OVERVIEW OF SHALLOW GEOTHERMAL ENERGY SYSTEMS IN AREAS

SGE is ubiquitous, available any time, weather independent, efficient and renewable

From 0 to 200 m under the surface (exceptionally up to 400 m) **SHALLOW**

Stored/exchanged in/with the subsurface **GEOTHERMAL**

Heat extracted/injected from/to the subsurface with (or without) HEAT PUMPS **ENERGY**

1. IAE, "Energy Technology Perspectives" (2016)
2. PBL Netherlands Environmental Assessment Agency, "Facts and Figures on Cities and Urban Areas" (2016)
3. Nature Geoscience 5, 671-696 (2012)
4. BP, "Statistical Review of World Energy" (2019)
5. Turcotte D.L. & Schubert G., "Geodynamics" (2nd ed. 2002)

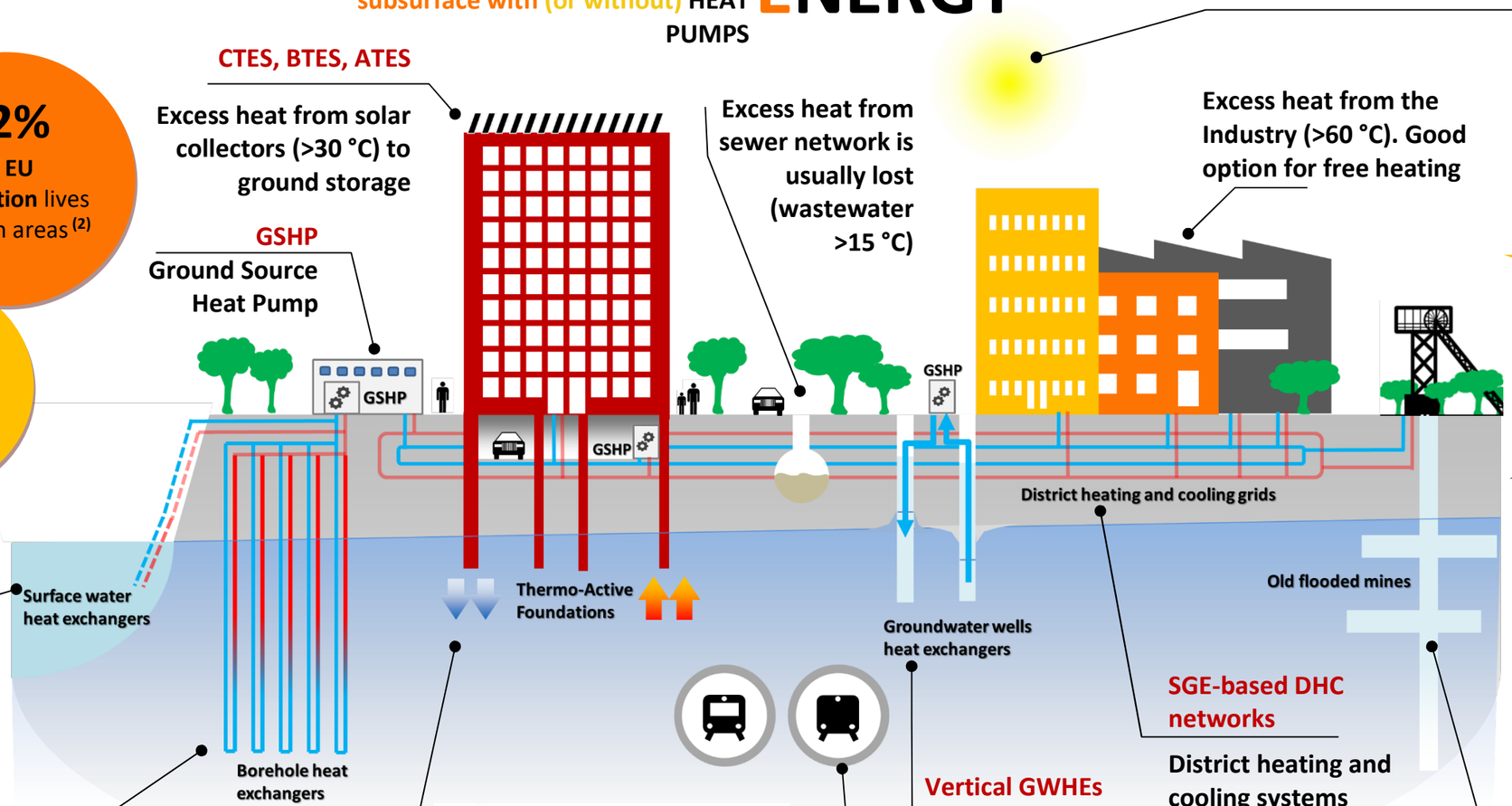
The Sun is the true main source of SGE

64 % of **World primary energy** is consumed in urban areas [1]

72% of **EU population** lives in urban areas [2]

70 % of **World CO_2 emissions** are concentrated in cities [1]

17% of **EU land** is considered as "**urban**" [2]



CTES, BTES, ATES

Excess heat from solar collectors (>30 °C) to ground storage

GSHP

Ground Source Heat Pump

Excess heat from sewer network is usually lost (wastewater >15 °C)

Excess heat from the Industry (>60 °C). Good option for free heating

Average solar radiation absorbed at the Earth's surface [3]

165 W/m²

World human average power consumption [4]

→ 34 mW/m²

Average power reaching the Earth crust from its internal heat budget [5]

40 - 90 mW/m²

Average value in continental areas ~ 65 mW/m²

OL-SWHEs, CL-SWHEs

Large water bodies like rivers, lakes and the sea show a reduced yearly temperature variation compared to air. Good option for free cooling

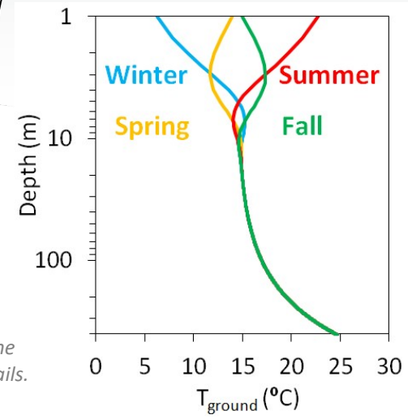
Vertical BHEs, BTES

The geo-exchange within the ground using close loop systems (CL).

Almost constant temperature along the year (10 - 18 °C) below 10m depth to 100 - 200 m

TAFs

Heat exchanger can be embedded in deep foundations (>10 m)



T_{ground} is dominated by solar irradiation close to the surface. Afterwards, the geothermal gradient prevails.

Vertical GWHEs

The groundwater exchange abstracting and injecting groundwater from the aquifers

Excess heat from underground infrastructures causes cumulative ground warming and warm air at tunnels (>25 °C)

SGE-based DHC networks

District heating and cooling systems powered with SGE technologies or combined with other RES or waste heat sources

CTES, GWHEs

Abandoned and naturally flooded mines with groundwater

Managing Urban Shallow Geothermal Energy

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OL and CL: open and closed-loop / SW and GW: surface- and groundwater / B: Borehole; C: Cavern; A: Aquifer / HE: heat exchanger; TES: thermal energy storage / TAF: Thermo-active foundation / DHC: District heating and cooling