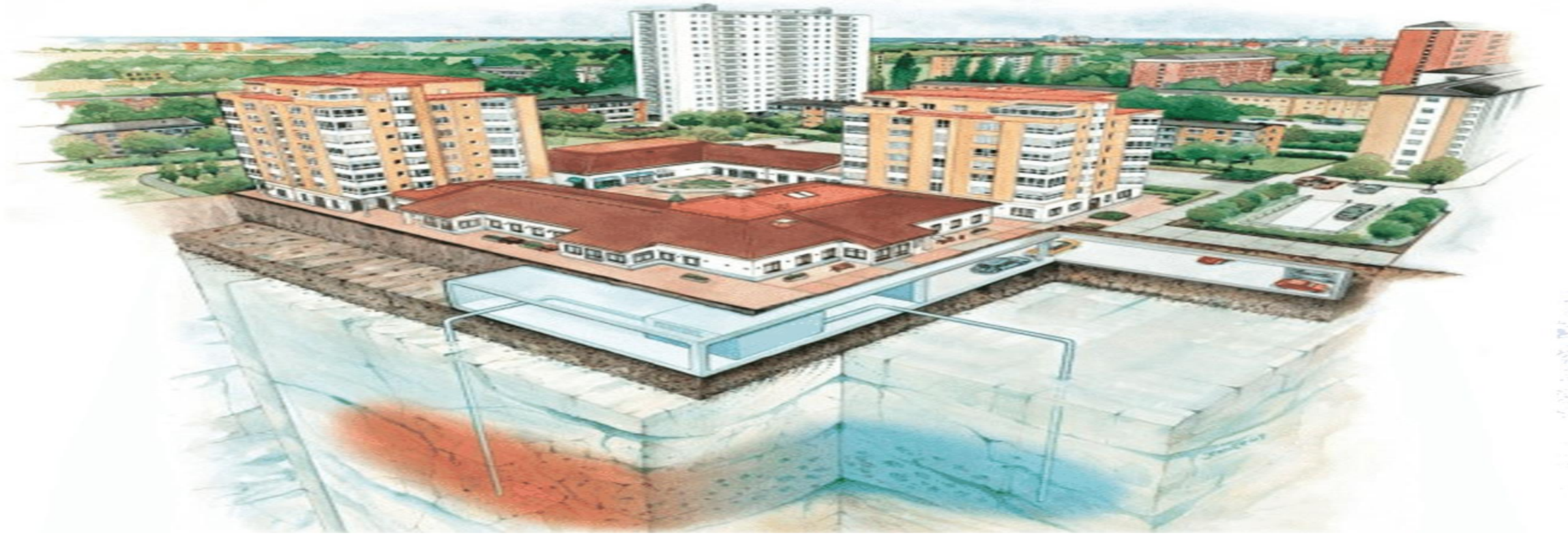
Underground Thermal Energy Storage for Carbon Neutral Communities



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Acknowledgment

3rd International Conference on Underground Space Environments & The Excellent Graduate Students Academic Summer Camp, 06 September 2023

CA20139 – Adaptive Facades

IEA ES Task 43, 2023-2027, Thermal building mass storage

International Association of Underground Space Environments

建筑设备科学与工程学院
西安建筑科技大学
XI'AN UNIVERSITY OF ARCHITECTURE AND TECHNOLOGY

陕西省制冷学会
Shaanxi Association of Refrigeration

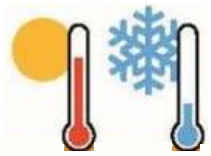
陕西省建筑设备科学与地下空间环境国际联合研究中心
International Jointed Research Center for Building Service Science and Underground Space Environment , Shaanxi

Architectural Facades and Products research group

Carbon Neutral Communities

Global GHG emissions by sector

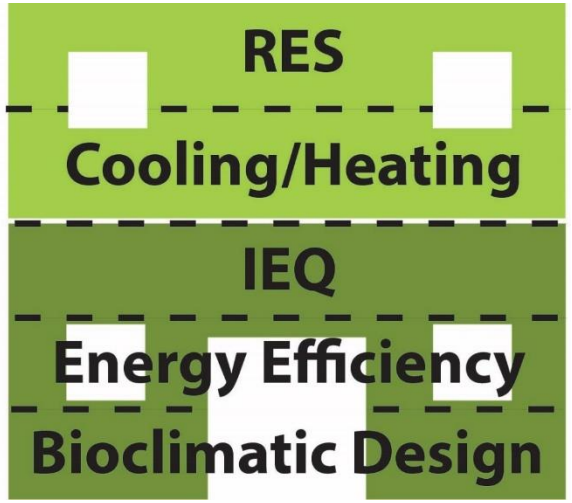
	Globe 2021 vs 1990 (fossil CO_2)	EU27 2021 vs 1990 (fossil CO_2)
Power industry	↗ + 87 %	↘ - 39 %
Other industrial combustion	↗ + 65 %	↘ - 41 %
Buildings	→ + 2 %	↘ - 32 %
Transport	↗ + 65 %	↗ + 16 %
Other sectors	↗ + 101 %	↘ - 23 %



Net Zero Energy Buildings

nearly Zero Energy (nZEB) and Net Zero Energy Buildings (NZEB)

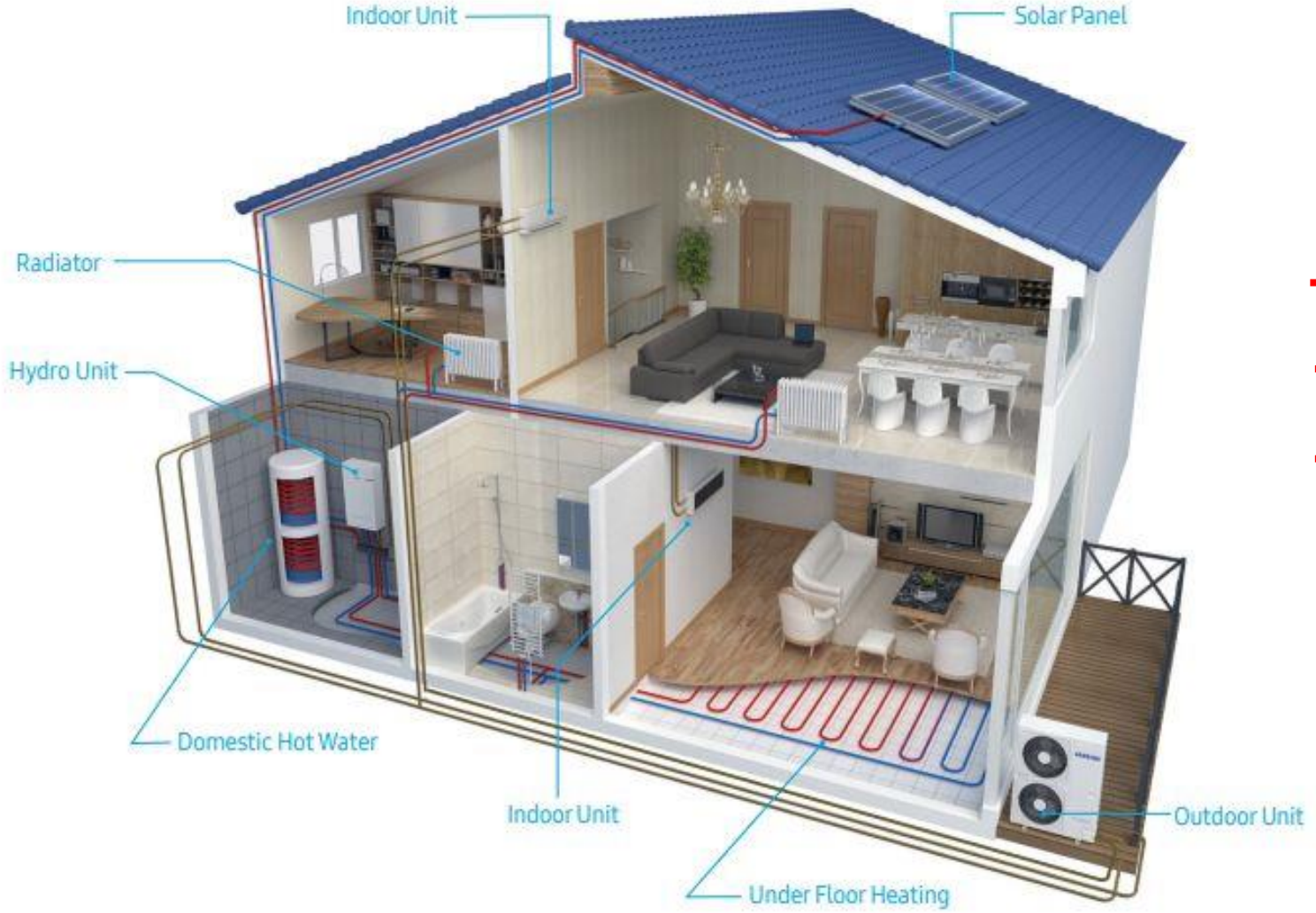
A NZEB is a grid connected, energy efficient building **that balances its total annual energy needs by on-site generation**



Attia, S. (2018) **Net Zero Energy Buildings (NZEB)** , Elsevier

Net Zero Energy Buildings

nearly Zero Energy (nZEB) and Net Zero Energy Buildings (NZEB)



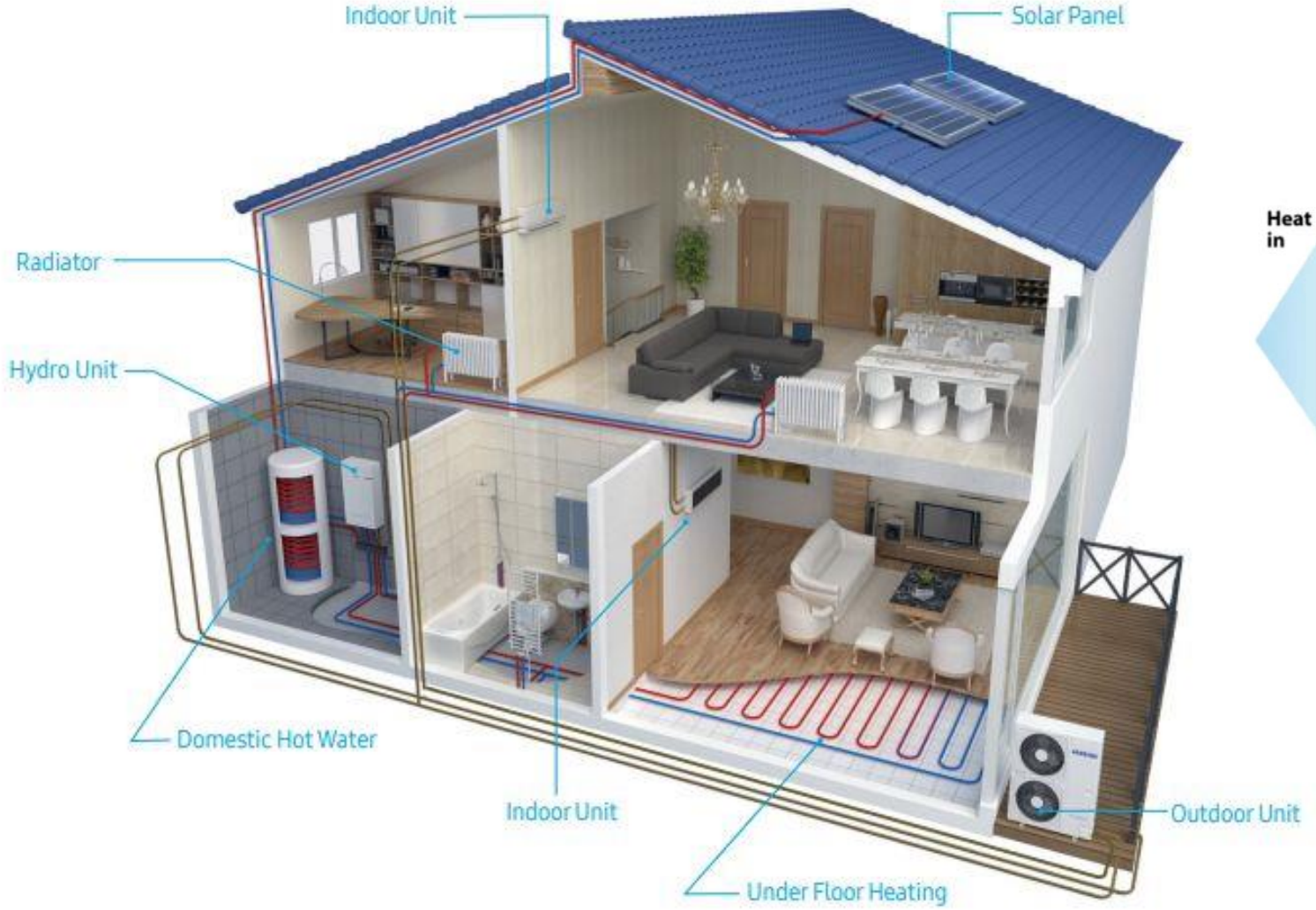
REGIMES DE TEMPERATURE

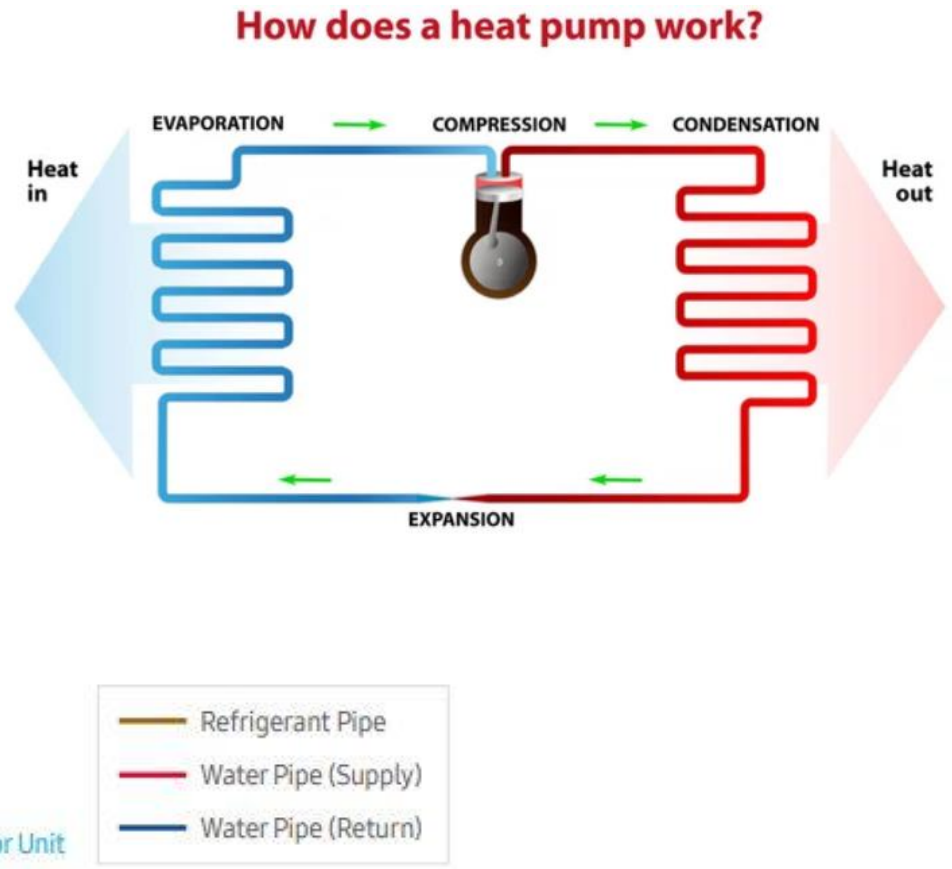
	T aller
~~Haute température~~	~~90°C~~
~~Moyen température~~	~~70°C~~
~~Basse température~~	~~55°C~~
Très basse température	30°C

Attia, S. (2018) **Net Zero Energy Buildings (NZEB)** , Elsevier

Net Zero Energy Buildings

All Electric with Heat Pumps





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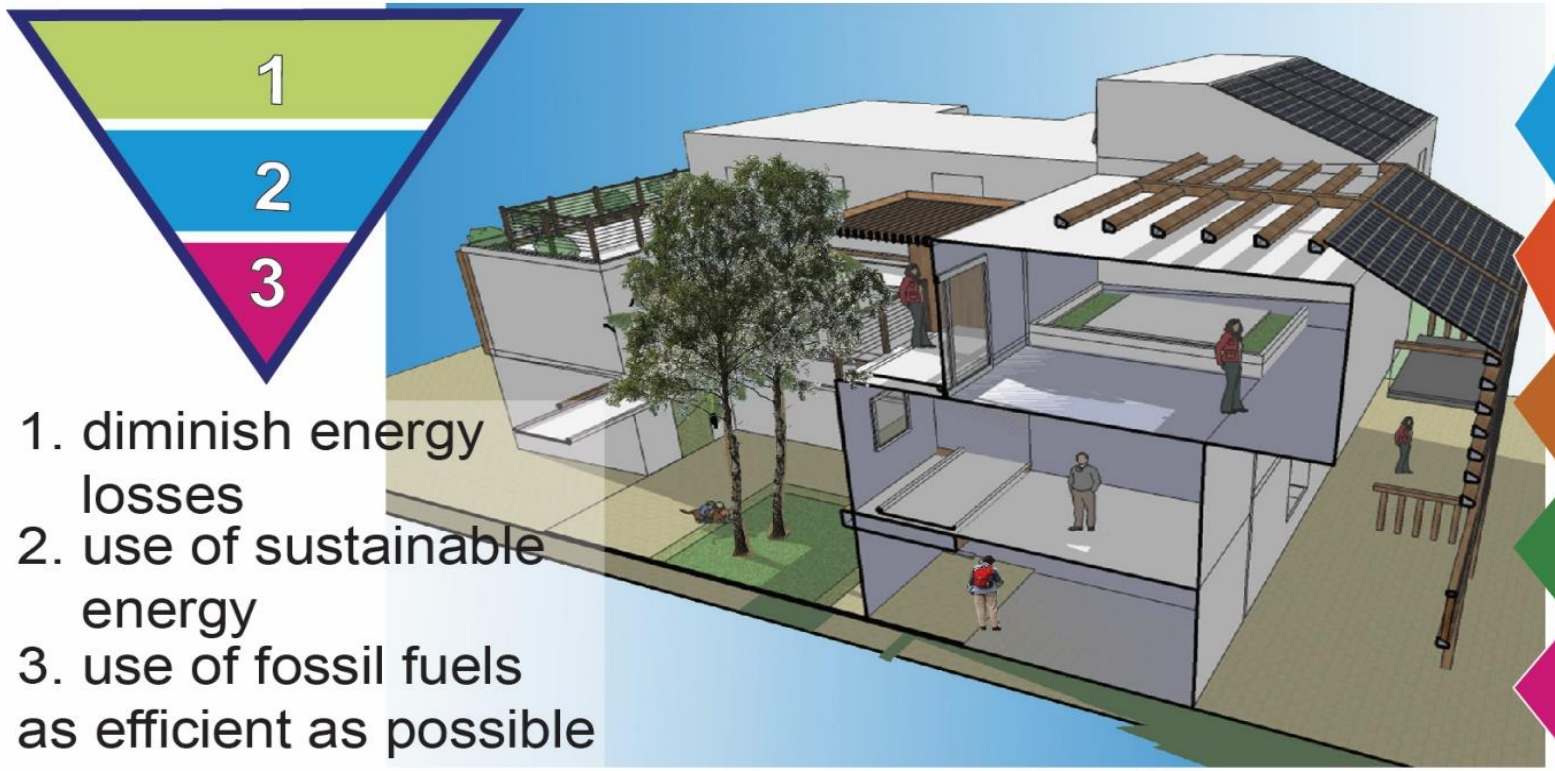
Net Zero Energy Buildings

nearly Zero Energy (nZEB) and Net Zero Energy Buildings (NZEB)

High Performance Design Process



Steps:

1. Reduce loads
2. Utilize Passive Opportunities
3. Optimize Active Systems
4. Incorporate Renewable Energy
5. Minimize Waste

Trias Energetica

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Net Zero Carbon Buildings

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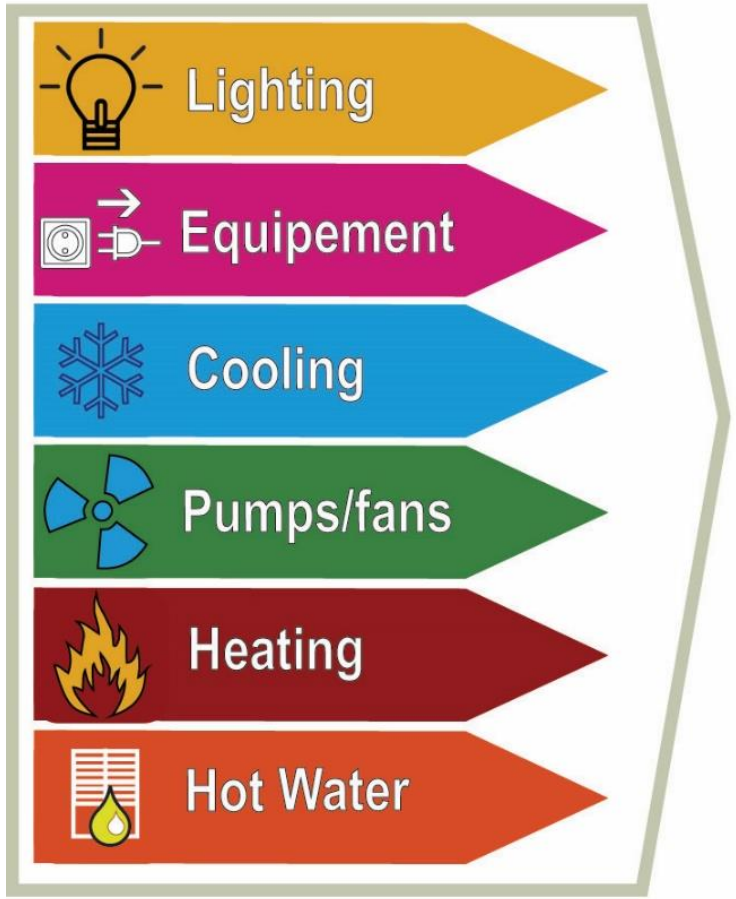
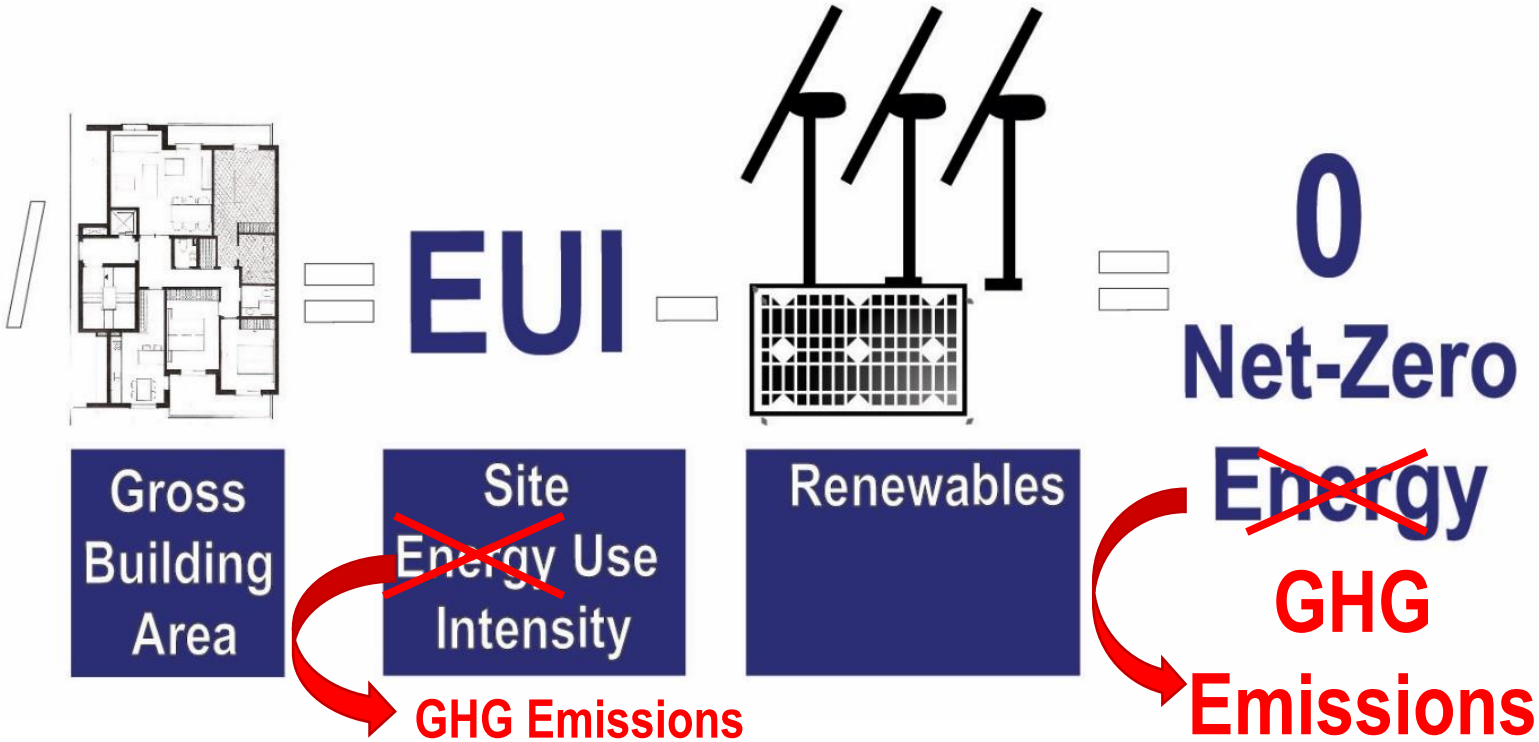
From Energy Use Intensity to GHG Emissions Intensity

Measuring ~~Energy~~ Emissions



ISO 52000-1:2021



Net Zero Carbon Buildings

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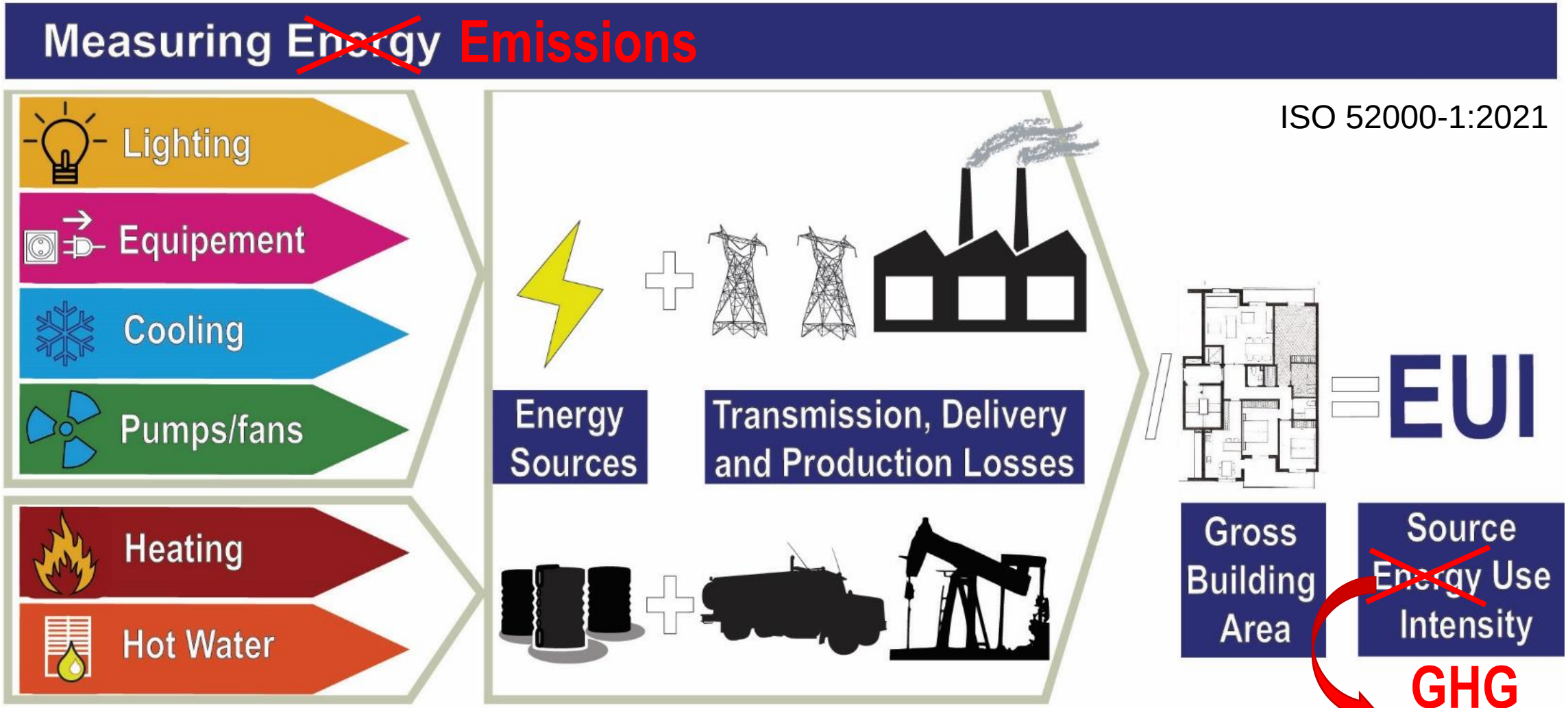
Converting the primary energy use intensity to GHG emissions

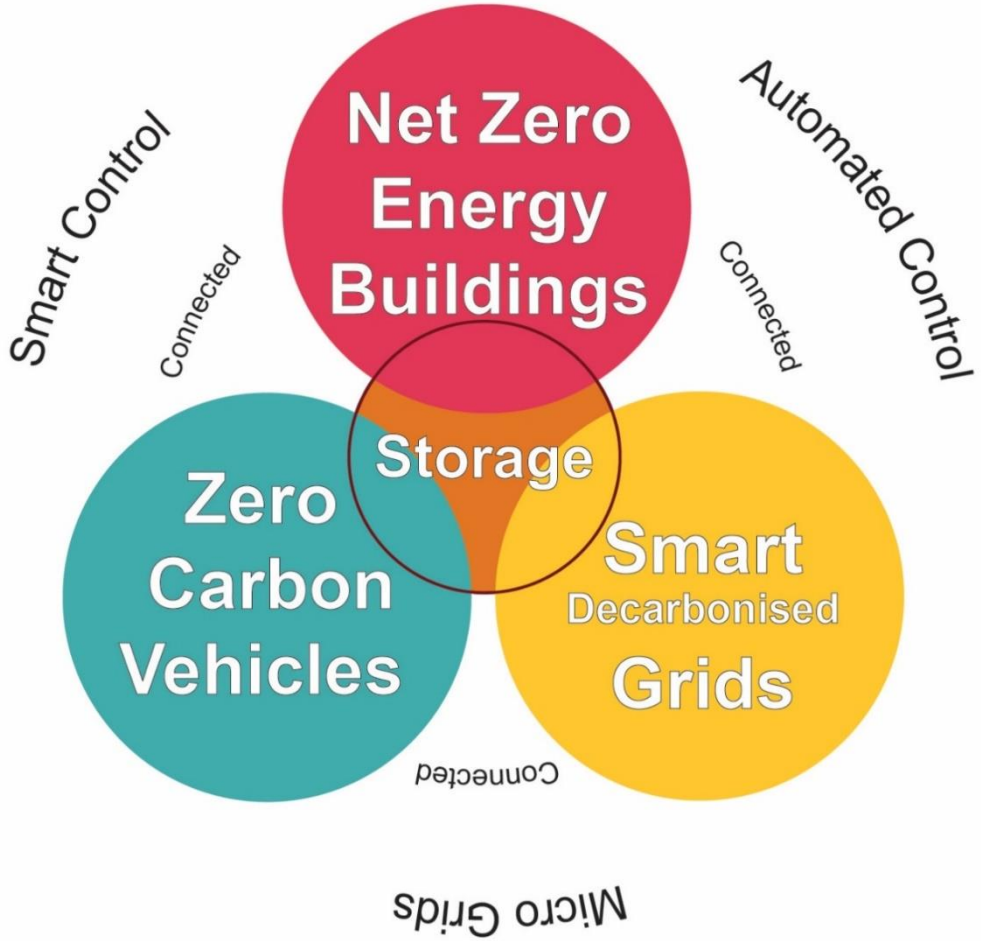


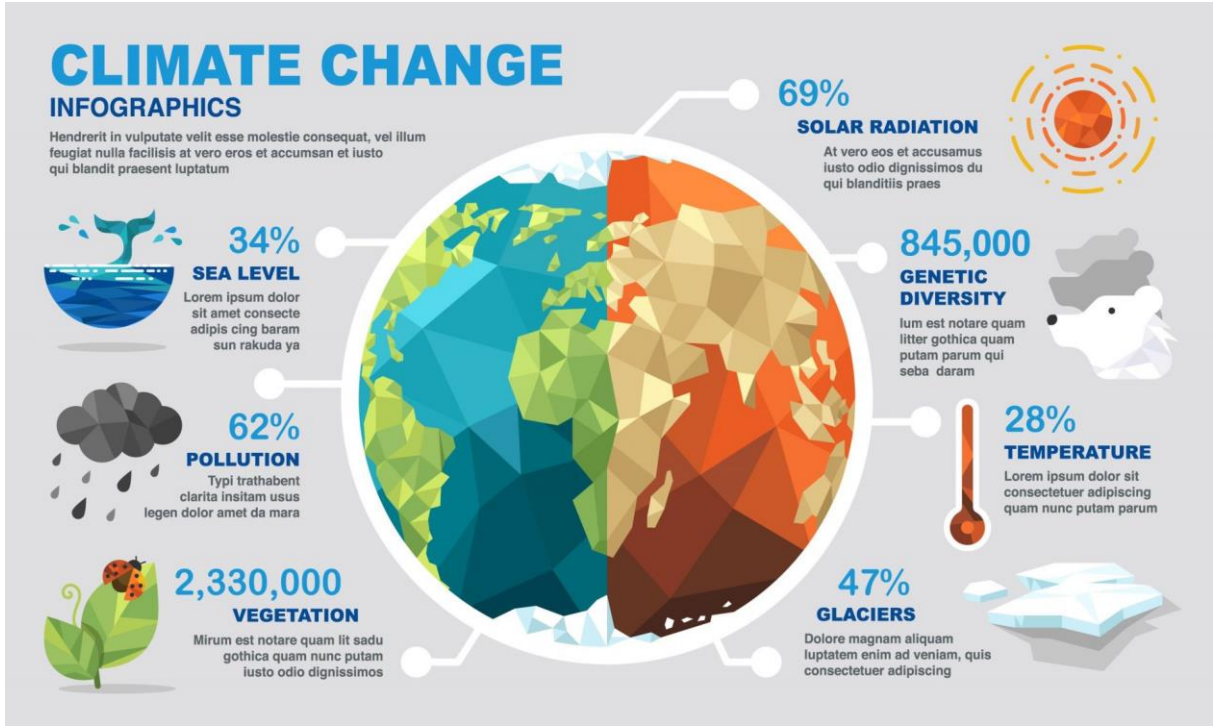
Carbon Neutral Communities

From Single Building to Community

Carbon Neutral Communities

Storage & Scale the Core of Carbon Neutrality





Resilience

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Thermal Storage

The Core of Carbon Neutrality

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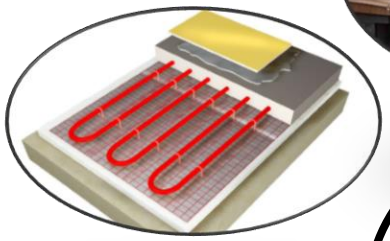
Buildings Storage Systems

Thermal Mass

Floor Heating Systems



Fuel Cells

Buffer Tanks

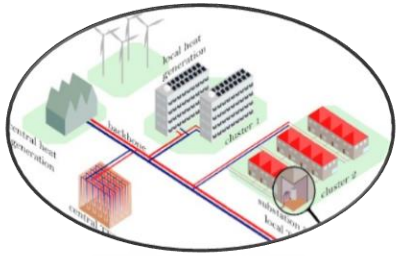
Batteries

PCM

TABs Thermally Activated Beams

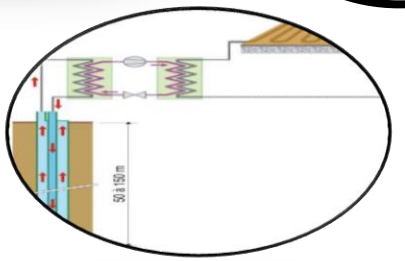
District Storage Systems

Mixed Use Districts



Neutral Networks

Energy Storage Systems



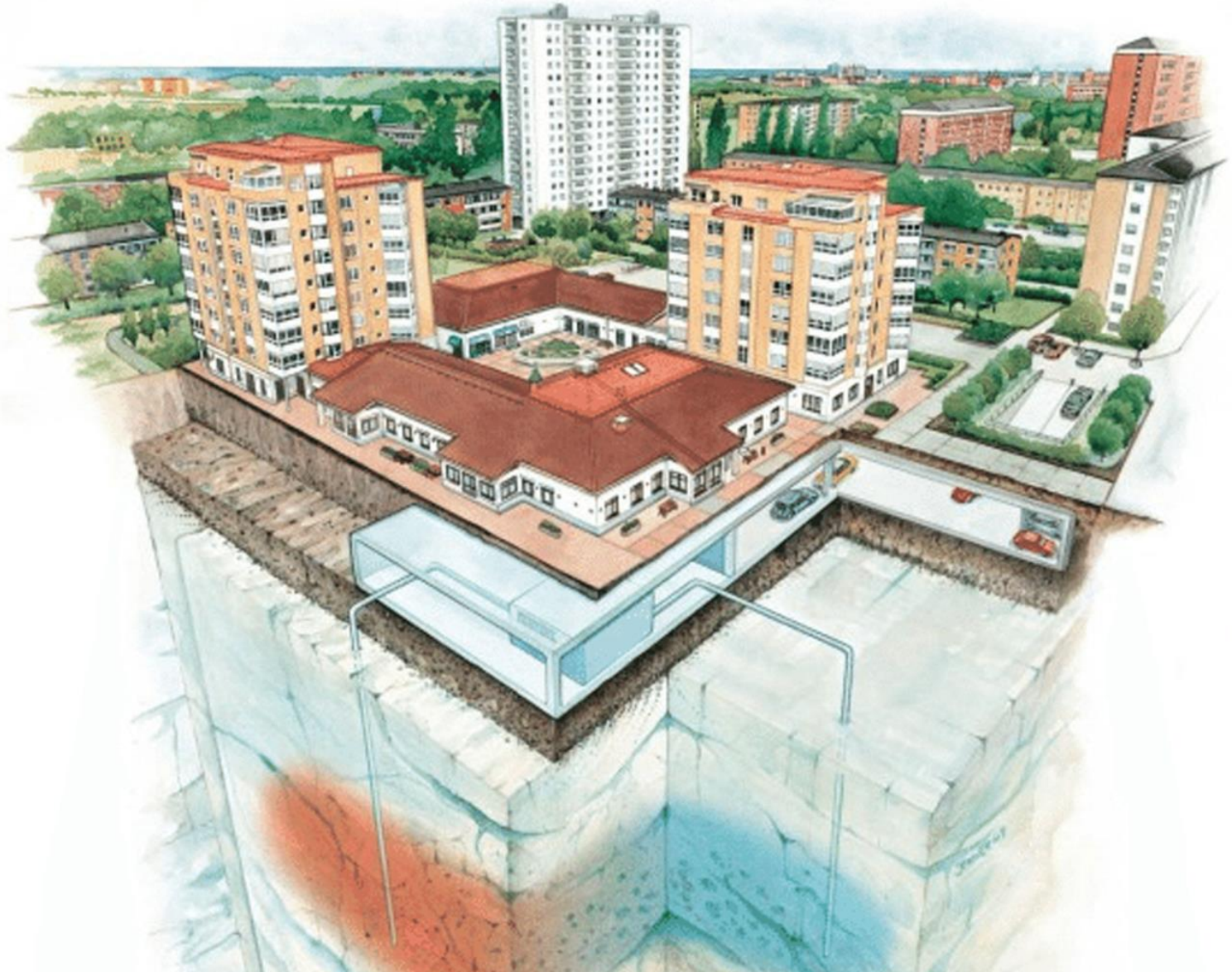
Geothermal Energy Storage

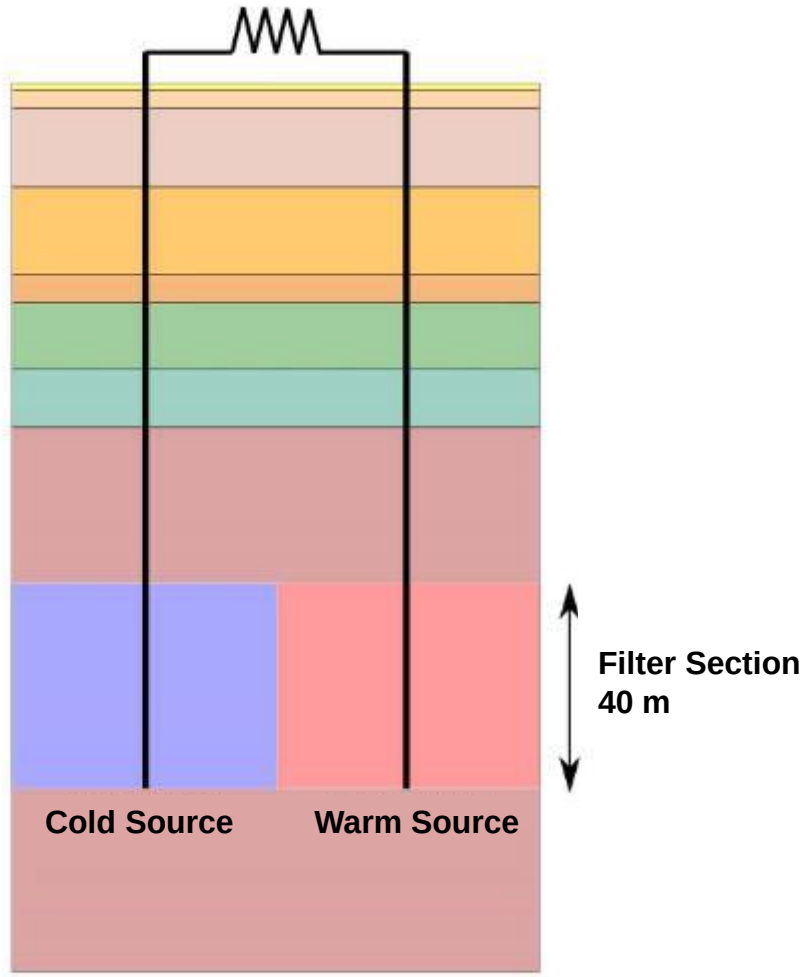
Micro Hydro Power for Storage

Shallow Geothermal Energy

Shallow Geothermal Energy

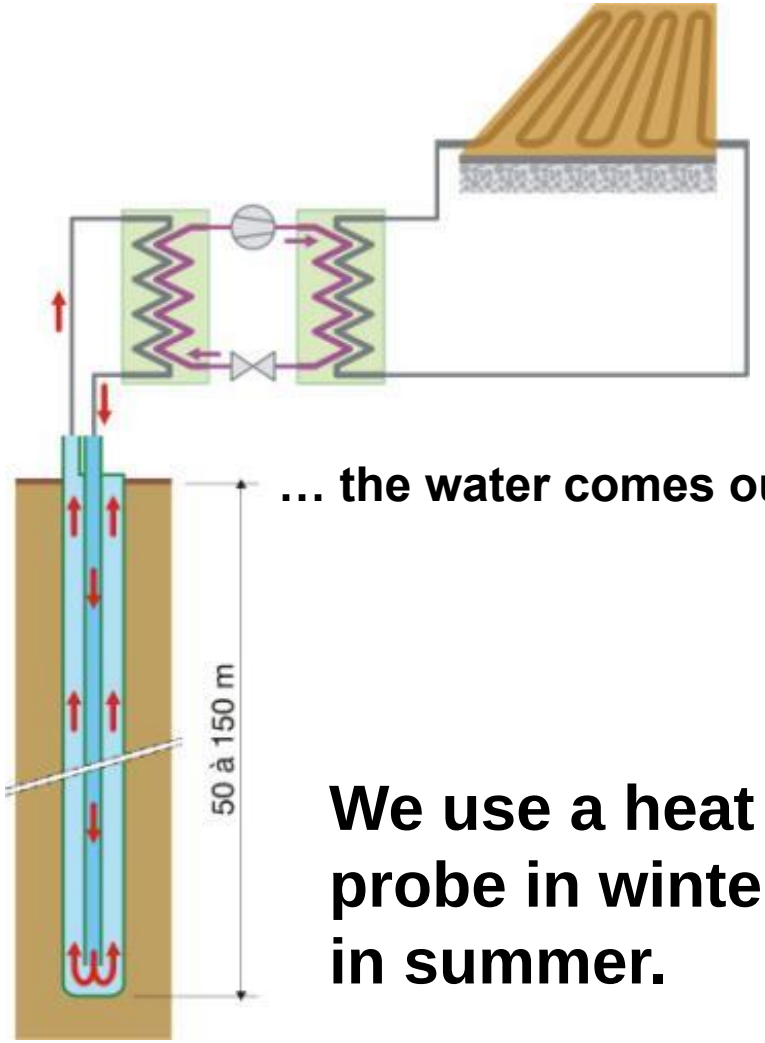
Aquifer Thermal Storage (ATES)





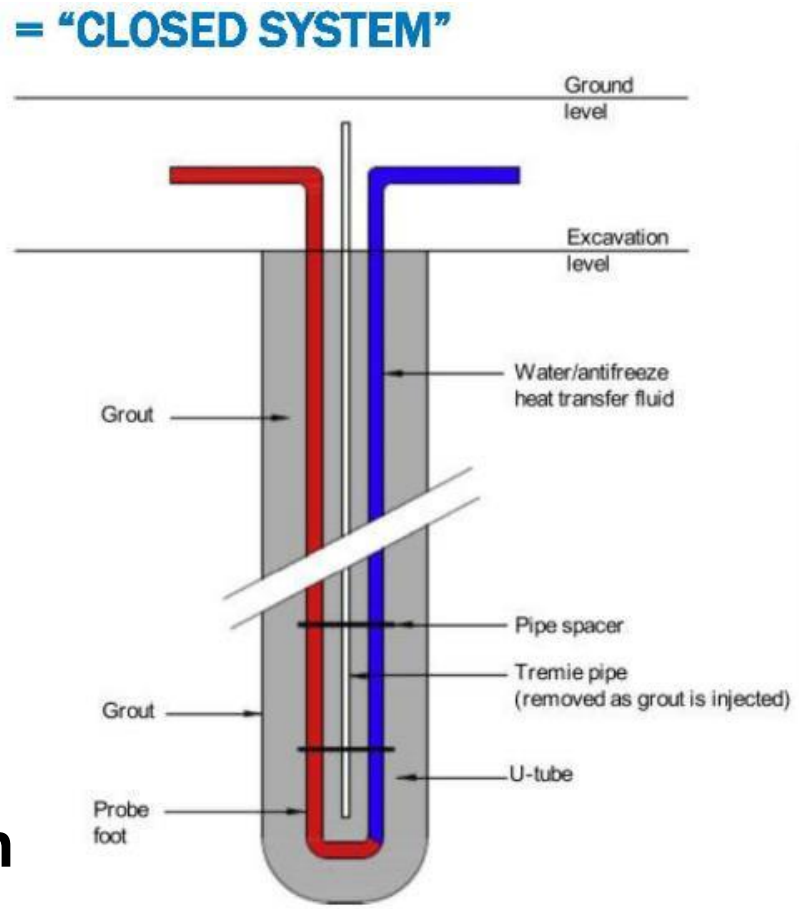
Shallow Geothermal Energy

Borehole Thermal Energy Storage (BTES)



… the water comes out of the borehole at 10°C

We use a heat pump on a geothermal probe in winter and cold water circulation in summer.



Shallow Geothermal Energy

Borehole Thermal Energy Storage (BTES)

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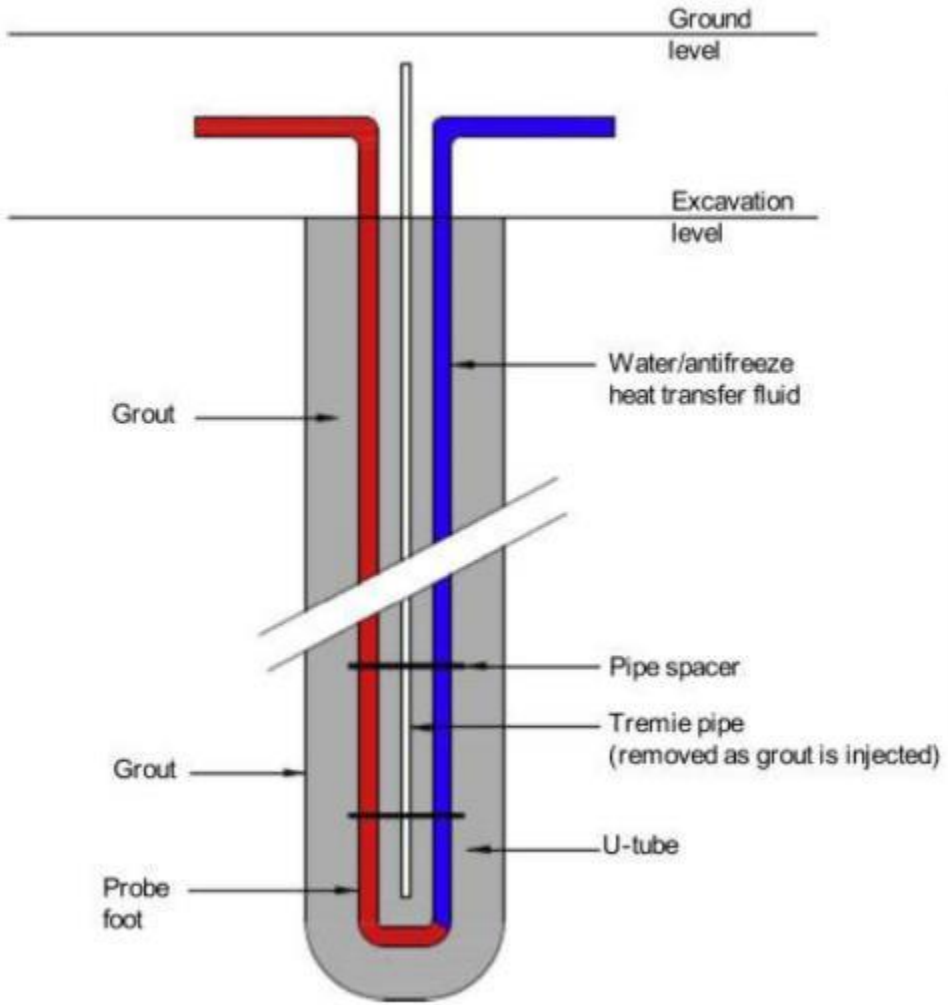
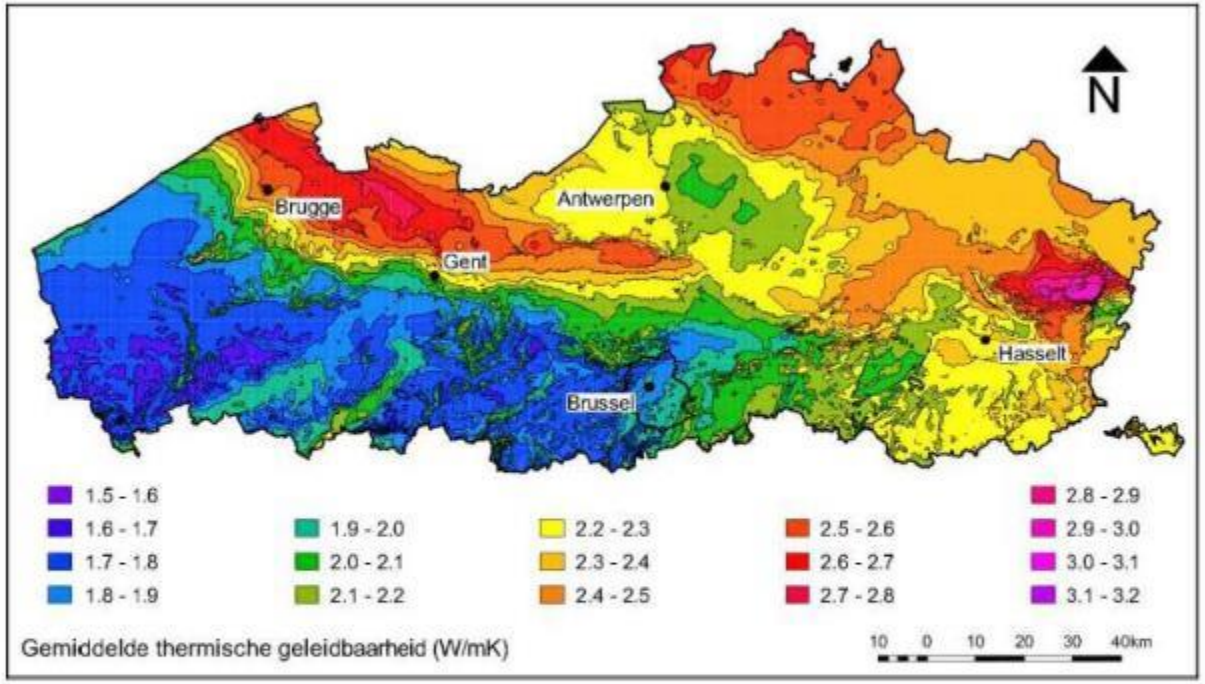
= "CLOSED SYSTEM"

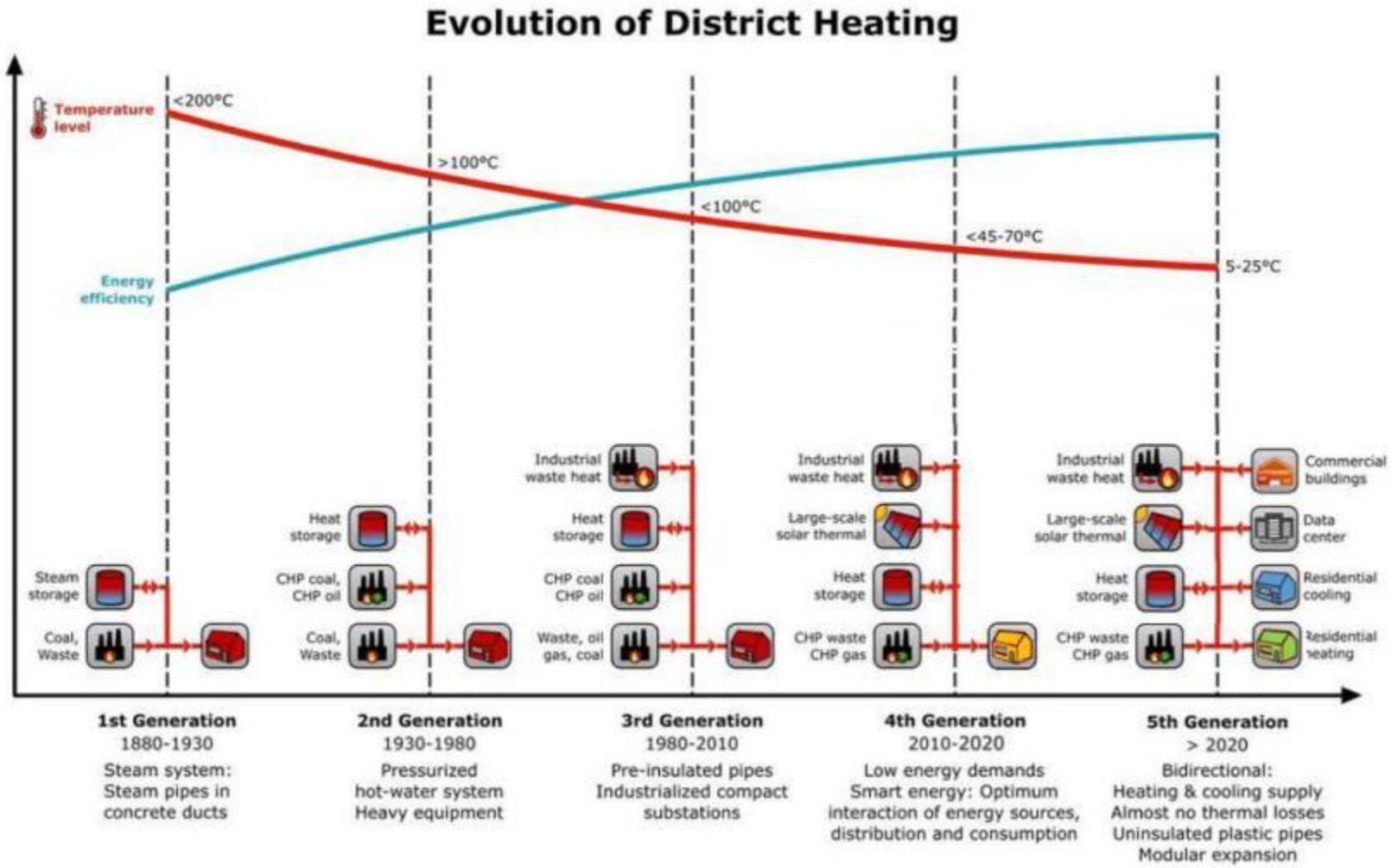


FEASABLE "EVERYWHERE"



Heating Grids

District Heating



4th Generation:
District heating grid with a collective source

5th Generation:
Thermal energy directly from the subsurface
(T 5 – 25 °C)

Case Studies

Conclusion

Conclusion

Neutral Grid with collective ATES-boreholes

NEUTRAL GRID

-Allows to connect different buildings from different owners under a public infrastructure.
-Can be managed and operated by a private/public third party.

COLLECTIVE ATES WELLS

-ATES wells and boreholes are part of the public domain
-Need to make sure they don’t get connected
-Require continuous monitoring from the environmental authorities
-Need to make sure that their efficiency will not decrease with time.

Thank you for your attention

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