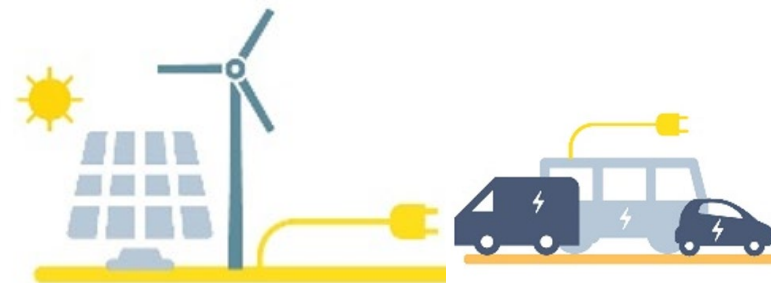


# Renewable energy for thermal use



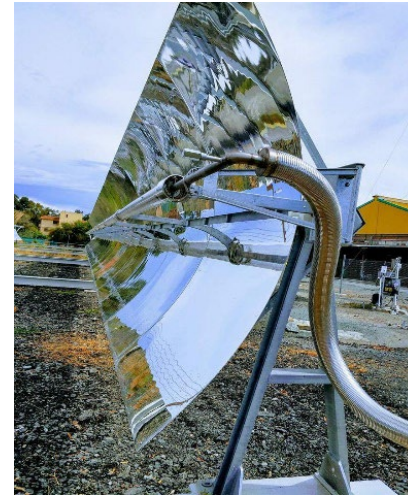
Yong Chen

IRENA Innovation and Technology

Urban Transition Mission under Mission Innovation, 24 April 2024

## For both DHC and building levels

- **Solar thermal** applications (Flat-plate glazed, evacuated-tube collectors and concentrating solar energy for heating)
- Direct utilization of **geothermal energy**
- **Bioenergy and waste-to-Energy** (co-gen)
- **Surplus RE electricity** for heating through sector coupling
- **Heat pumps** (different heat sinks, small and large-scales)



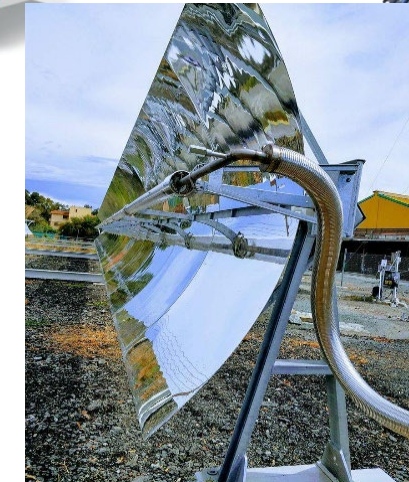
# Solar Thermal Applications

## Flat-plate glazed collectors:

- Temperature range: 80-100°C
- Applications: household hot water, pool

## Evacuated-tube collectors (10-30 tubes @ 2.5-7.5cm in diameter X 1.5-7.5 m):

- Up to 150°C suitable for cold, cloudy climate and for space heating
- High collector efficiency (over 90%)
- Either active open-loop or closed-loop



## Plastic collectors:

- Seasonal use for swimming pool only
- Large collector areas needed

## Medium-temp CSP

- Direct solar radiation needed
- For large building compound and industrial process heat



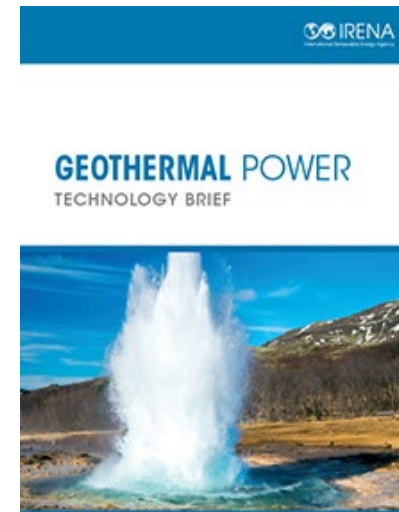
## Geothermal-based DHC

### Deep Geothermal (ranging 80-250°C), :

- Suitable for DHC leveraging the waste heat extracted from reinjected water in the geothermal power generation (Co-generation)

### Ground-source/shallow Geothermal :

- Heat-pumps used to move around the heat leveraging the geothermal energy (constant temperature underground 4-6 feet deep)
- It can provide heating, cooling (through absorption chillers) and hot water.
- More costly, space needed (especially for horizontal loop-field), and suitable for new construction/areas;
- CoP for heating ranging normally 3-5, while for cooling up to above 20 subject to the geothermal source like aquifer.



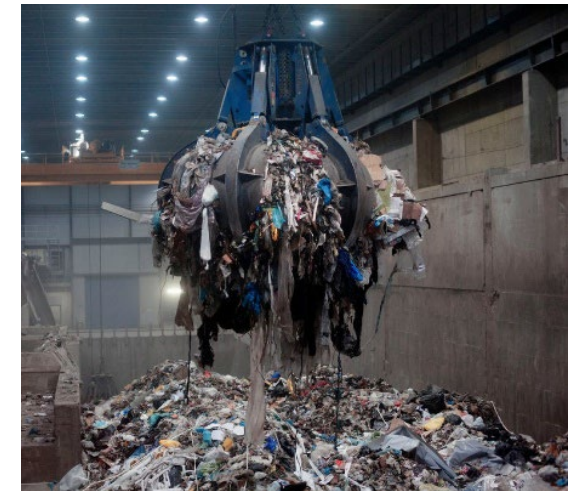
## Mature technologies delivering win-win solutions (electricity, heat, biogas and liquid biofuels while waste disposal)

### Incineration (up to 1,000 °C)

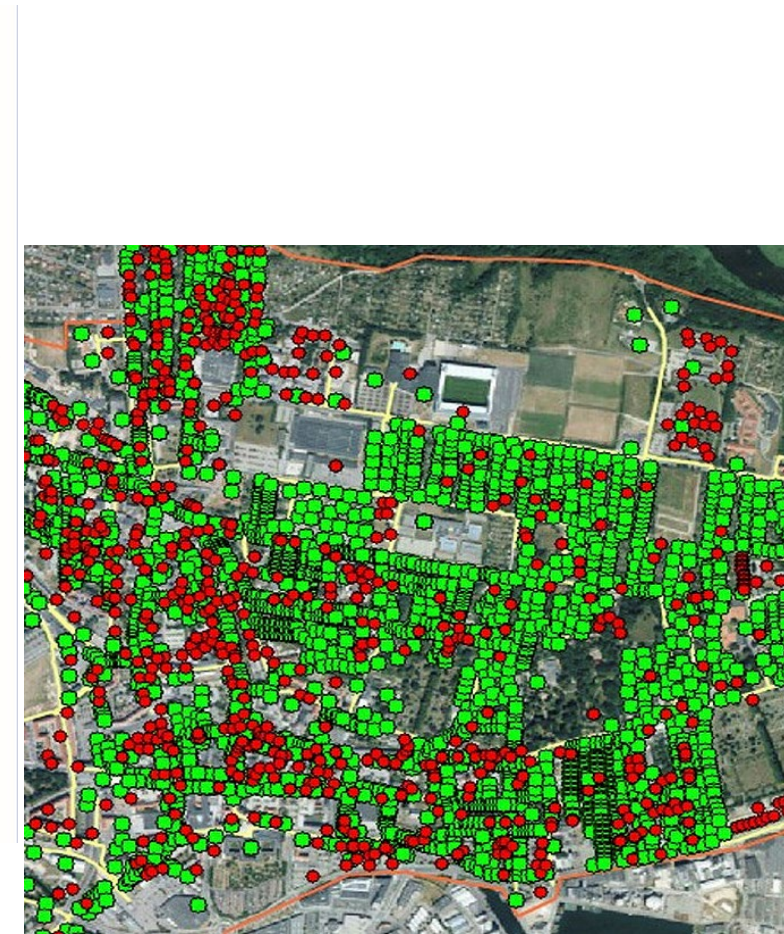
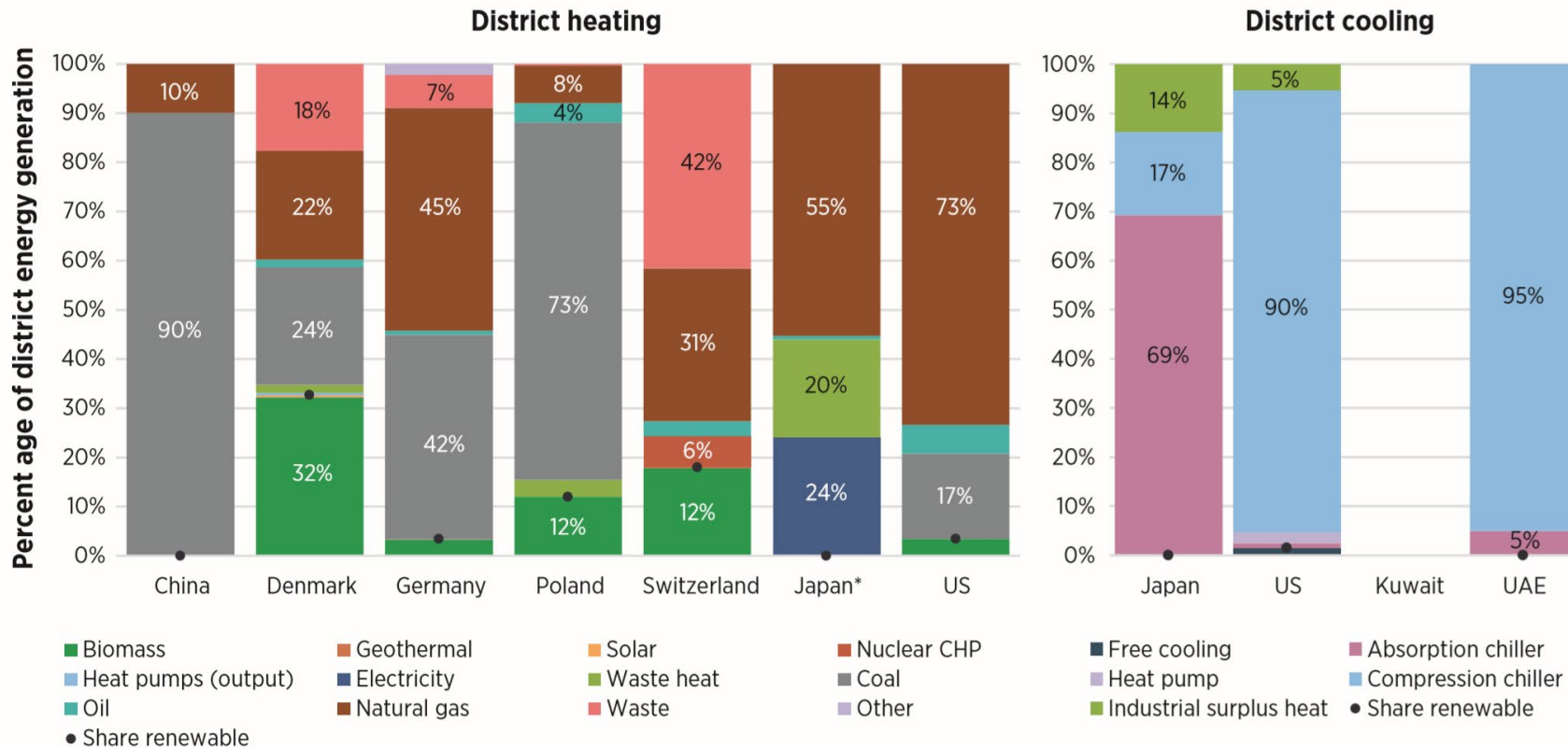
- Reduce the waste volume by above 90%;
- Flue gas pollution control is key (subject to composition of the waste)
- Gasification
- Pyrolysis
- Plasma Arc Gasification (2,200-11,000 °C)

### Anaerobic digestion:

- More suitable for wetter and biodegradable solid wastes, waste water treatment, sludge
- Located in the peri-urban/suburbs



# District Heating and Cooling (DHC) with RE



GIS image of district heating system in Denmark

Currently:

- fossil fuels are still an important source of energy for total heating while cooling is usually powered by electricity
- RE shares in DH are rather low, but has potential to grow
- The 4th generation of DH networks are in favor of RES

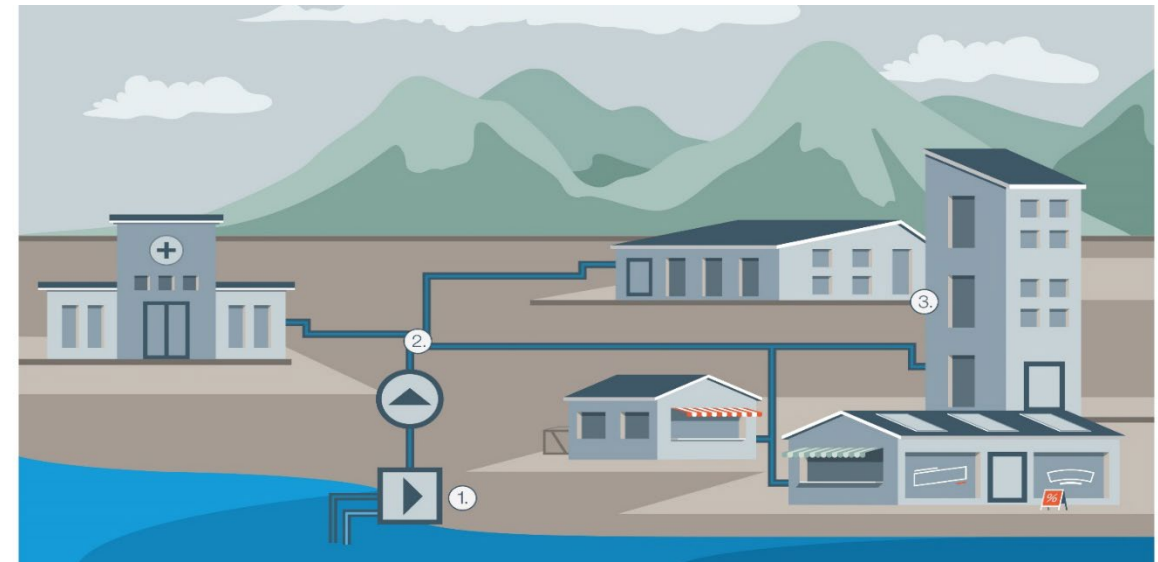
## RE sources for DH:

- WtE;
- Biomass
- Direct use of geothermal energy
- Solar thermal
- Heat pumps/electric heater using surplus REe
- Waste heat



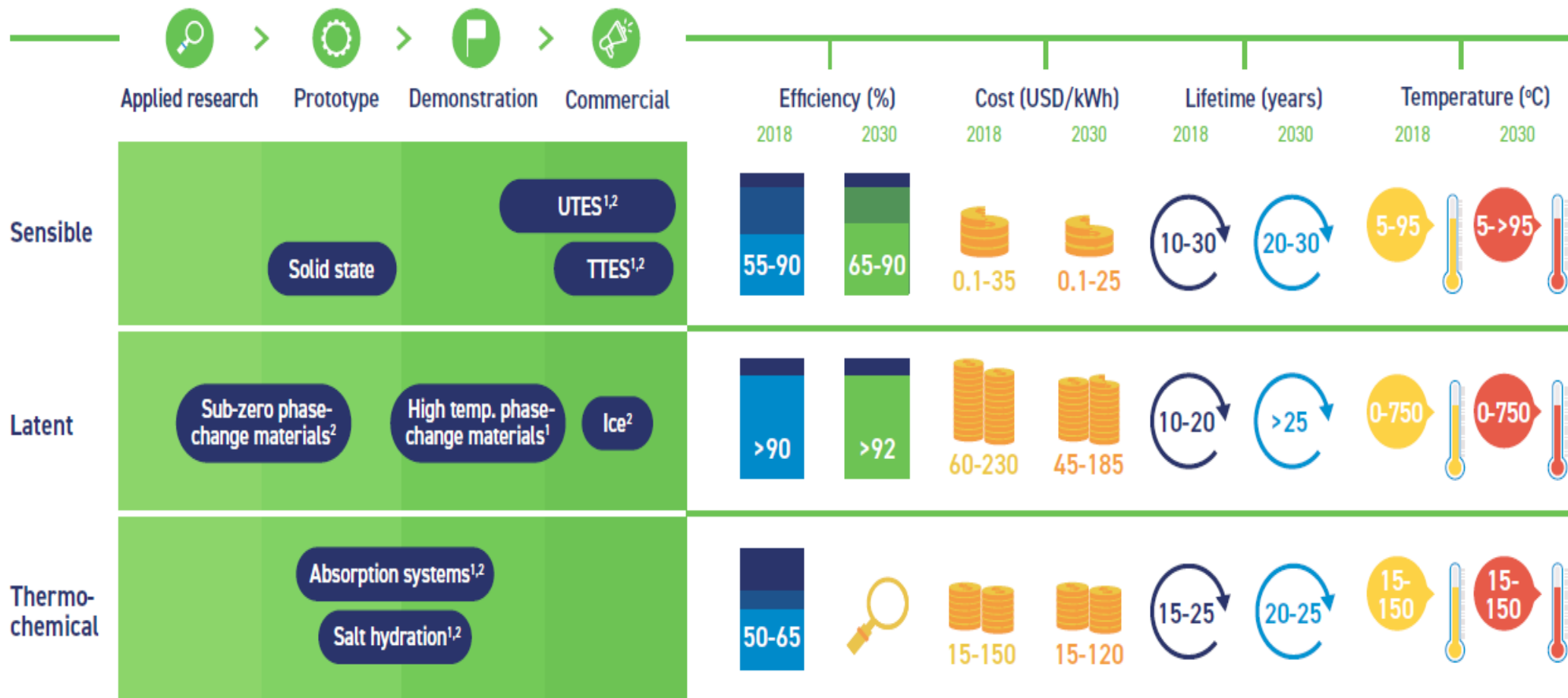
## RE sources for DC:

- Free cooling sources air, seawater, water from a river, or groundwater to achieve higher efficiency
- Solar thermal for absorption chillers



# TES for District Heating and Cooling

## District heating and cooling



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# TES for individual buildings

## Buildings



Applied research   Prototype   Demonstration   Commercial

Sensible

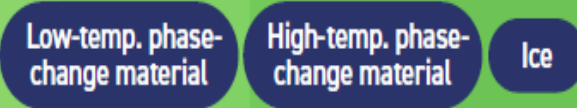


Efficiency (%)   Cost (USD/kWh)   Lifetime (years)   Temperature (°C)

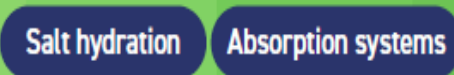
2018   2030   2018   2030   2018   2030   2018   2030



Latent



Thermo-chemical



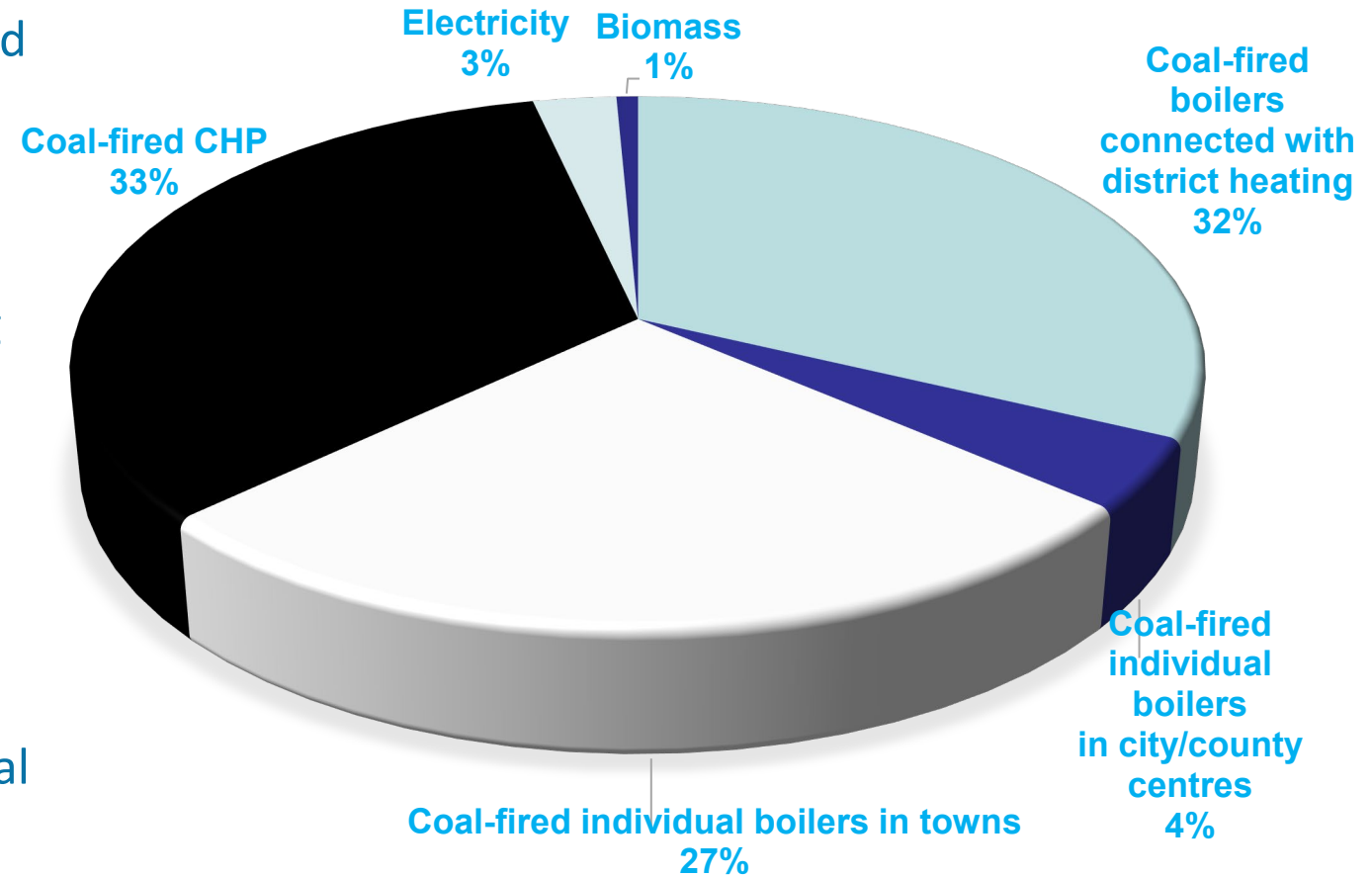
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# Zhangjiakou Energy Transformation 2050: District heating

## Current heating demand and supply

- 150 million m<sup>2</sup> of floor area in the city required space heating services
- 32% is covered by DH systems through 3 453 km networks, including 1 092 km of the main network and 2 361 km of pipelines connecting the main network to buildings.
- 33% by heating systems in building complexes (1 117 coal-fired boilers with capacity <35 tonnes of steam/hour and 63 boilers with capacity above this size)
- 95% of space heating services were met by coal



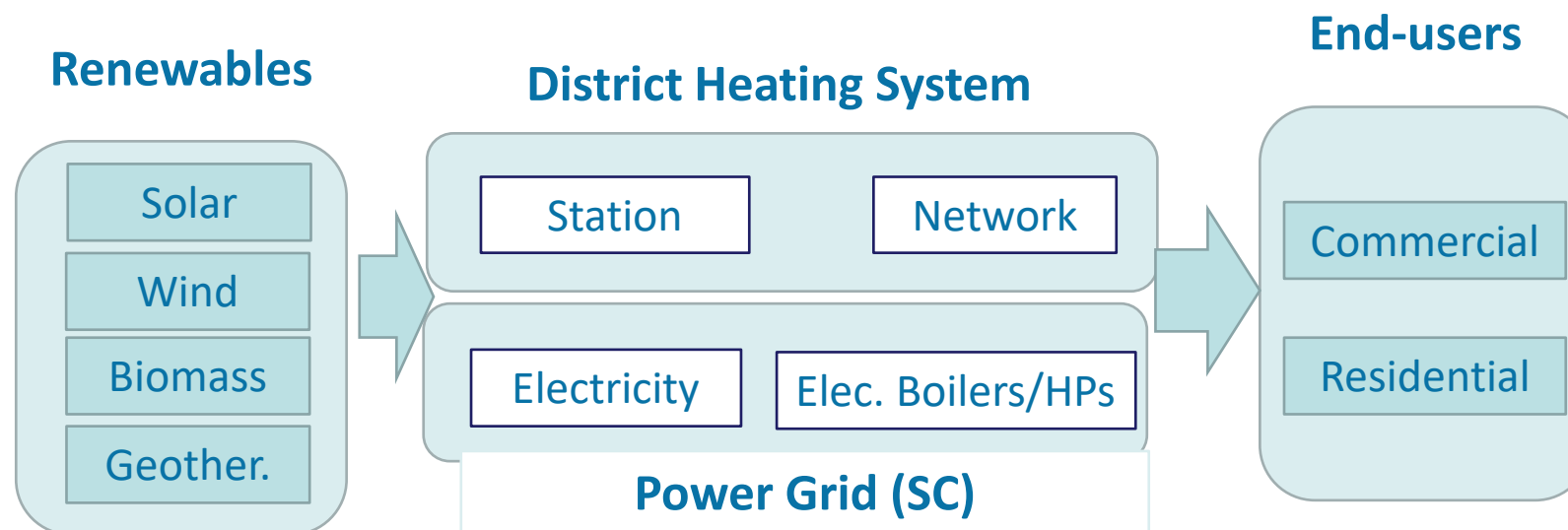
# Zhangjiakou Energy Transformation 2050: District heating

## Conventional (coal CHP) to RE heating solutions → Policy objectives for transformation of heating sector

- District heating with renewables as a measure for phaseout of coal use
- Concentrating solar thermal (tower) with seasonable energy storage for building complex
- Scale up the biomass and geothermal for heating
- Surplus renewable electricity for heating through DH and thermal energy storage



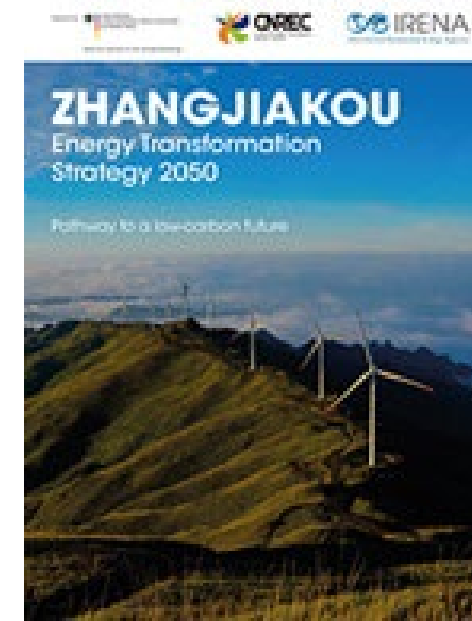
### Transformation



Supported by:



based on a decision of the German Bundestag



# Parabolic Trough Collector System for Industrial Steam Production in Limassol, Cyprus

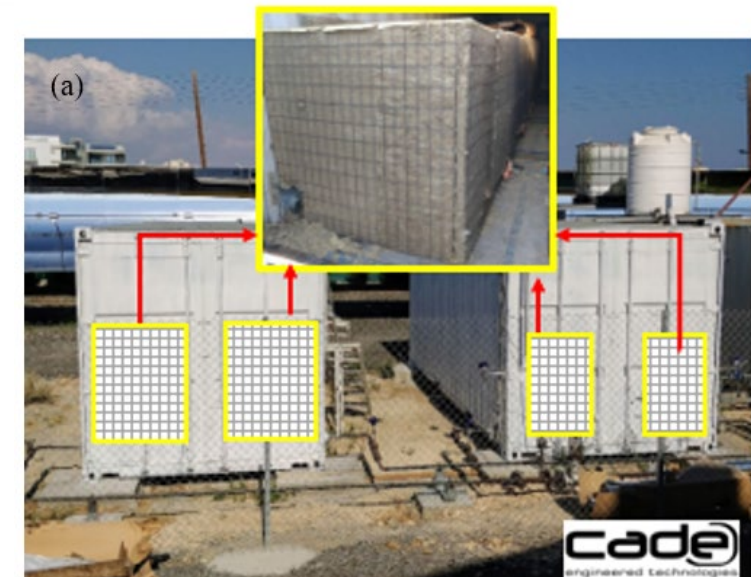
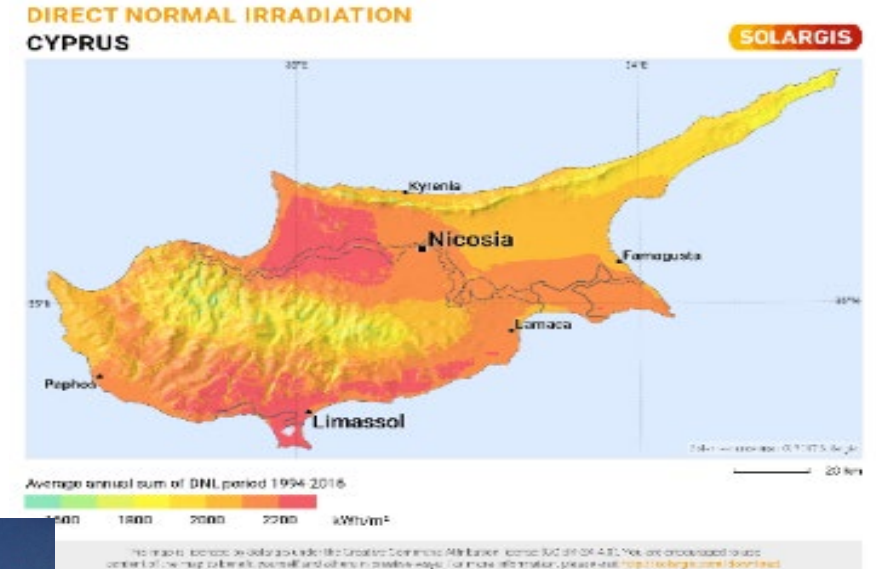
Contributed by Prof. Soteris Kalogirou ([soteris.kalogirou@cut.ac.cy](mailto:soteris.kalogirou@cut.ac.cy))

Department Chair, Department of Mechanical Engineering and Materials Science and  
Engineering, Cyprus University of Technology

# Juice Production in Cyprus with Solar Energy

## The case profile:

- Direct normal irradiance (DNI) resources of up to 2200 kWh/(m<sup>2</sup>a)
- The industrial sector is ranked as the 2<sup>nd</sup> largest fossil fuel consumer
- Innovative application of parabolic trough collector (PTC) technology to produce heat in one of the biggest soft and drinks industries, called KEAN, located in Limassol
- Concrete thermal energy storage (CTES) with advanced composition of concrete is applied to meet the heat demand in winters



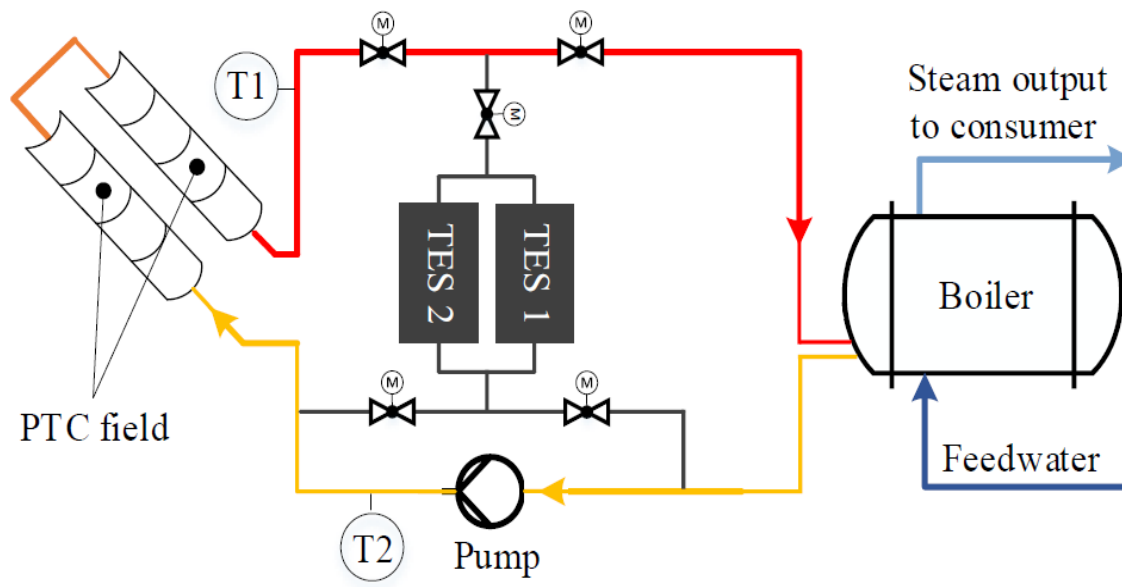
# The PTC with CTES system

## *The system configuration and capacity*

- 8 PTC (CF100) connected in 2 parallel rows of 4, with an aperture of 3 m and a length of 12 m
- Nominal thermal capacity: 125 kWth.
- PTCs employ a highly efficient receiver tube for operation at temperatures up to 425 C.
- CTES performance: operation temp up to 400 C

## *System operation performance*

- Advanced processor to control all the operation modes and strategies to make the system dispatchable and autonomous
- After a year of operation, the system responds perfectly to the Strategies and Modes and supply the required amount of steam to the factory when is needed even at times when there is no solar radiation.



# Thank you



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