22 expo acaire 2023

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Cartagena

| 27, 28 y 29 de septiembre |

The Role of Renewables and Thermal Grids in the Decarbonization of Energy Districts –

Insights from Europe and Switzerland

Dr. Willy Villasmil
Lucerne University of Applied Sciences and Arts

28 September 2023

Thermische Netze Schweiz
Réseaux Thermiques Suisse
Reti Termiche Svizzera

HSLU Lucerne University of Applied Sciences and Arts

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Education

- PhD, ETH Zurich (2013)
- MSc in Mechanical Engineering, ETH Zurich (2010)
- BSc in Mechanical Engineering, Simon Bolivar University (2006)

Areas of Expertise

Thermal Grids, Thermal Energy Storage, Modeling and Simulation of Energy Systems

Professional Career

- Lecturer for Thermal Grids, Institute for Building Technology and Energy, HSLU
- Head of Research Thermal Grids, HSLU
- Member of the Board of the Swiss Association for Thermal Grids
- Head of Research Group, Competence Center for Thermal Energy Storage, HSLU (2017-2023)
- Senior Development Engineer, Flow Products (UK, 2015-2017)
- Postdoc, Laboratory for Solar Technology, Paul Scherrer Institute (2013-2015)

Las Mujeres en los Distritos Térmicos

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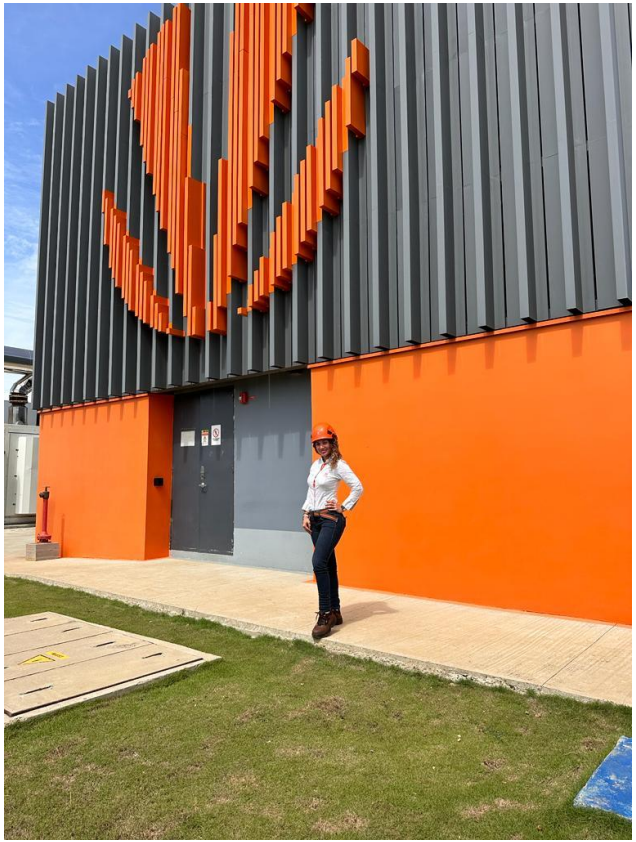

MARJORIE JIMÉNEZ

Líder de Operaciones CNC del Mar

#DTenColombia
#LaIgualdadDeGéneroEsConmigo

Climate Change is Real

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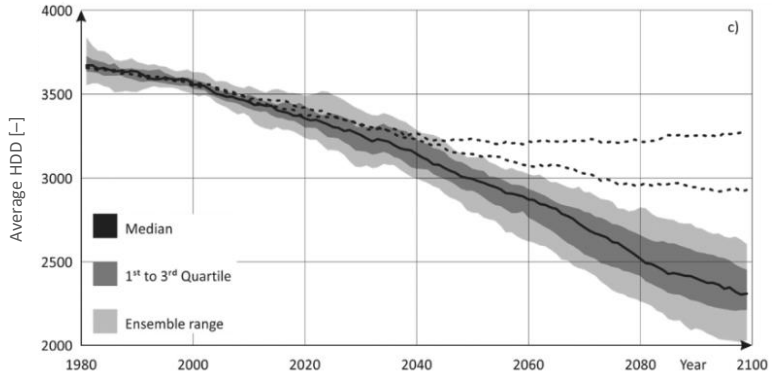
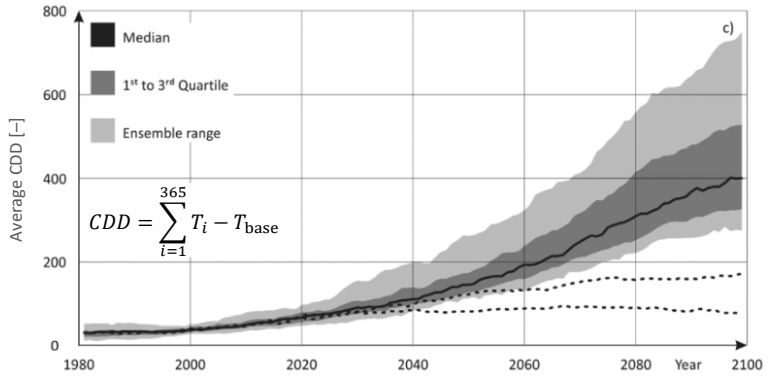
Average Heating Degree Days (HDD) in Switzerland

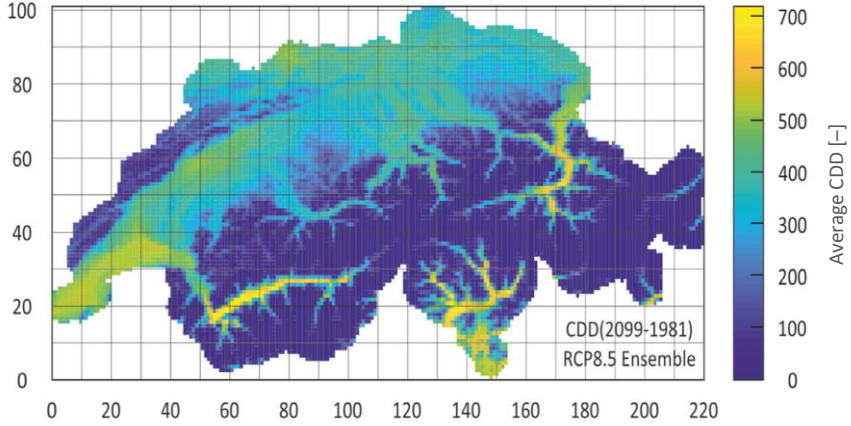


$$HDD = \sum_{i=1}^{365} T_{\text{base}} - T_i \qquad T_i = \frac{T_{i,max} + T_{i,min}}{2}$$

Average Cooling Degree Days (CDD) in Switzerland

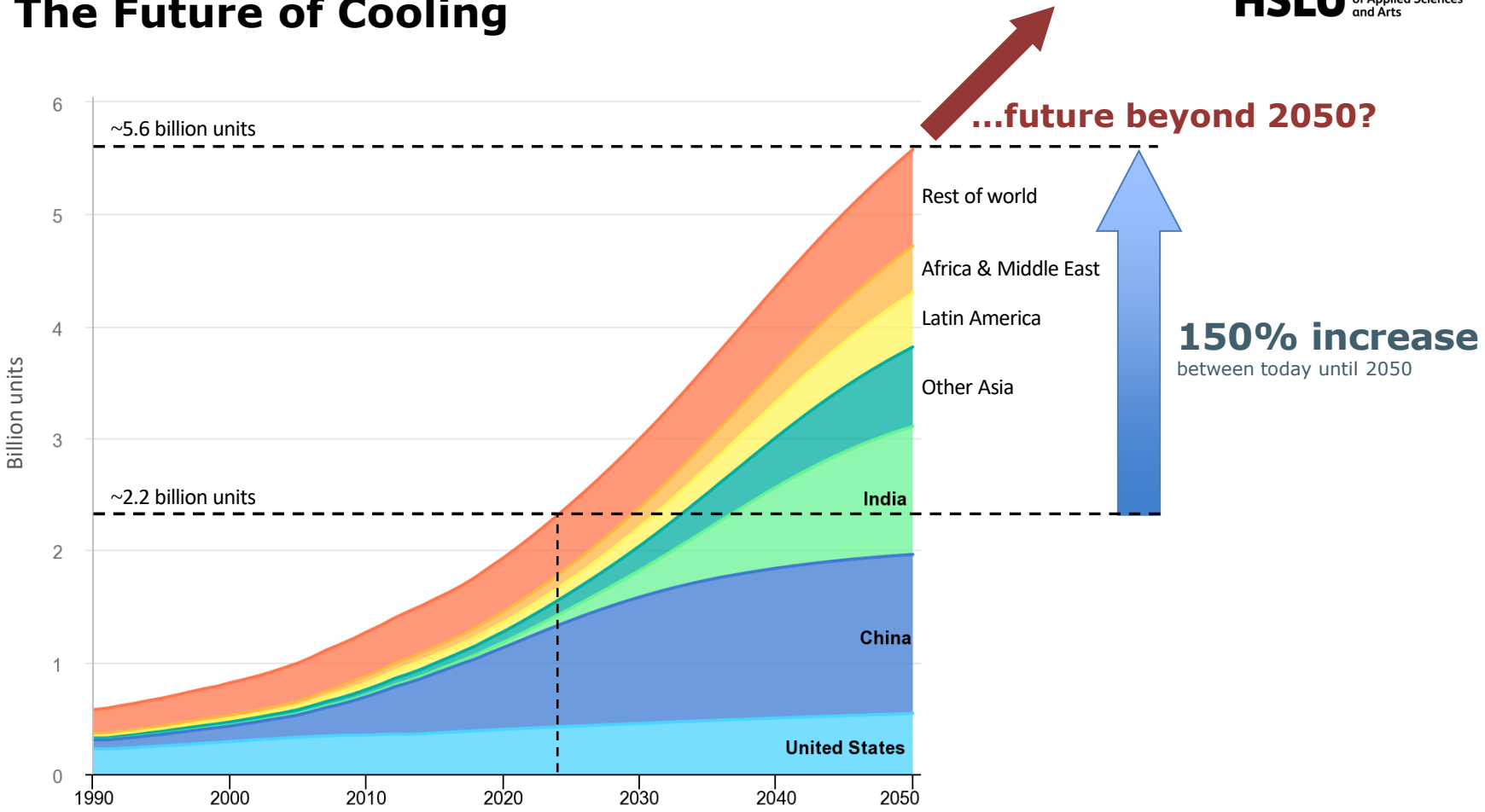


Increase in CDD in Switzerland until 2100



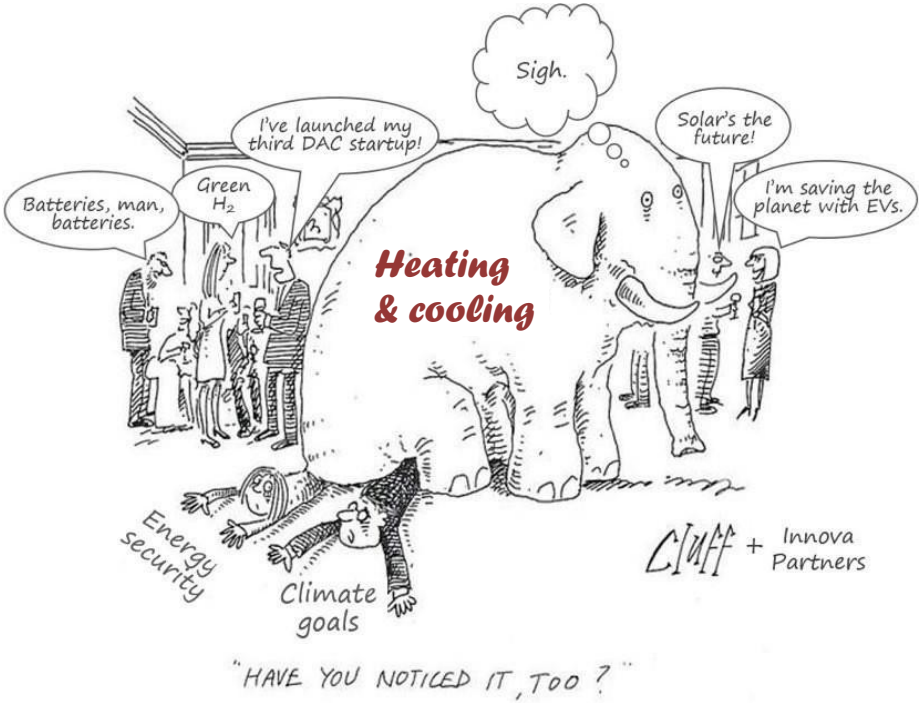
Source: Berger M, Worlitschek J, *The link between climate and thermal energy demand on national level: A case study on Switzerland*, Energy and Buildings (2019)

The Future of Cooling



Source: IEA, Global air conditioner stock, 1990-2050, IEA, Paris https://www.iea.org/data-and-statistics/charts/growth-in-global-air-conditioner-stock-1990-2050.

The Elephant in the Room…

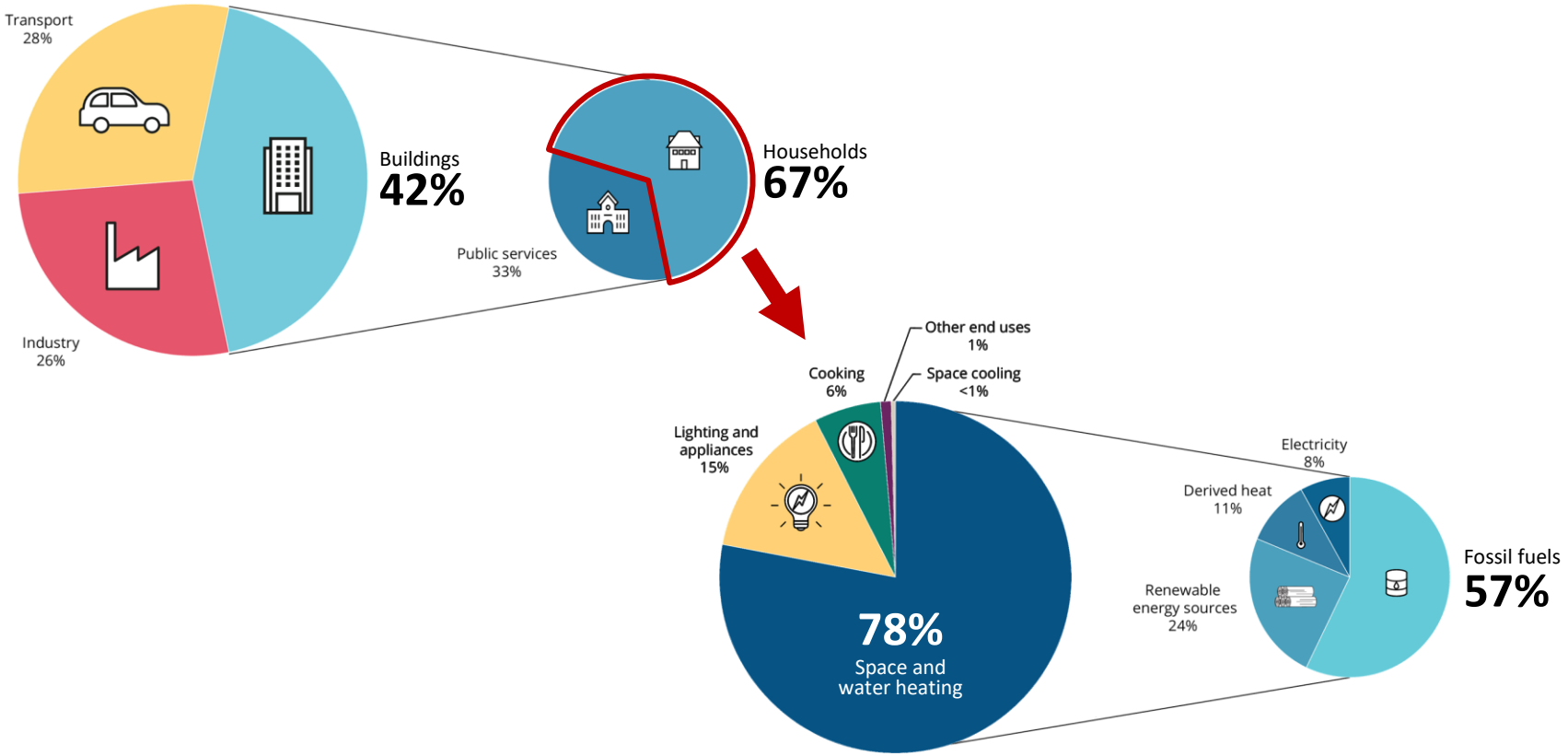


Energy consumption for
heating & cooling

50%

Heating and Cooling in Europe

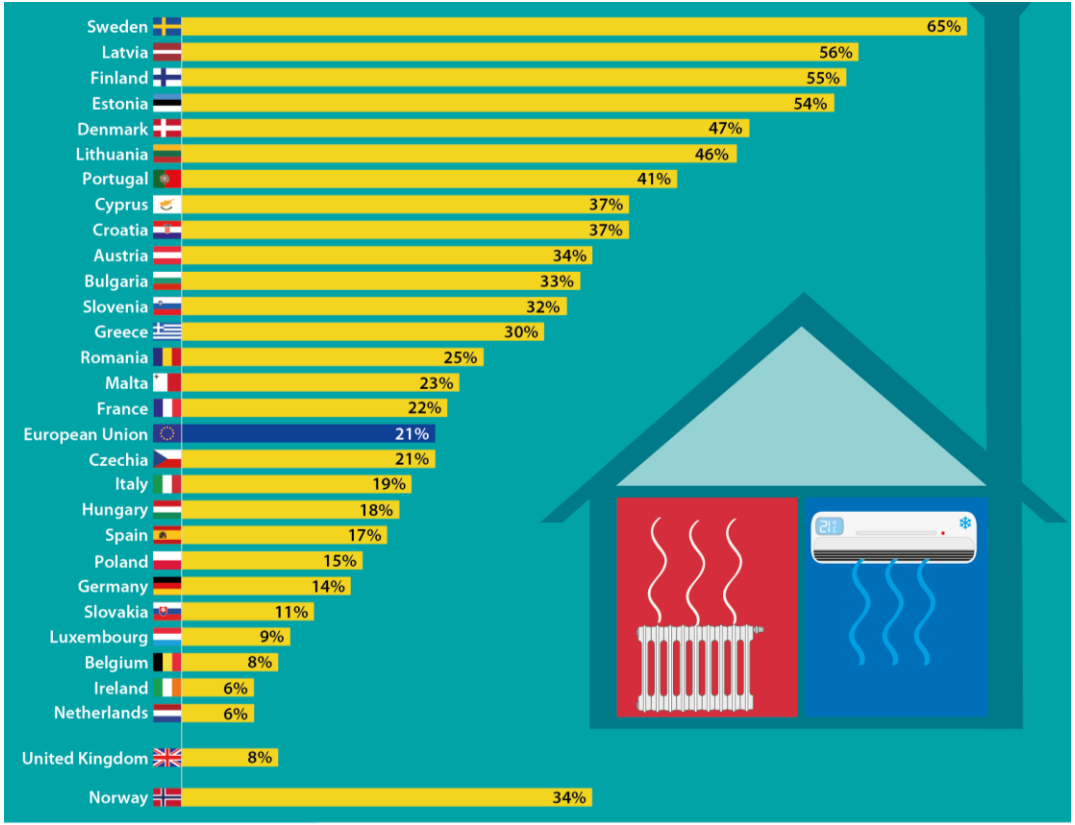
…and its reliance on fossil fuels



Source: European Environment Agency, *Decarbonising heating and cooling – a climate imperative*, doi: 10.2800/515288 (2023)

Heating and Cooling in Europe

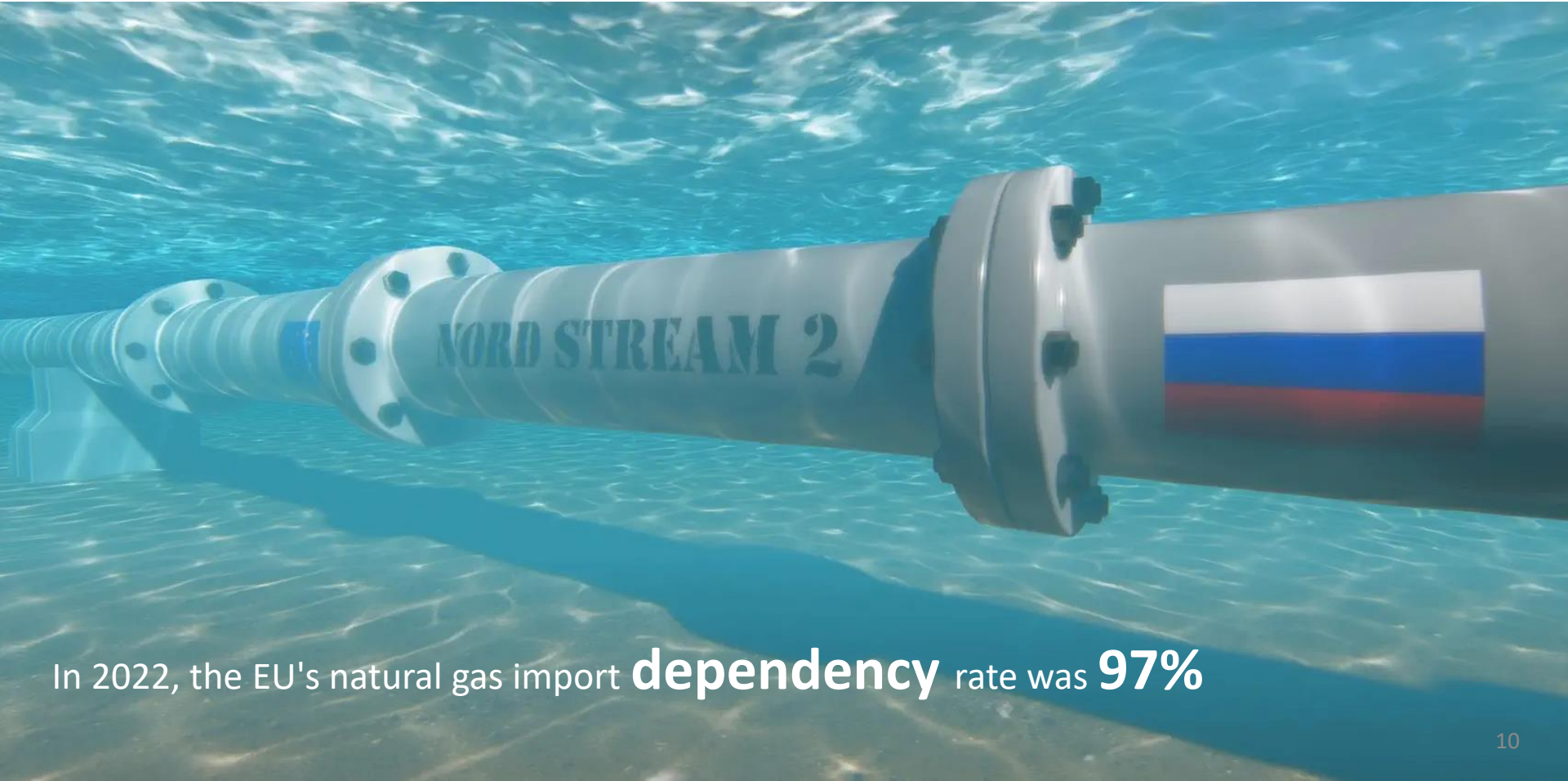
Share of renewable energy per country



27%

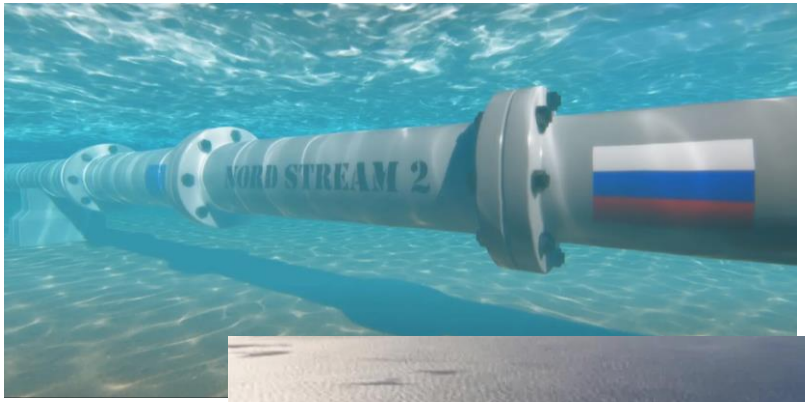
ec.europa.eu/eurostat

Europe’s Problem with Natural Gas



In 2022, the EU's natural gas import **dependency** rate was **97%**

Europe’s Problem with Natural Gas



Gas markets are becoming ‘extremely difficult’ to predict. It’s a big problem for Europe this winter

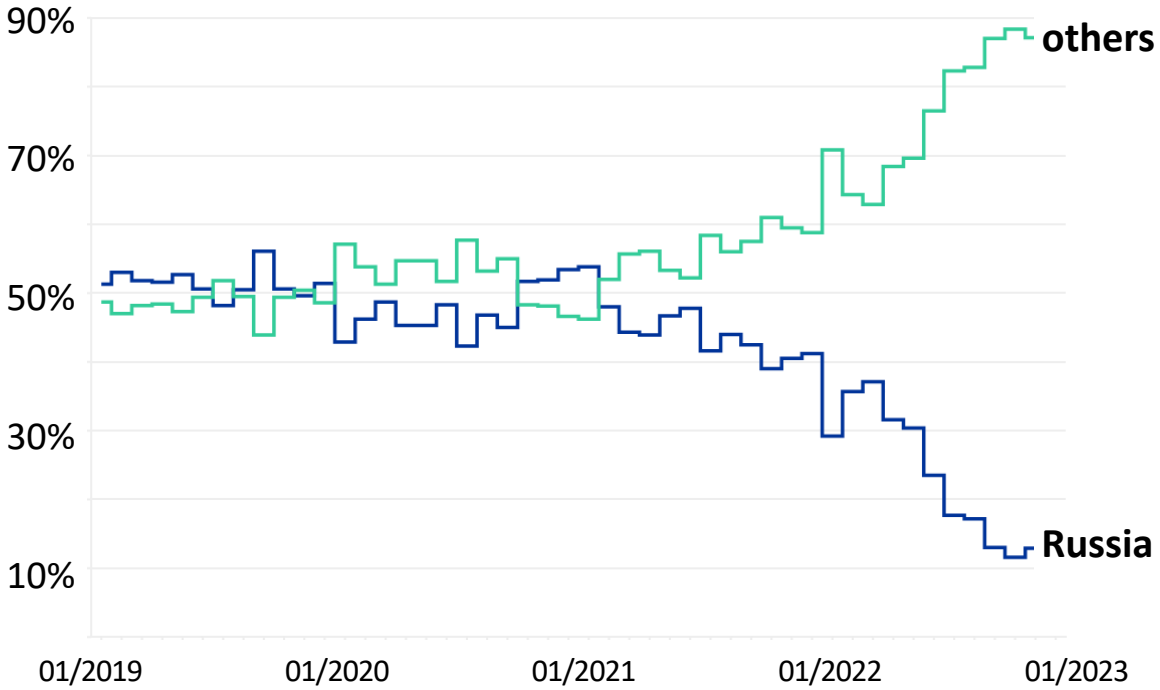
PUBLISHED TUE, SEP 12 2023•3:43 AM EDT | UPDATED TUE, SEP 12 2023•4:50 AM EDT

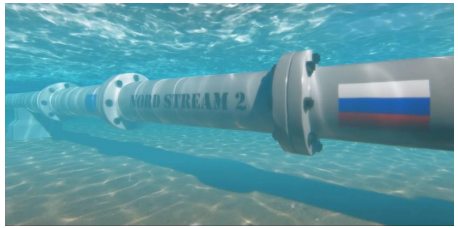
Price of Natural Gas (EU Dutch TTF)

source: tradingeconomics.com

EU's diversification away from Russian gas

Great, but still does not solve the problem…

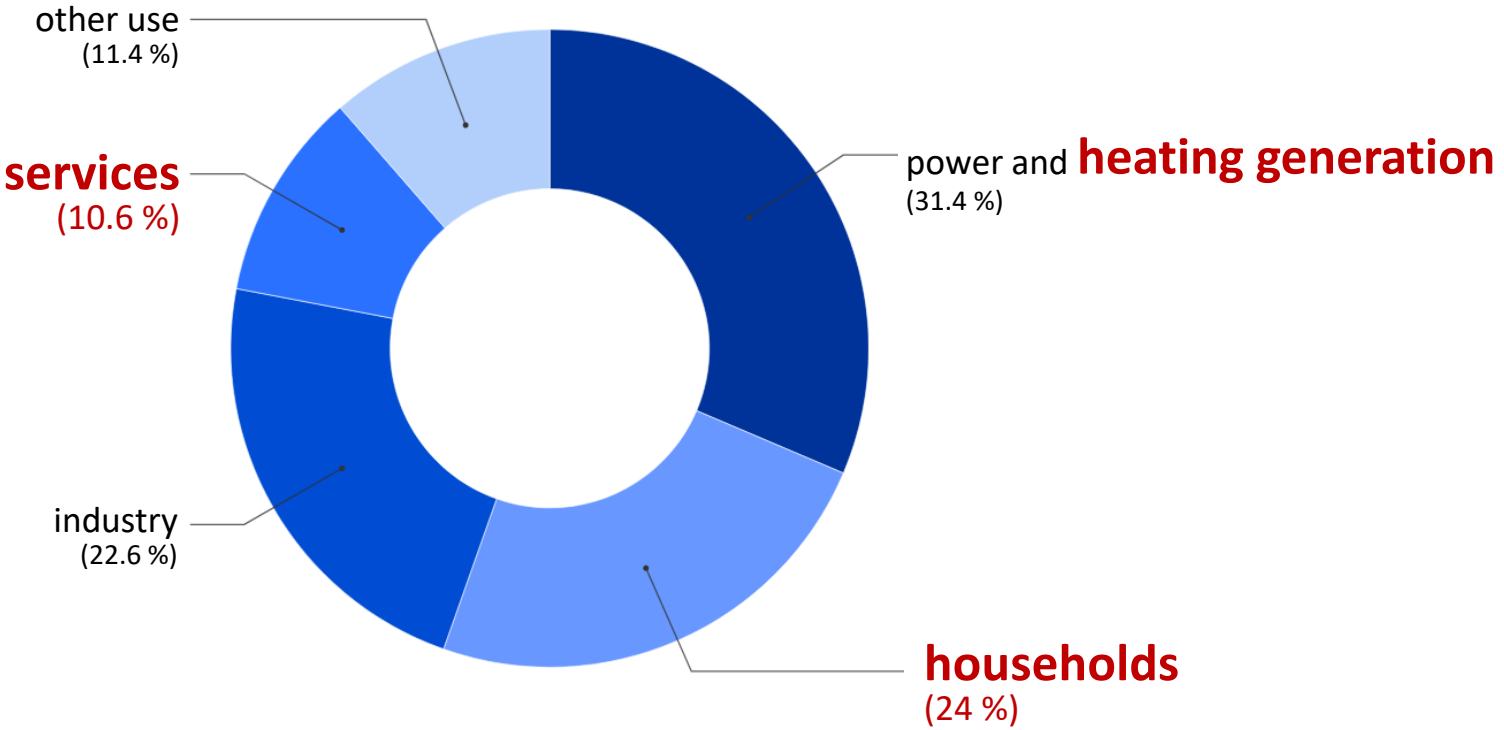




Source: European Commission (https://www.consilium.europa.eu/en/infographics/eu-gas-supply)

Gas Consumption in Europe

How do we use gas for?



Source: Eurostat (https://www.consilium.europa.eu/en/infographics/eu-gas-supply/)

Gas Consumption in Europe

Do we really need it?

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Resource
1950°C

not so smart…
(at least thermodynamically speaking ☺)

Massive exergy destruction

Demand
60°C

Space heating

Domestic hot water

Take-aways:

- Think first on the demand
- Think on exergy efficiency

Energy Strategy Switzerland 2050
Options for a carbon-neutral energy system

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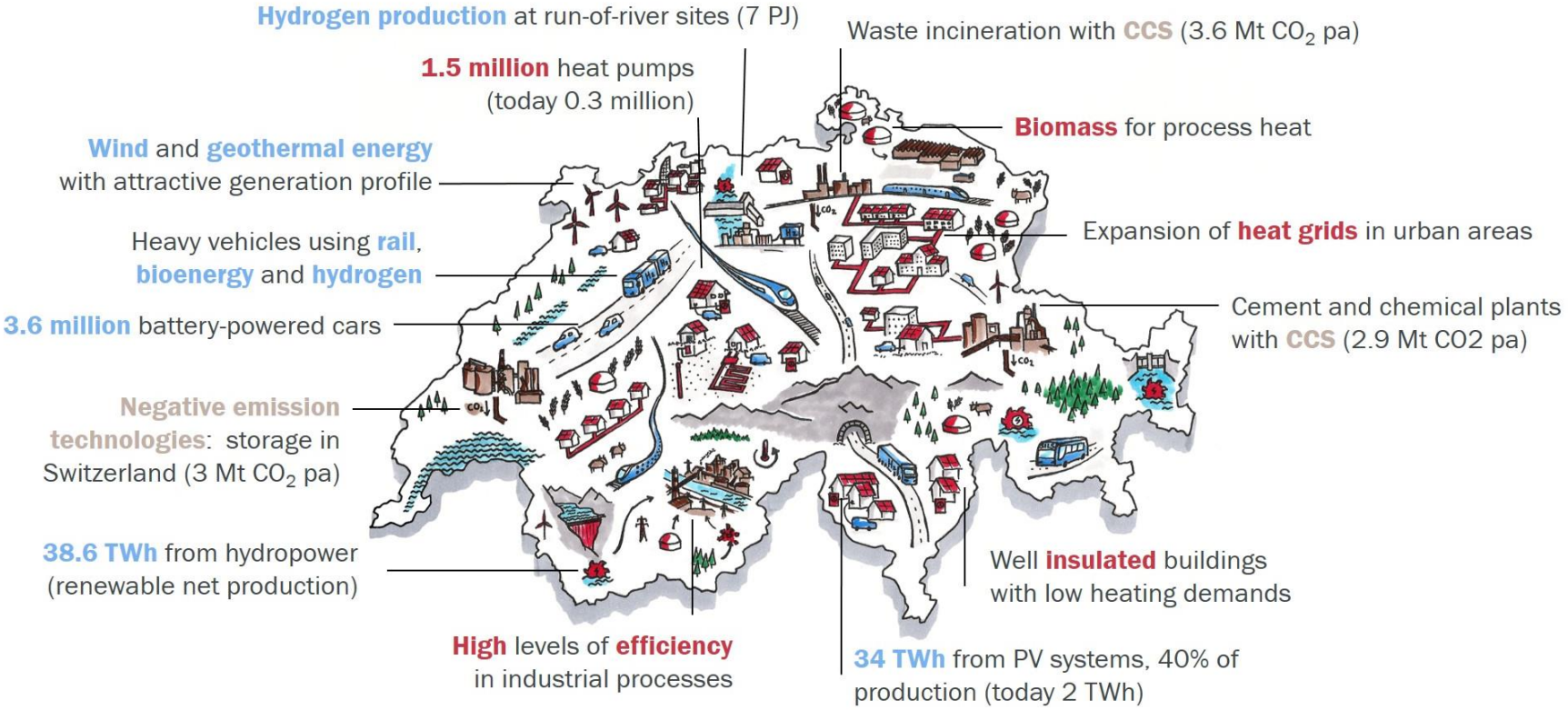

Potential of renewable heat sources in Switzerland
The importance of thermal grids

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Potentials of renewable heat sources in Switzerland (TWh)

Heat source	Available	S1	S2	S3	S4
Waste to energy	2.3	2.3	2.3	2.3	2.3
Waste water treatment plants	2.6	2.5	2.5	2.5	2.5
Lakes	134.3	13.6	0.6	0.7	0.7
Rivers	9.4	7.4	9.2	0.6	0.7
Ground water	4.7	3.4	3.7	4.6	1.1
Geothermal	72.9	8.2	19.1	27.2	30.9
Others		4.9	4.9	4.6	4.2

Scenario S1 favors lakes
Scenarios S2-S4 favor geothermal

Exploiting these potentials is **strongly dependent on thermal grids!**

Source: Jakob M, Reiter U, et al. *Erneuerbare- und CO2-freie Wärmeversorgung Schweiz* (2020)

Many renewables but which one to choose?
The key role of strategic energy planning

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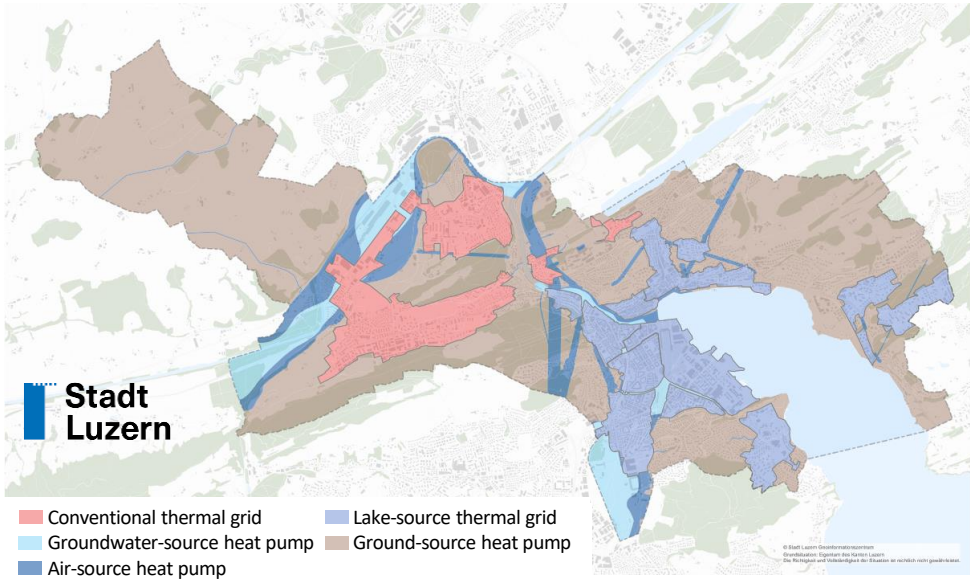
- Development of thermal grids **requires a vision → local energy plan**
- **Local governments** play a key role:
  - Provide guidance for prioritization of renewables
  - Prevent individual solutions
  - Plan infrastructure accordingly

Energy Plan of the City of Lucerne



Thermal Grids in Switzerland
Current situation

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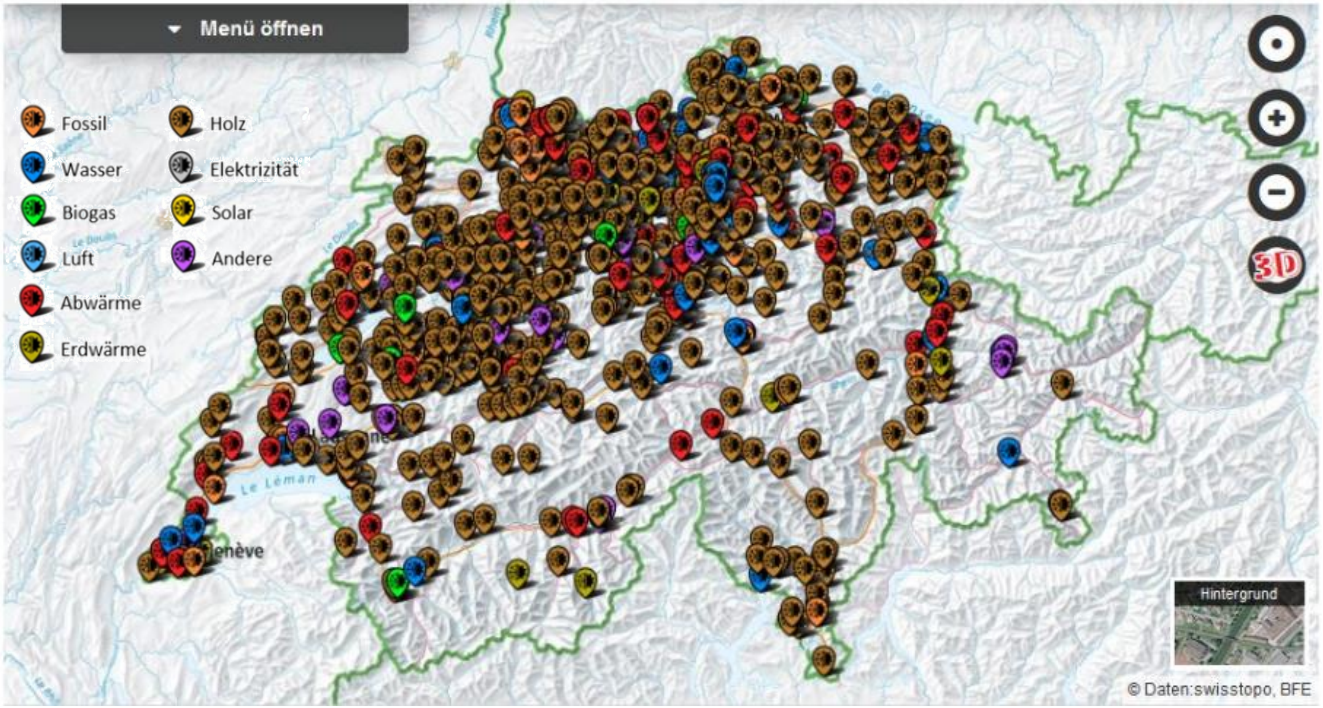
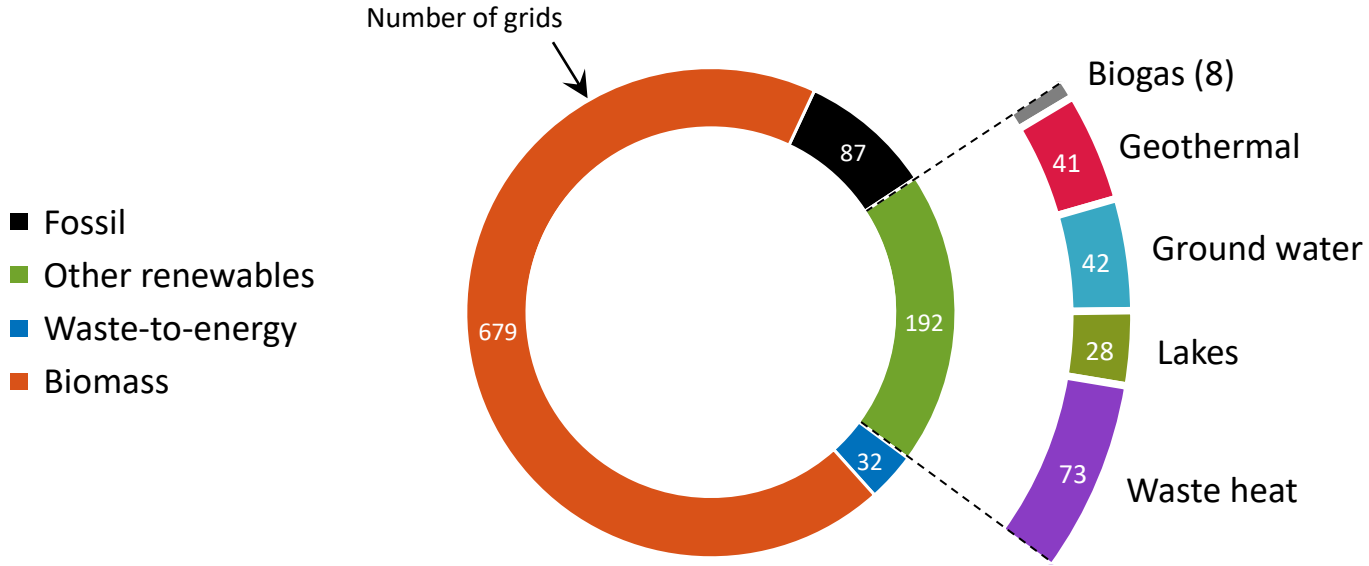
More than **1'000 thermal grids**
8.5 TWh heat per year
~1.5 billion USD annual turnover



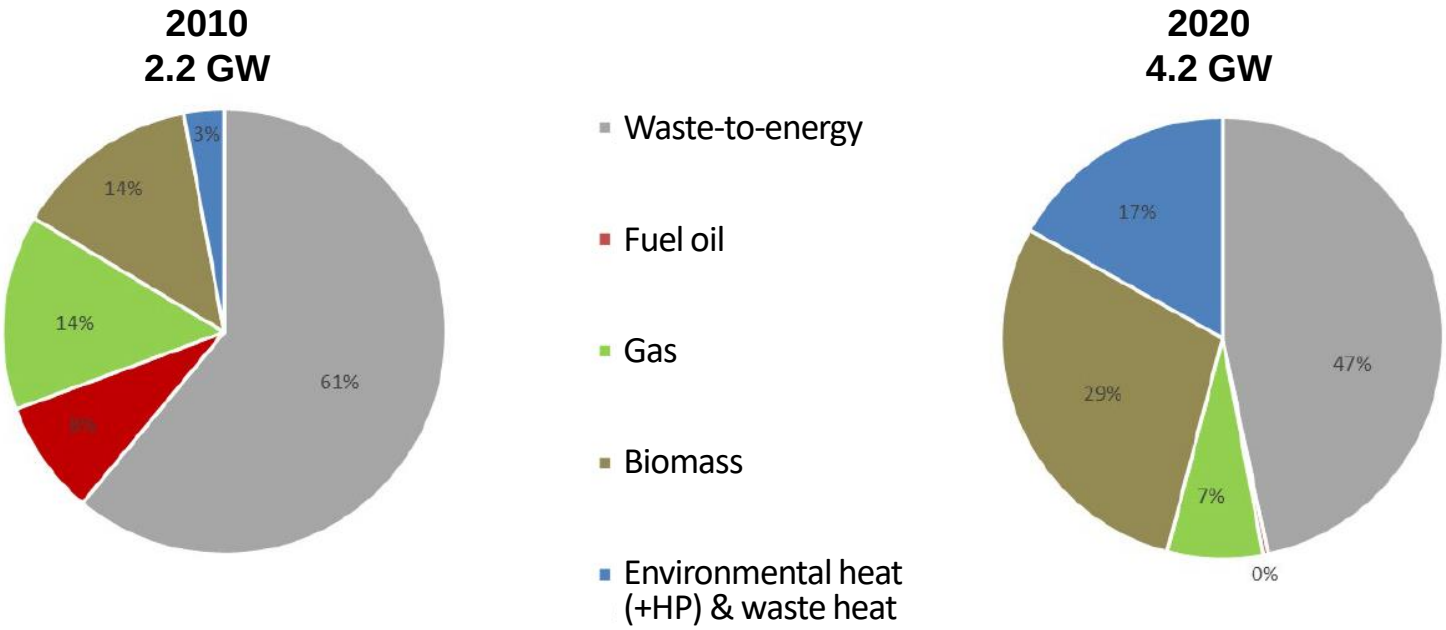
Source: Interactive map «Thermal Grids» on map.geo.admin.ch (Link)

Thermal Grids in Switzerland
Current situation



Thermal Grids in Switzerland – Past Decade Development

Installed Capacity and Energy Sources



Today: most grids in Switzerland are high temperature (>80°C). The most common heat source is waste-to-energy.

Source: Hangartner D, Ködel J, *Liste "Thermische Netze"*, Auswertungsbericht 2020.

Thermal Grids in Switzerland – Outlook 2050

Installed Capacity and Energy Sources

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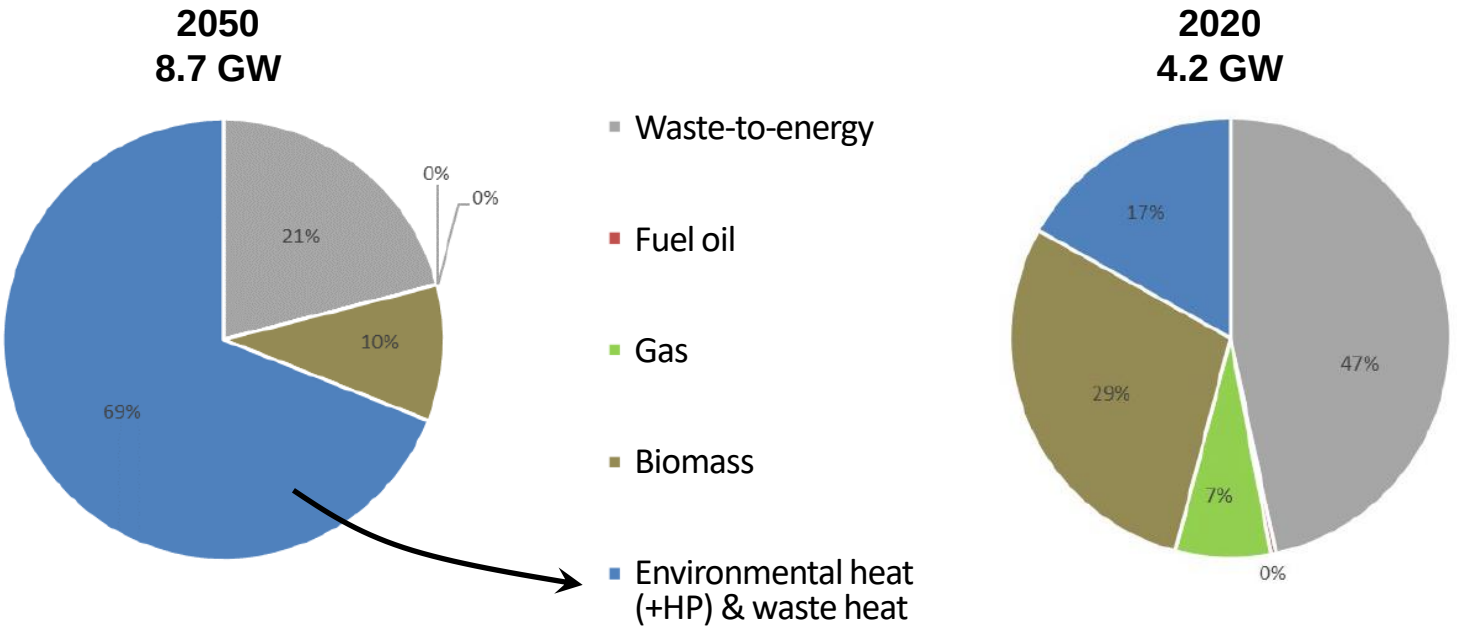
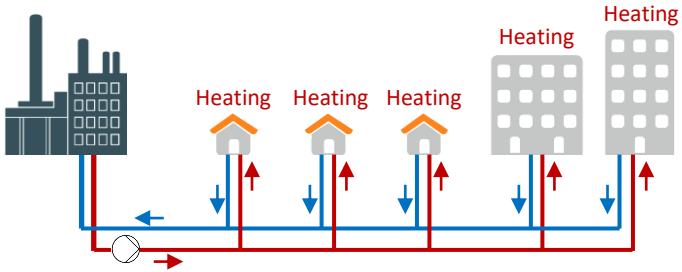


Future: trend toward low-temperature grids.
Many of them are being realized with cooling capabilities (<20°C).

Source: Hangartner D, Ködel J, *Liste "Thermische Netze"*, Auswertungsbericht 2020.

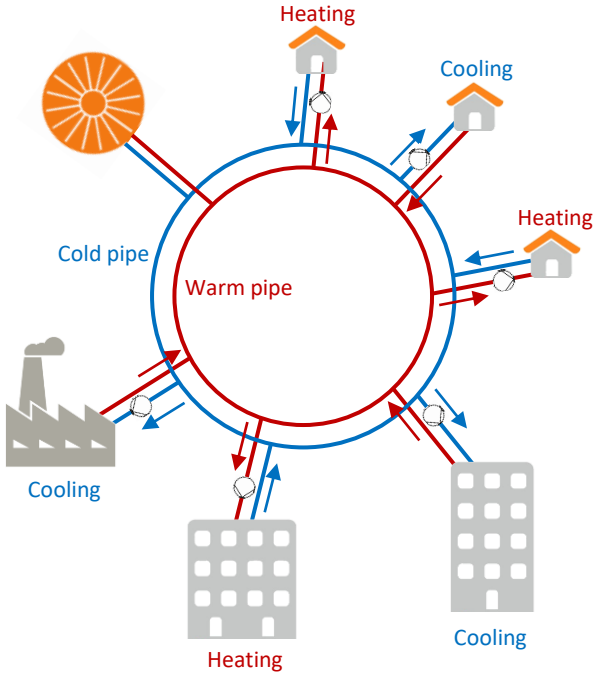
Thermal Grids
Navigating current and future typologies

Traditional grids



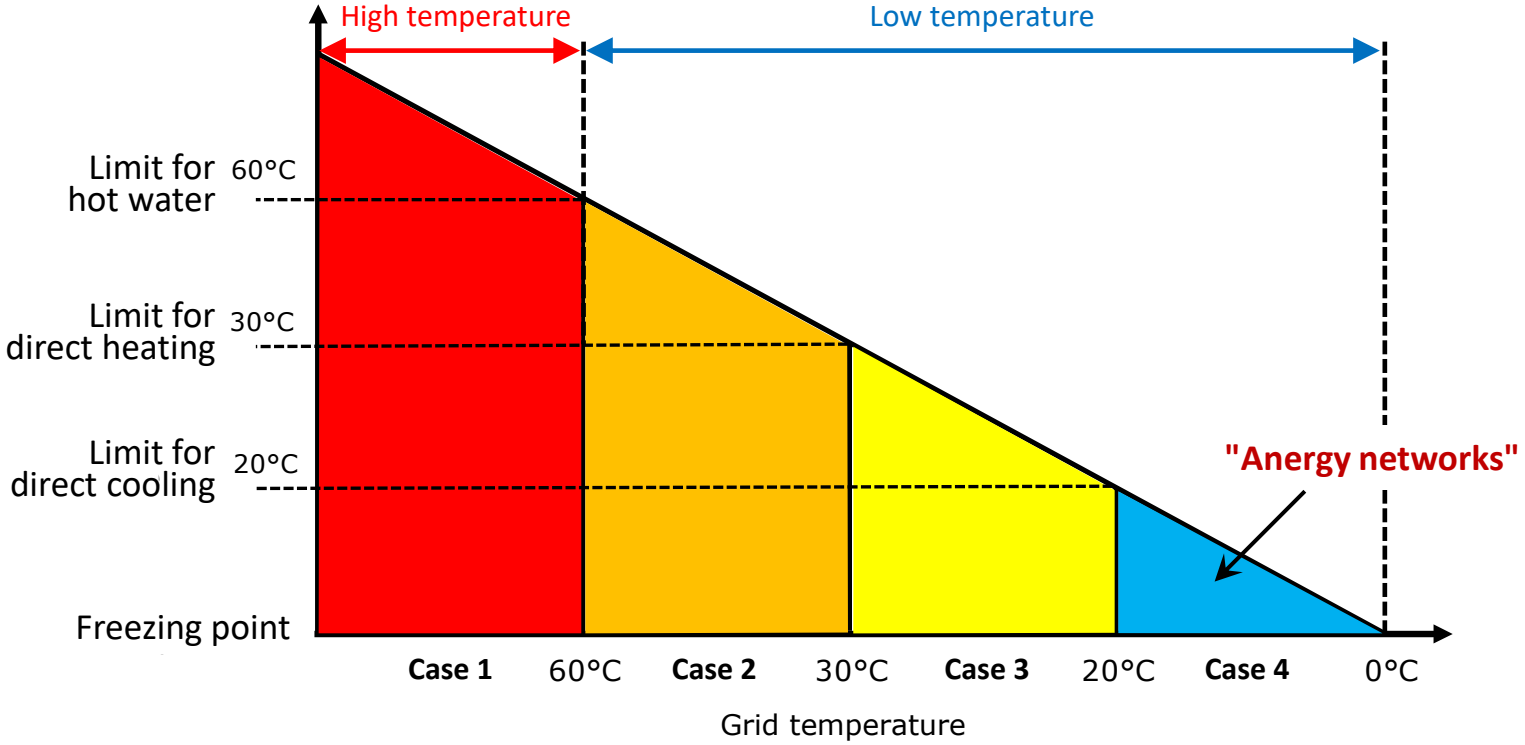
High-temperature grids,
directed flow, unidirectional

Last generation grids



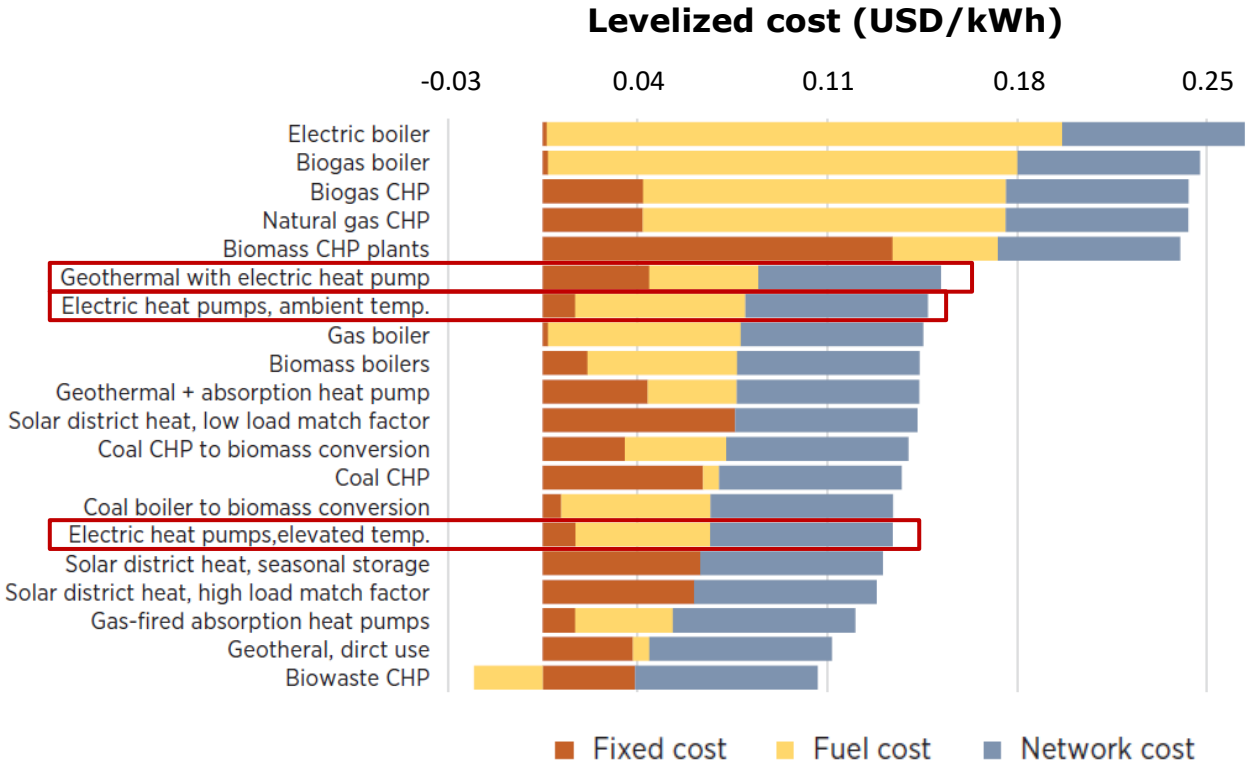
Low-temperature grids,
undirected flow, bidirectional

Thermal Grids
Temperature classification



Source: Nussbaumer T, Thalmann S, Hurni A, Mennel S, '*Faktenblatt Thermische Netze*', EnergieSchweiz (2021)

The Cost of Heat
Technologies comparison



Source: IRENA, Renewable Energy in District Heating and Cooling: A Sector Roadmap for REmap, International Renewable Energy Agency (2017)

Geothermal with Electric Heat Pumps

The "Anergy Network" in Suurstoffi

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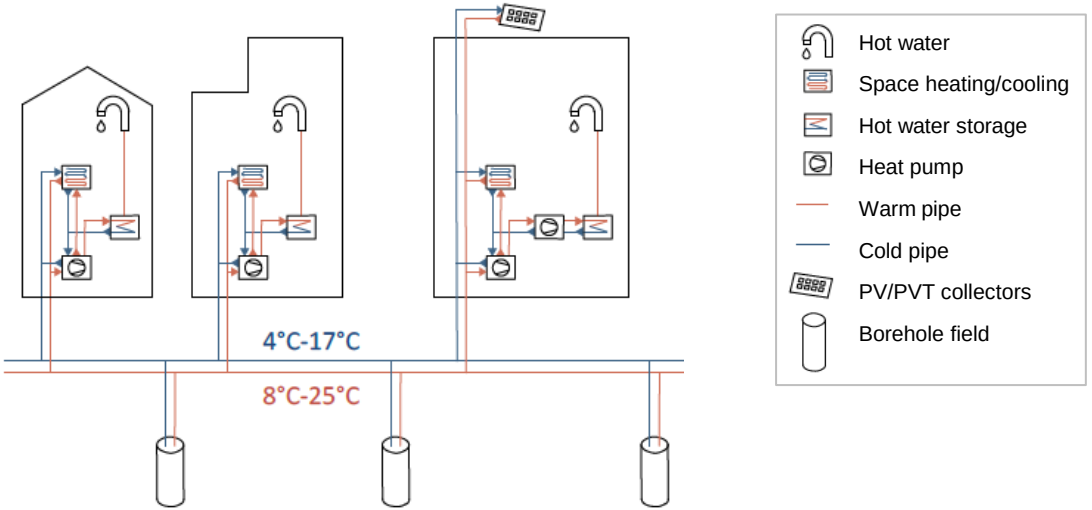
Geothermal with Electric Heat Pumps

The "Anergy Network" in Suurstoffi

Borehole thermal energy storage (BTES): heating + cooling
Storage regeneration: **waste heat** (from buildings) **+ PVT collectors**

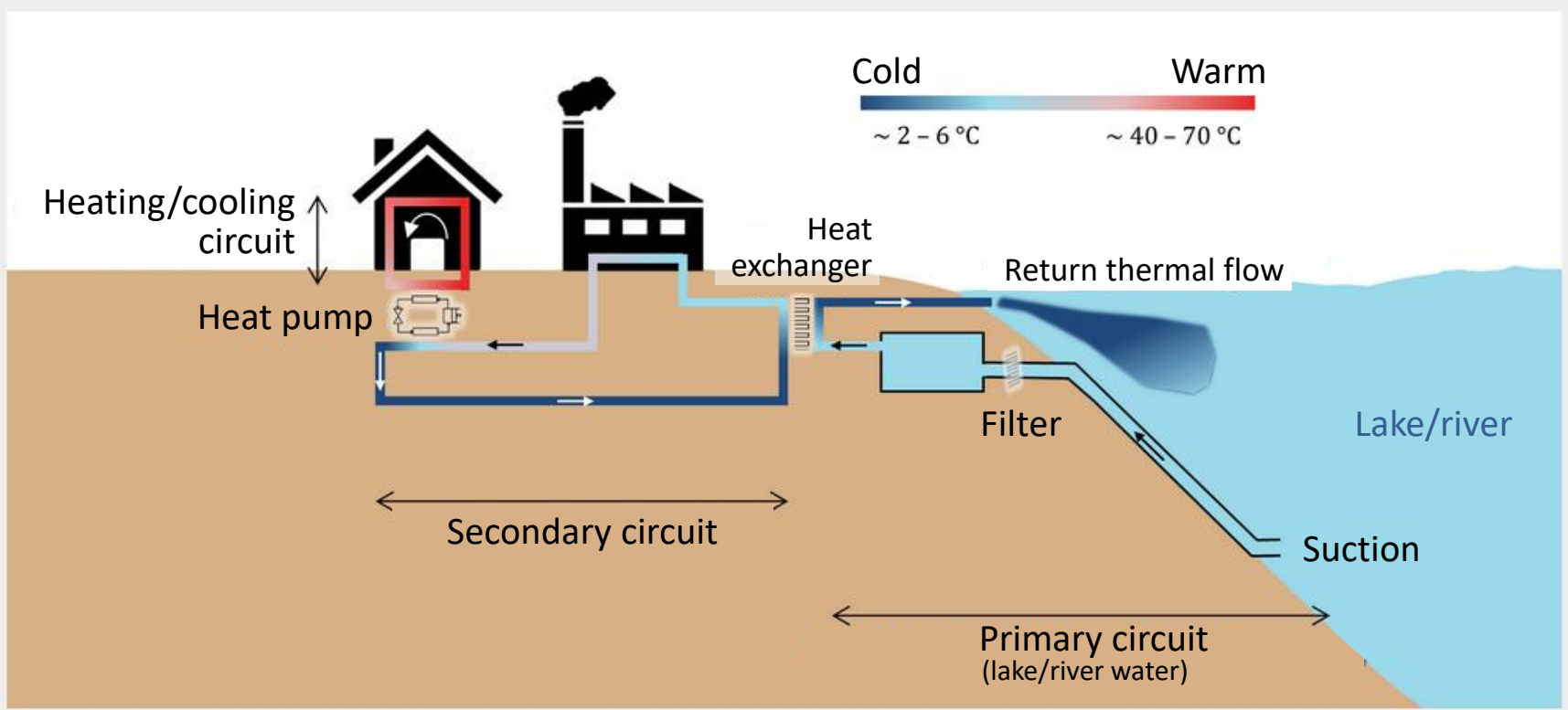
Heated surface area: ~170'000 m²
Heating demand: 10.6 GWh/a
Cooling demand: 2.4 GWh/a

BTES: ~**400 boreholes** (4.7 GWh/a)
PVT: ~9'500 m²
PV: ~2'500 m²



Water-source Heat Pumps

Using lakes and rivers as heat sources



Water-source Heat Pumps
GeniLac grid in Geneva

Water-source Heat Pumps
GeniLac grid in Geneva

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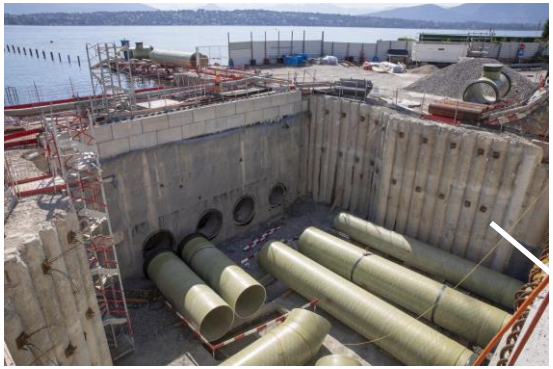

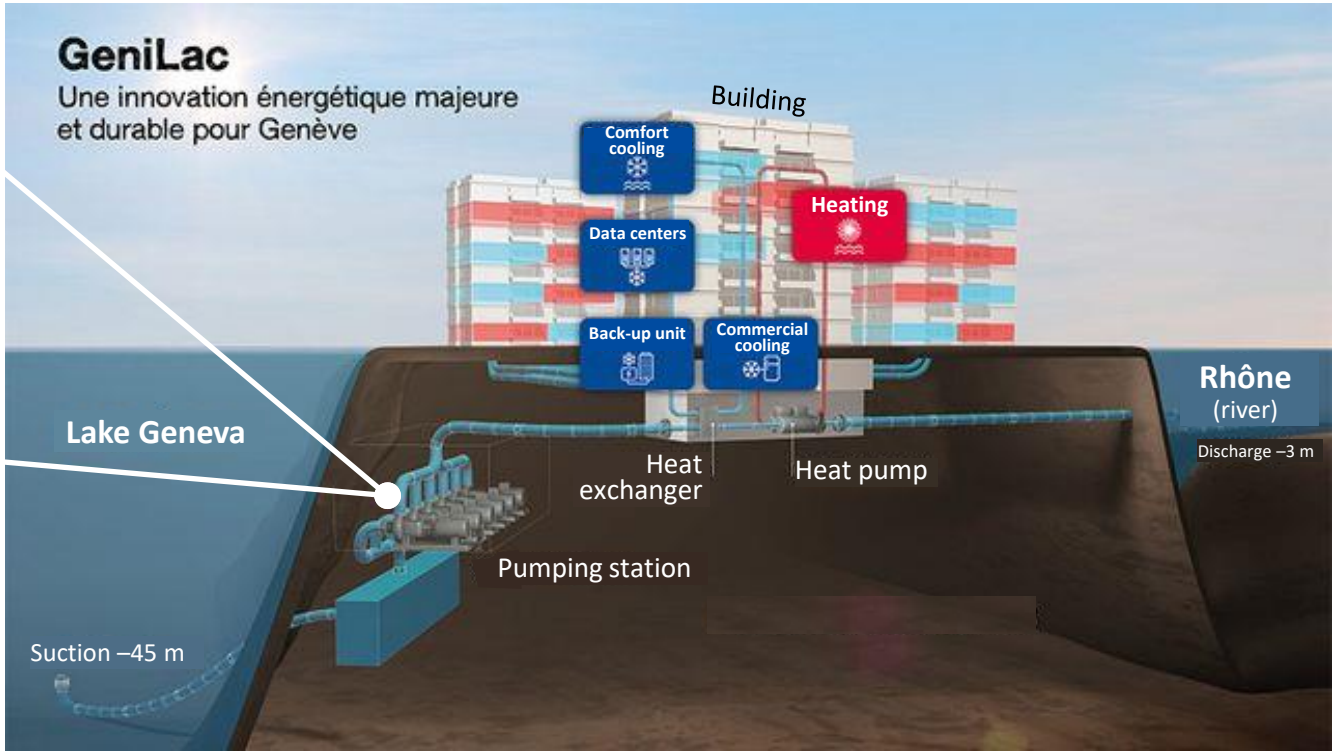

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RECHENZENTRUM
OSTSCHWEIZ

Berg-Käserei Gais

Waste heat revalorization

The high-tech data center in Eastern Switzerland

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RECHENZENTRUM
OSTSCHWEIZ

Waste heat revalorization

From waste heat to cheese

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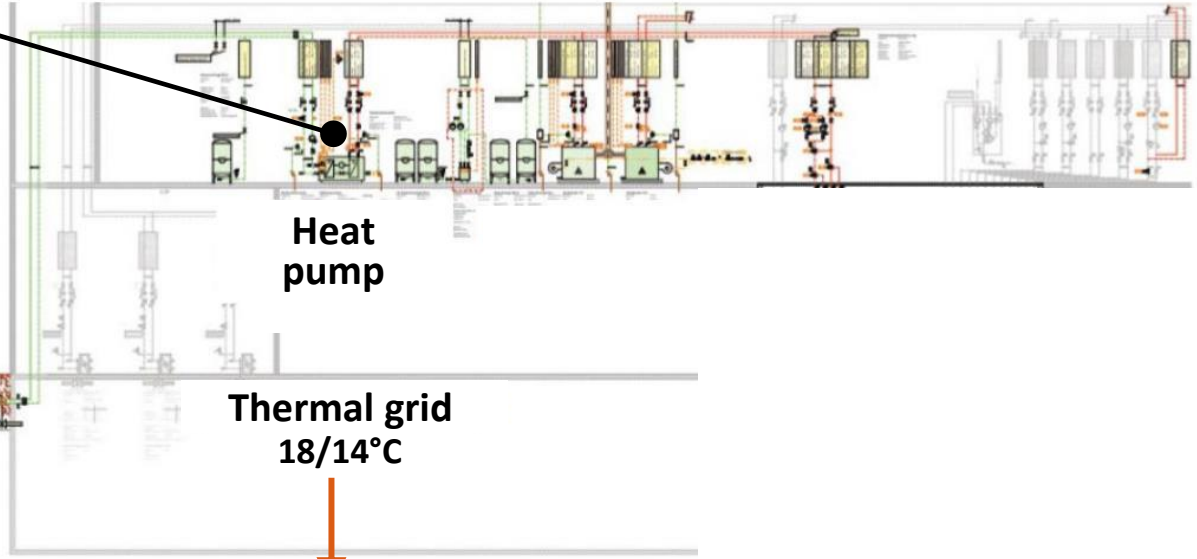
Heat pump
Thermal power: ~520 kW
2-stage screw compressor

Gas boilers
(620 kW + 220 kW)

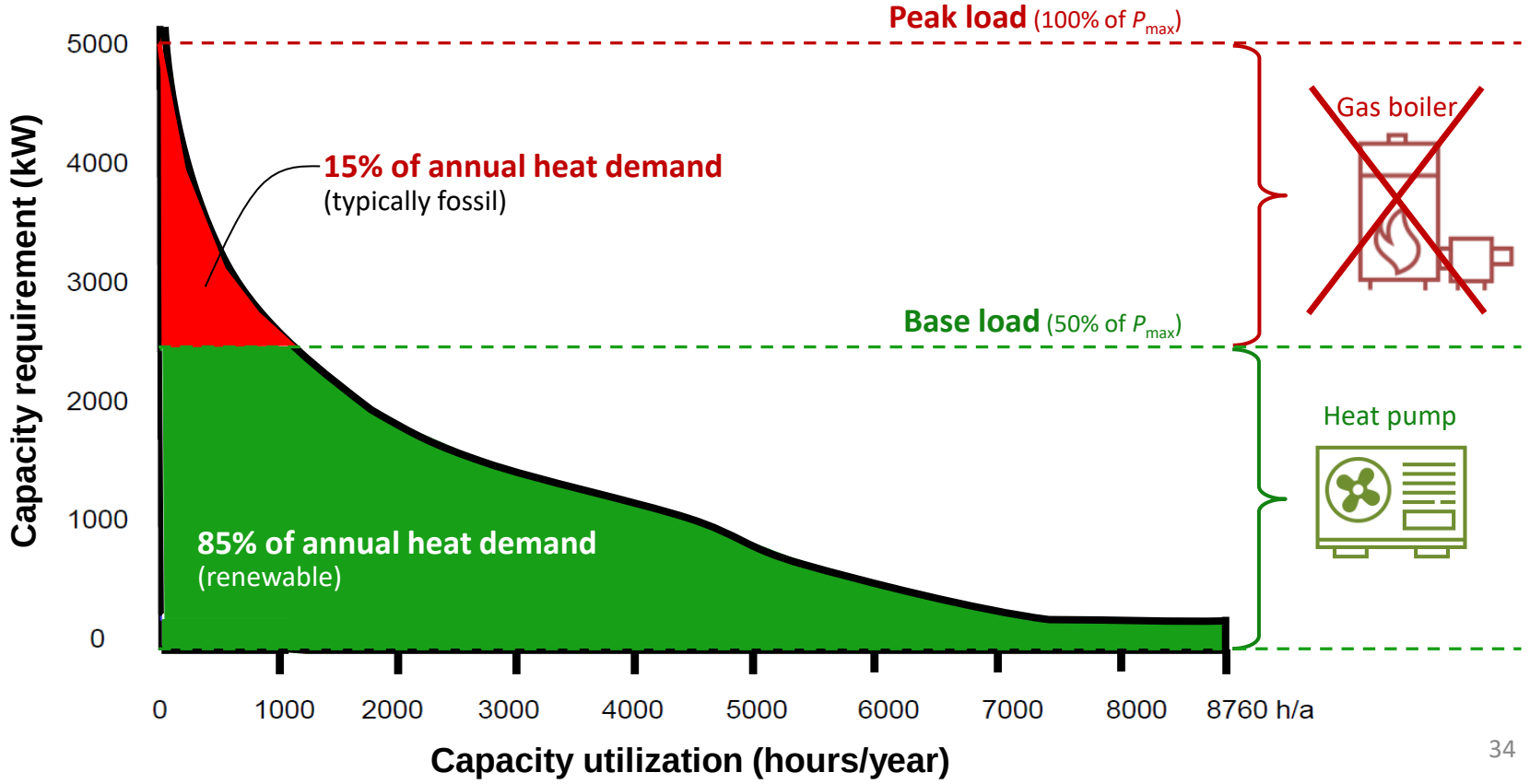


PV production: 230 MWh/a
Waste heat: 1.5 MW (~20°C)

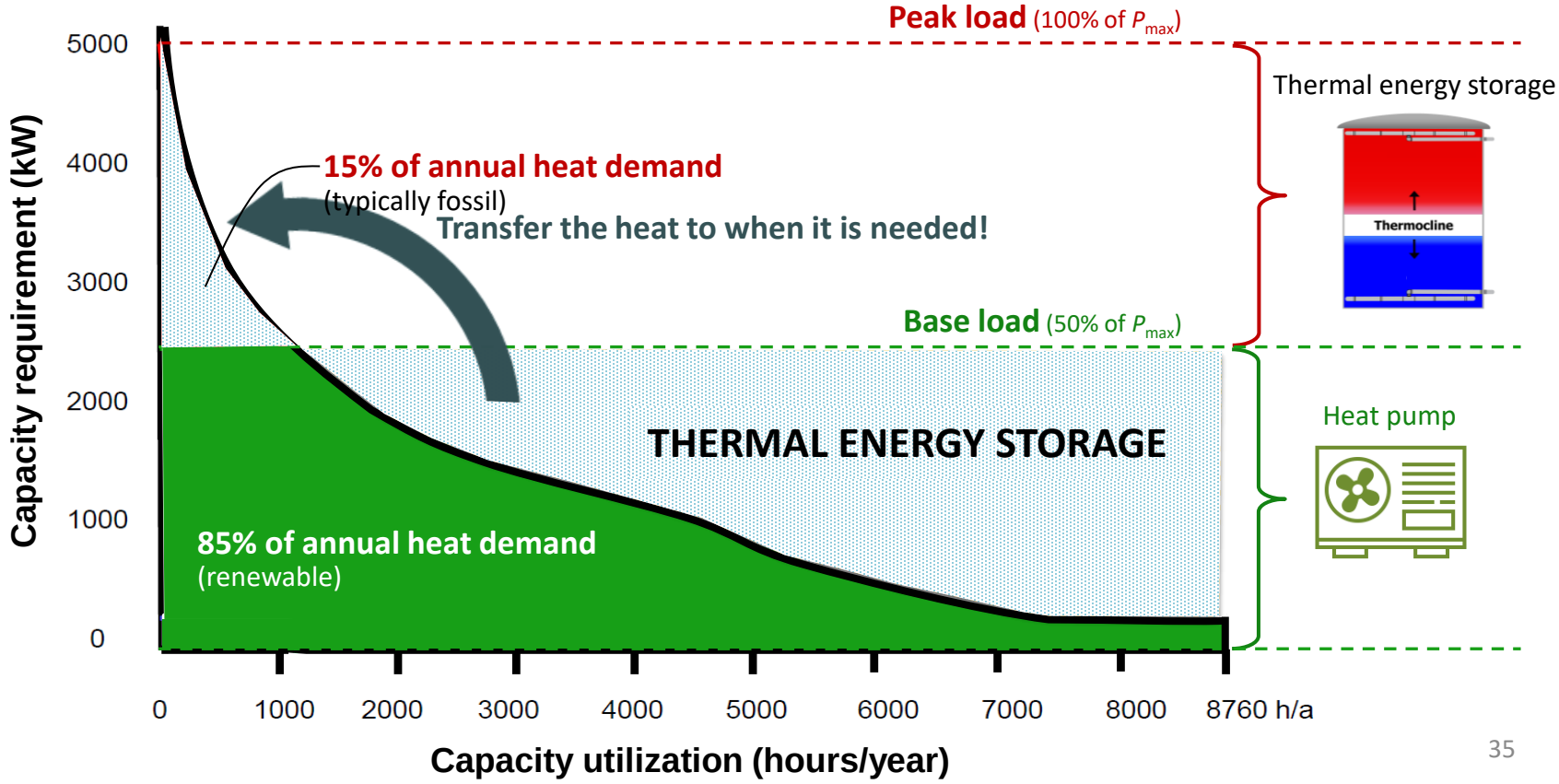
Cheesy diary
+150 households

Low-temp heat → households
Medium-temp heat → cheese factory
→ exergy efficient!

The Ultimate Challenge
Decarbonizing the peak load



The Ultimate Challenge
Decarbonizing the peak load



Take-aways

- **Thermal grids** are key to exploit renewable energy resources
- (Local) government plays a key role → strategic **energy planning**
- Think on **eXergy** efficiency
- Don’t forget **thermal energy storage**!

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Thank you!

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