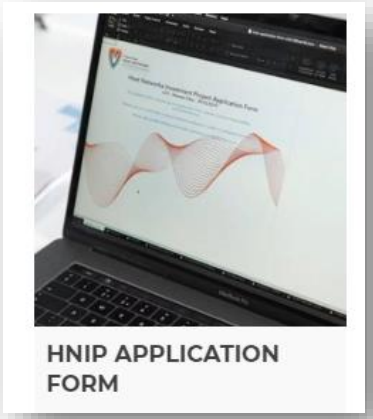


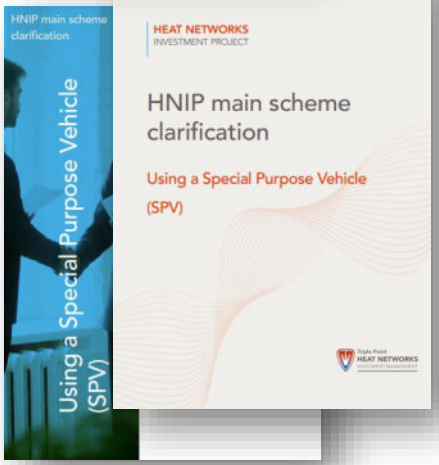


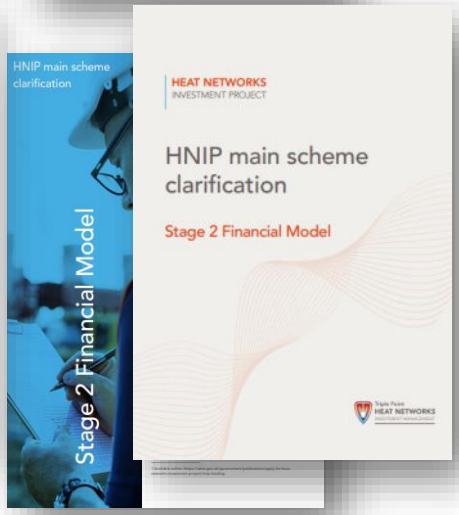












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Thank you



Visit our website and fill in the contact form to receive updates from us www.tp-heatnetworks.org

Alternatively, email us with any questions or to be added to the mailing list enquiries@tp-heatnetworks.org

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Lunch
&
Funding Surgery
HNIP
District Heating and Cooling

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