# Towards a Net-Zero Future: The vital role of geothermal and solar thermal in providing sustainable cooling solutions

## Cooling technologies and key aspects for future systems

Reuven Paitazoglou
15.05.2023

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# Towards a Net-Zero Future:
# The vital role of geothermal and solar thermal in providing sustainable cooling solutions

Fraunhofer IEG

COOLING DOWN

## Cooling technologies and key aspects for future systems

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AGENDA
1) Importance of cooling
2) Cooling technologies and key-/future aspects
3) Best-Case examples

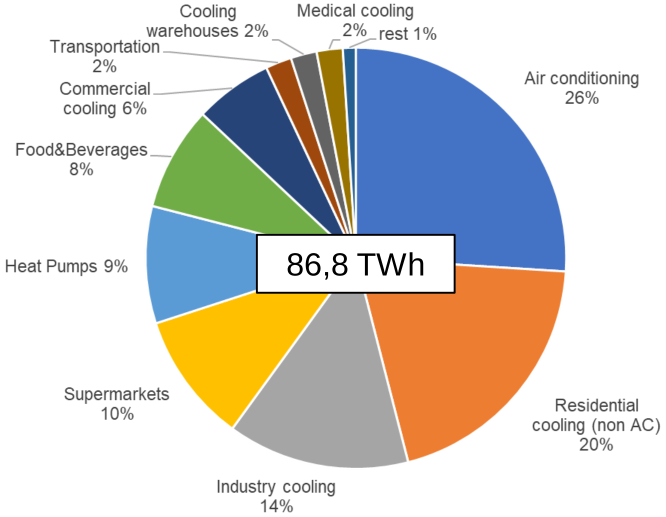
# Keep it cool

## Importance of cooling

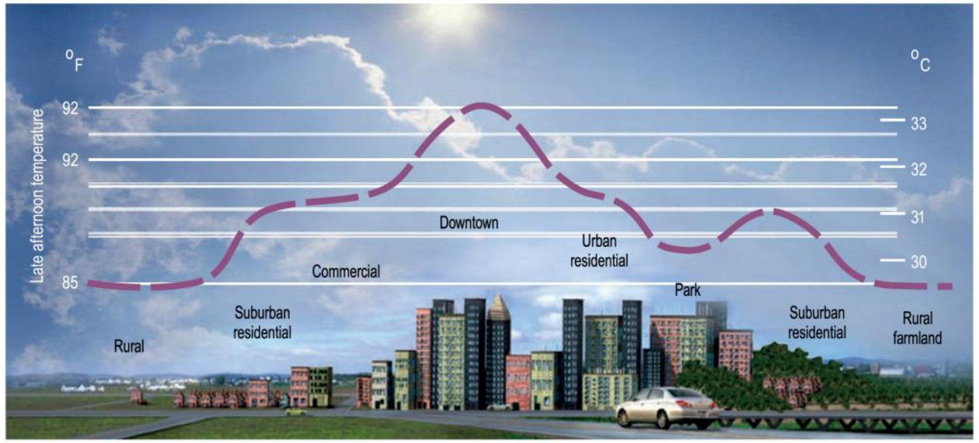
- Rapidly increasing cooling demand
- High density of people, increased comfort awareness, modern glass fronts, interior thermal loads, climatic / demographic reasons, etc.
- Refrigeration causes about 15%-20% of the global electricity consumption
- Worldwide increase of air-conditioning appliances
-   growing electricity consumption + CO2-emissions
-   growing risk of power outages at peak load

- Final energy use for space cooling (residential and commercial buildings) worldwide more than tripled between 1990 and 2016 to 2.020 TWh
- Energy used in mainly electricity

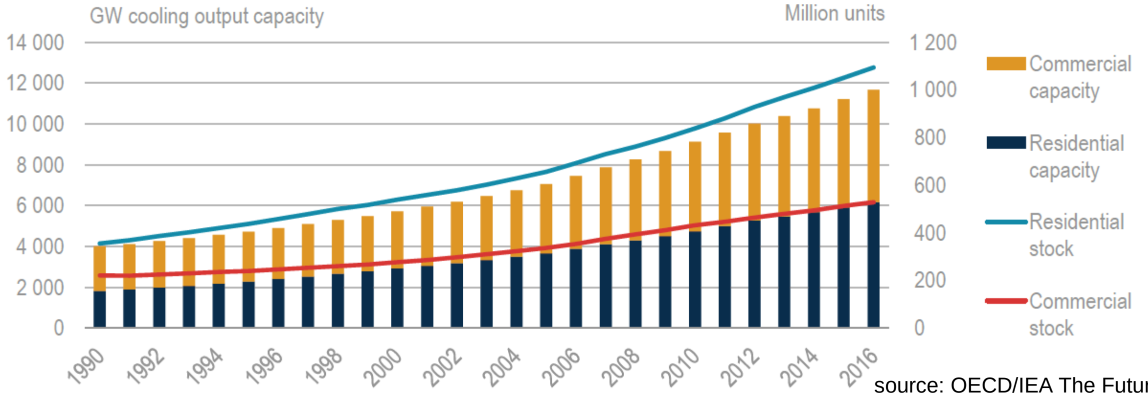
Final energy usage for cooling in Germany (2017)




source: VDMA, Energiebedarf für Kältetechnik in Deutschland, 2019 [3]



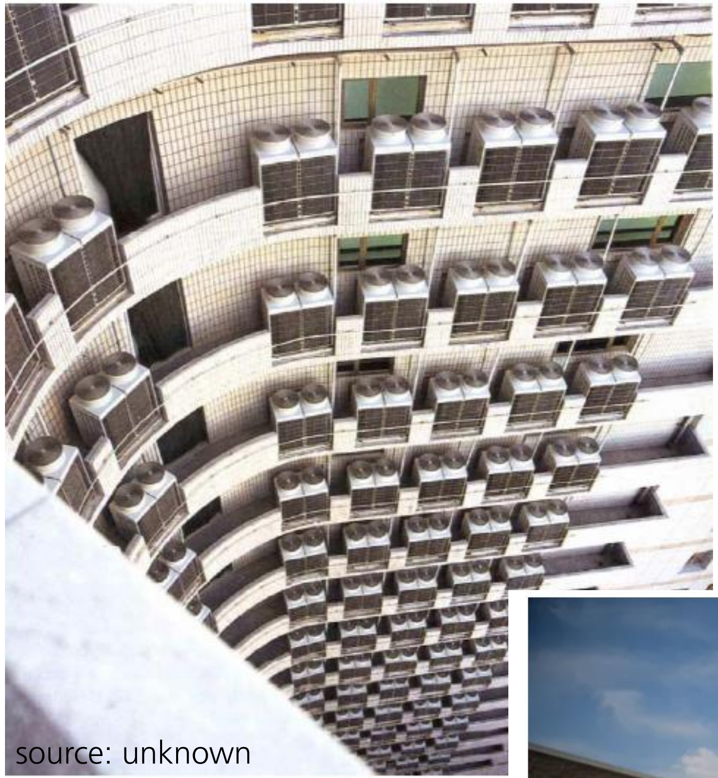

Source: Lawrence Berkeley National Laboratory, Heat Island Group, http://heatisland.lbl.gov/, 2013 [2]




source: OECD/IEA The Future of Cooling, 2018 [1]

# Keep it cool

## Power failures related to increased electricity demand



source: unknown

*A New, Deadly Risk for Cities in Summer: Power Failures During Heat Waves*

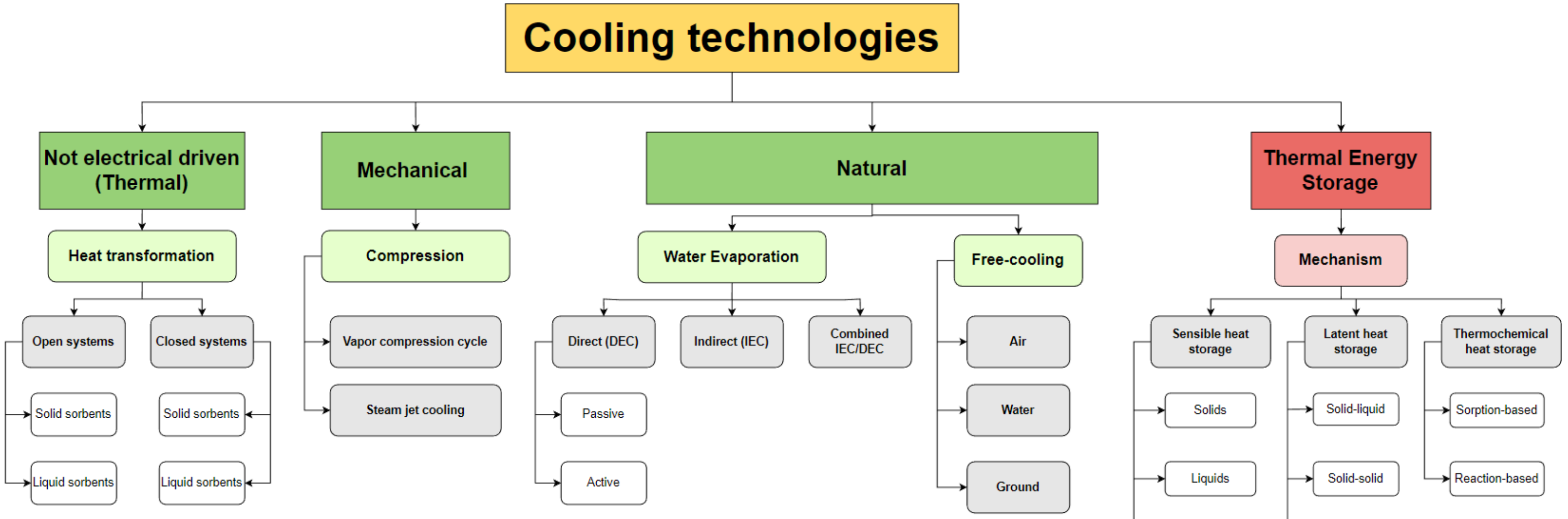
The author of a new study said the combination of blackouts and extreme heat "may be the deadliest climate-related event we can imagine."

Source: New York Times (https://www.nytimes.com/2021/05/03/climate/heat-climate-health-risks.html) [4]

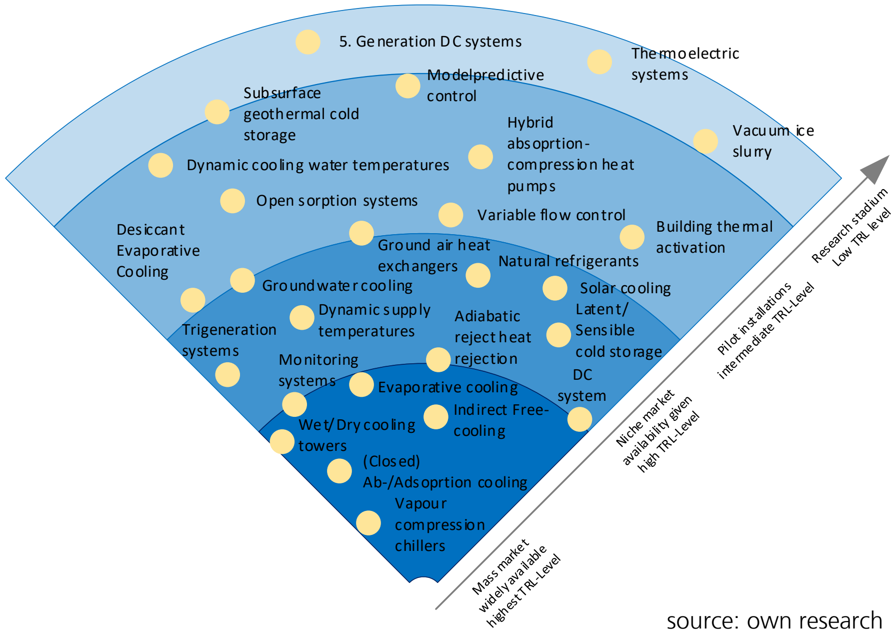

The changing climate also seems to be making power failures more common. From 2015 to 2020, the number of blackouts annually in the United States doubled, Dr. Stone said. And those blackouts were more likely to occur during the summer, suggesting they were being driven in part by high temperatures, which increase demand on the electrical grid as people turn up their air-conditioners.

# Broad spectrum of (alternative) cooling technologies

## Mapping and technological assessment of cooling technologies (incl. storage)



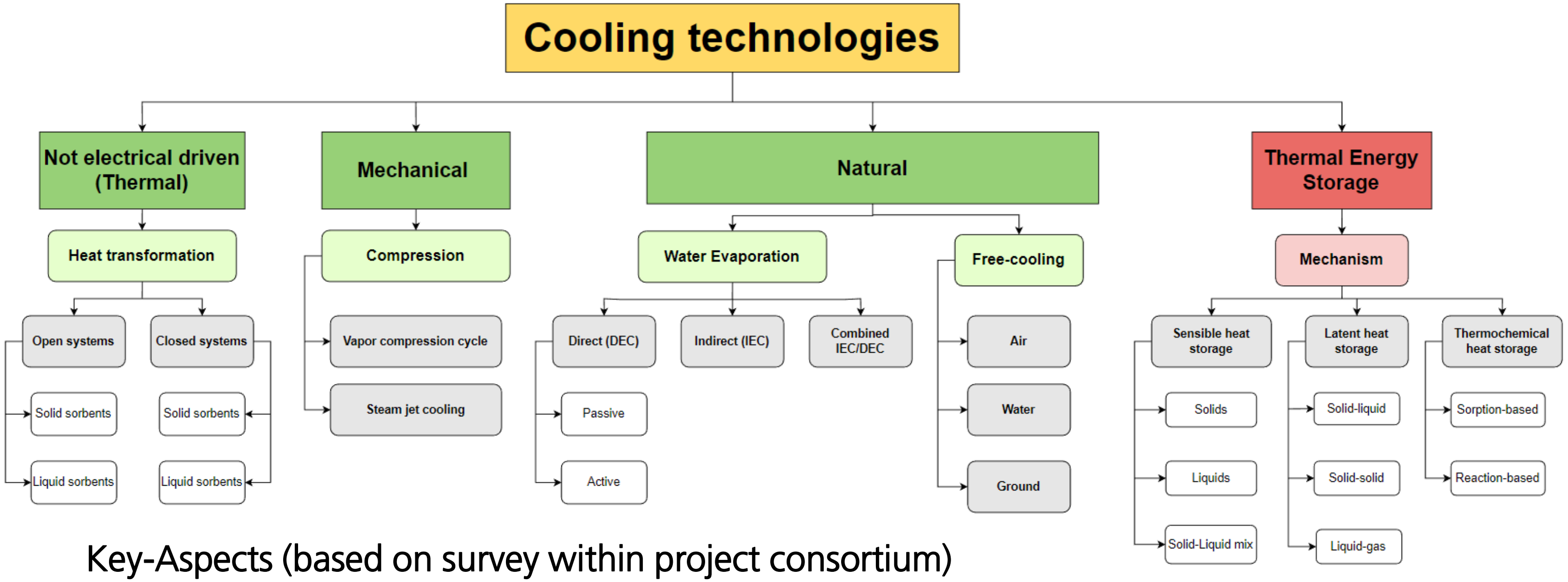

Technology radar on cooling technologies and technological aspects




source: own research

# Broad spectrum of (alternative) cooling technologies

## Mapping and technological assessment of cooling technologies (incl. storage)




### Key-Aspects (based on survey within project consortium)

- Role of electricity driven systems very high (small-scale system, <50kW)
- Passive cooling systems dependent on climatic conditions
- Short-/Longterm storage solutions of high importance
- 5th Generation Grids
- Integration of heat and electricity from renewables of utmost importance
- Cooling system efficiency (COP, SEER, water consumption, etc)
- CO2-Emissions / Market availability and low values of LCOC

### Next step:

**Strengthen representativeness of Key-Aspects**

→ Reach out and ask webinar attendees to participate at the survey

→ Impulses from various stakeholders

→ 20-30min / browser-based survey

# Important aspects in future cooling systems

## Mapping and technological assessment of cooling technologies (incl. storage)

### 5th Generation grids and integrated solutions

- bidirectional heating and cooling grids for urban and densely populated areas
- Prosumer grid
- Integration of heat pumps for heating and/or cooling
- Seasonal thermal storage and high integration potential for renewables energies

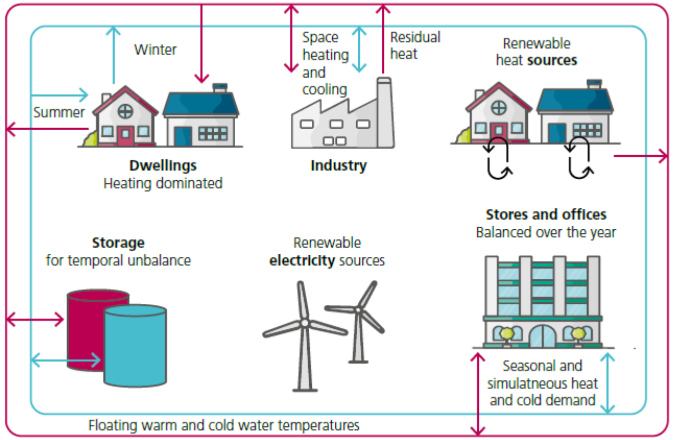
### Subsurface cooling storage and shallow geothermal systems

- Systems for geothermal heating and cooling supply (<400m)
- Subsurface serves as heat reservoir for direct usage or via geothermal probes/heat pumps
- Supply of building complexes or city quarters with renewable heat
- Passive/natural and active cooling systems

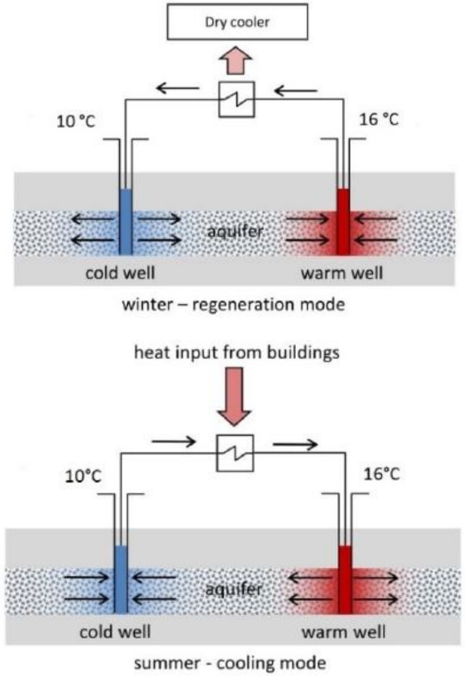
### Thermal storage solutions long & intermediate term

- Subsurface can be used for longterm cooling
- Active cooling systems with ice-storage integration

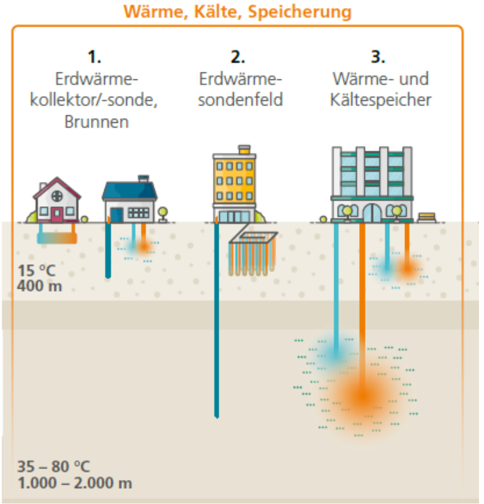
Heating and cooling grid




source: Fraunhofer IEG, ROADMAP OBERFLÄCHENNAHE GEOTHERMIE [5]




source: Finalreport, Energienetz Berlin Adlershof [6]



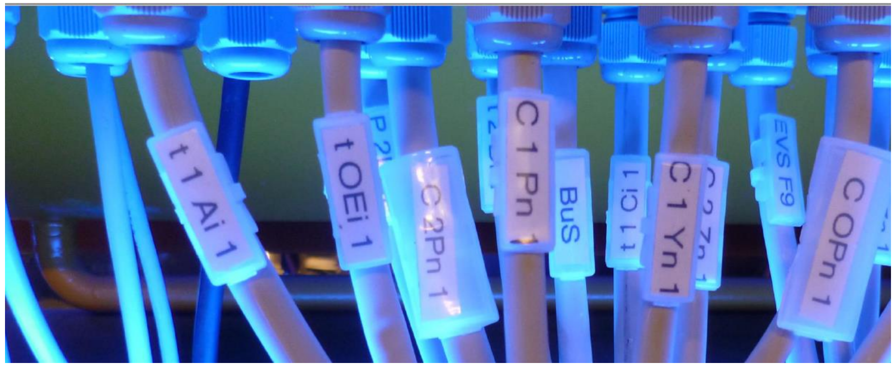

source: Fraunhofer IEG, ROADMAP OBERFLÄCHENNAHE GEOTHERMIE [5]

# Important aspects in future cooling systems

## Mapping and technological assessment of cooling technologies (incl. storage)

### Optimization of cooling operation

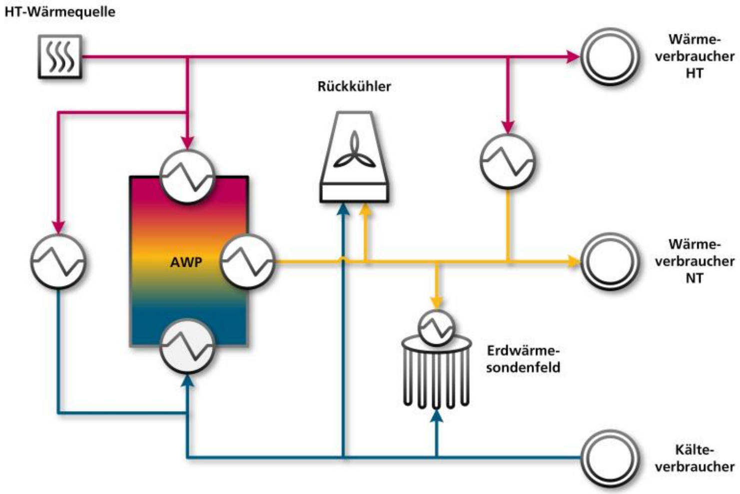
- High efficiency in part-load operation
- Dynamic and variable flow regimes for external circuits
- Dynamic supply and cooling water temperatures
- Integration of storage capacities and free-cooling mode
- Control concepts „tailored“ to system characteristics
- Monitoring is a key-aspect for success



source: Jan Albers

### Solar cooling and thermally driven cooling systems

- Thermally driven ab-/adsorption systems, small-scale applications ←→big-scale applications
- Closed and open sorption systems
- Thermally driven heat pumps can be used for LT-Heat supply and ground regenation
- Alternative to electrical driven systems with very low electricity demands



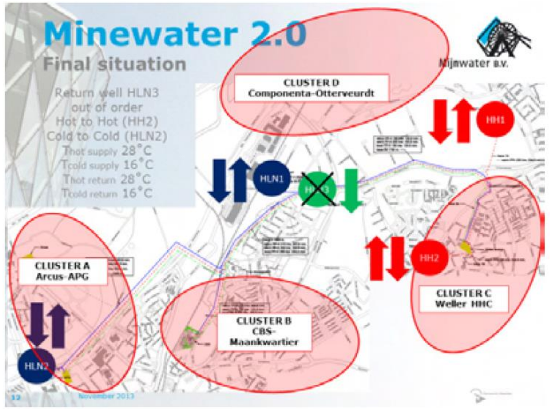

source: Fraunhofer IEG, GeoCool [7]

# Bestcase examples for an efficient cooling supply

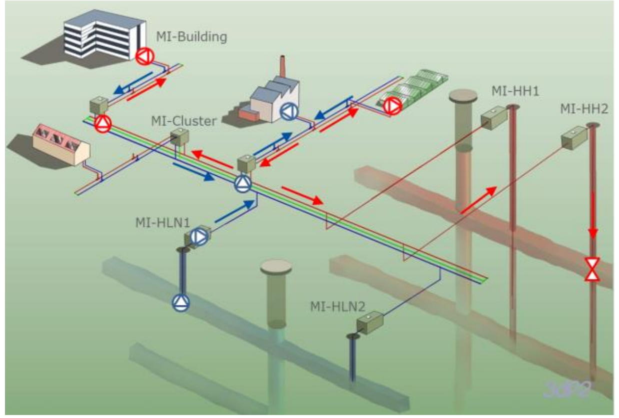
## 5th Generation Grids and Subsurface Energy Storage

### Minewater 2.0 project in Heerlen, NL

- Hydrogeothermal system: Geothermal dubletes and saisonal thermal aquifer storage in mines
- Commissioning in 2005 and continuously expanded
- Depth values of 600 to 800m
- $T_{cold}$ <15°C, $T_{warm}$ >35°C, $T_{return}$ ~25°C
- Capacities: Heating 4.4MW | Cooling 4.2MW



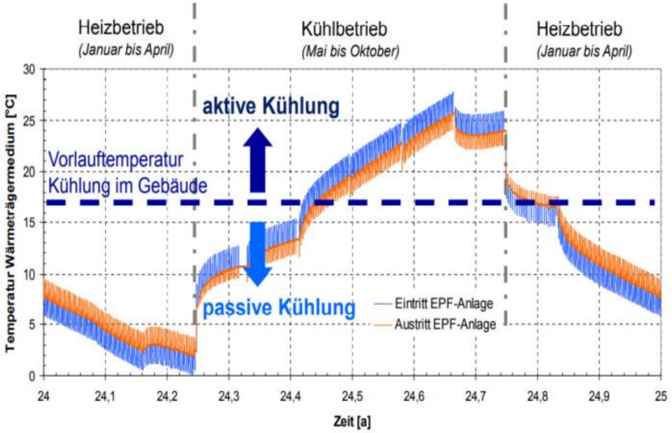

source: SMART ENERGY REGIONS [9]



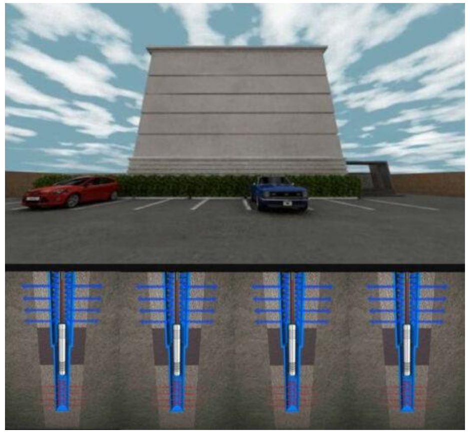

source: Verhoeven et al (2014) [8]

### Colocation data centre „ColocationIX“ in Hamburg, DE

- Geothermal cooling system of a data center in a bunker
- Depth of geothermal probes at 100-200m
- Power Usage Effectivness (PUE) of 1.05$kWh_{el}/kWh_{el}$
- Cooling capacity 200-800kW
- In-Row cooling, concrete activation, adiabatic reject heat devices
- Award „Deutscher Rechenzentrumpreis“ in 2014




source: Kübert Markus (2020) [10]



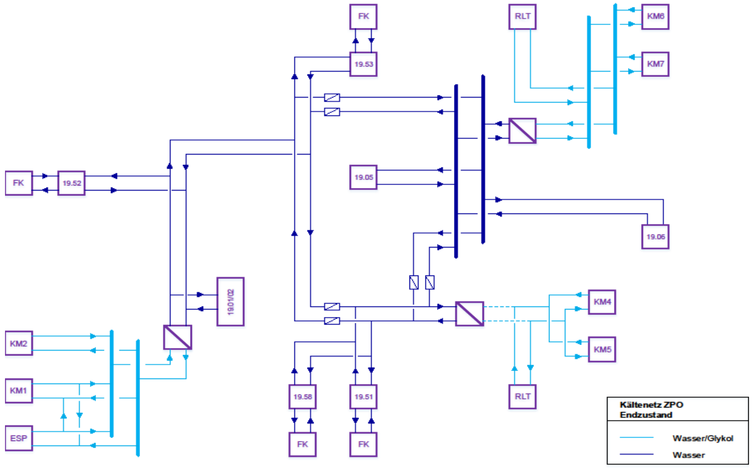
source: Consultix GmbH

# Bestcase examples for an efficient cooling supply

## Cooling Grids and Operation Optimization

### Energy Grid Berlin Adlerhof, DE

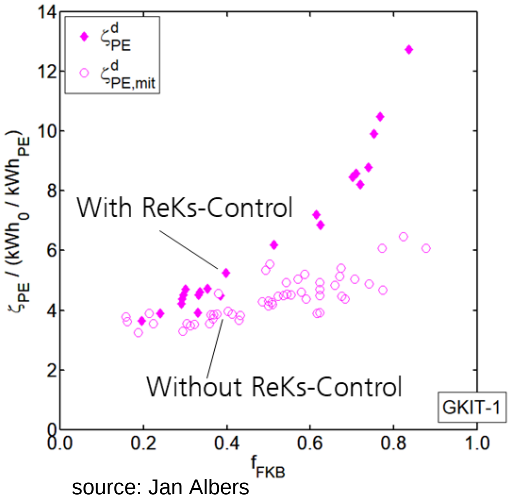
- Reactivation of ice storage (900kW)
- 7 chillers, 5 free-cooling towers, cooling capacity 4MW
- Coupling of subsystems / cooling grids
- Development of an overall control strategy
- Flexible operation of the cooling network
- Efficiency increase by 65%, primary energy savings 48%



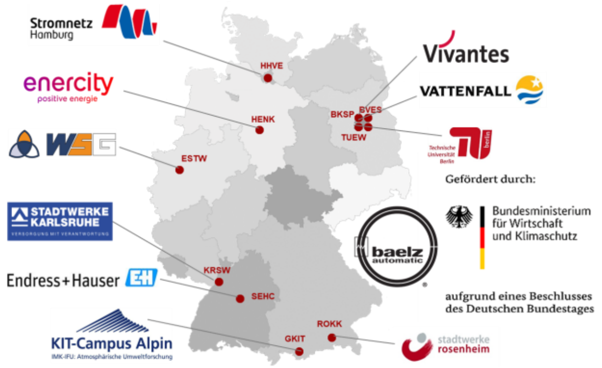

source: Anja Hanßke

### ReKs-project: Control strategies for energy efficient cooling systems, DE

- Development of control strategies for stand alone absorption chillers and complete cooling systems
- Model predictive system control with selection of the most PE-efficient combination of cold generators
- 10 Installations |14 Absorption Chillers | 1-3 years monitoring
- Reduction by more than 25% of specific electricity demand by means of active supply flow rate control
- Reduction of PE-consumption & operating costs of up to 70%




source: Jan Albers



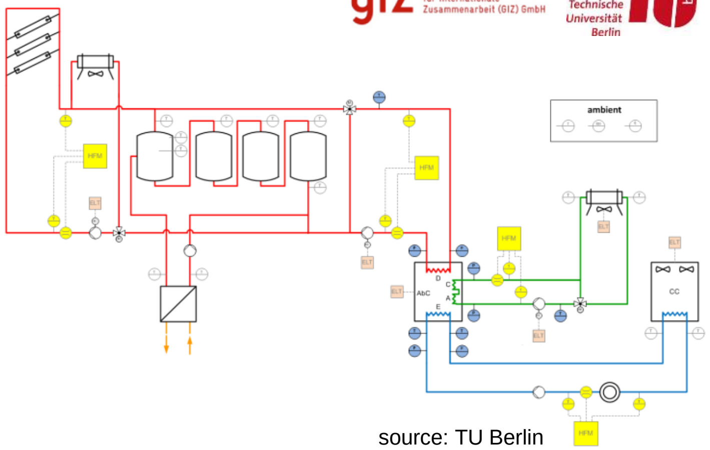

source: Jan Albers

# Bestcase examples for an efficient cooling supply

## Solar Cooling and Geothermal Cooling

### Solar Cooling in Industry and Commerce, JOR

- Commissioning 2014-2016 of 4 pilot solar cooling systems in Jordan
- CPC-system provides solarthermal energy
- Thermal energy storage and dynamic flow control
- Cooling capacity per chiller 50-120kW,
- 8-14°C supply temperature
- Electrical efficiency up to 23 kWh/kWh




source: TU Berlin

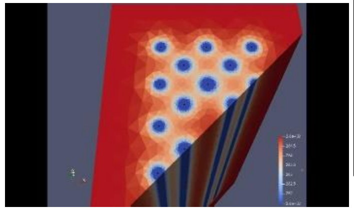
source: R. Paitazoglou

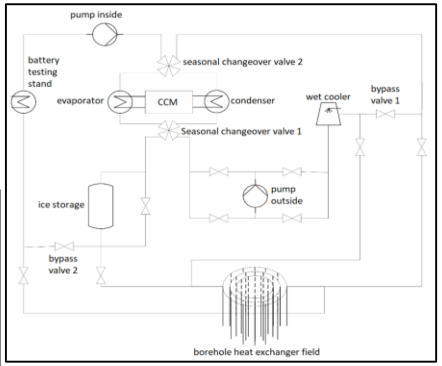
source: R. Paitazoglou

### MissElly project, DE

- Multivalent cold supply via free cooling, BHE, ice storage, CCM
- Joint project of the Voltavision GmbH and the Fraunhofer IEG started in March 2020
- 310 kW cooling @16 °C
- Simulation/Demonstration

Fraunhofer IEG
BHE simulation

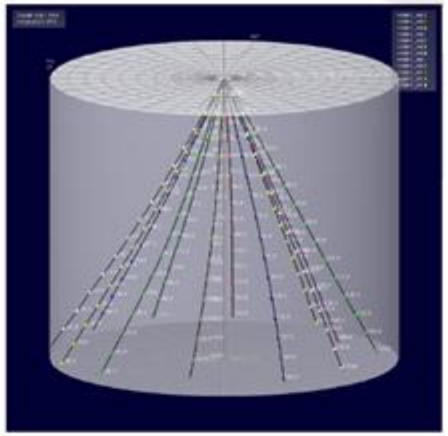





source: Fraunhofer IEG, R. Ignacy

### GeoStar, DE

- Development as a central scalable system concept of geothermal probes for the combined heating and cooling supply of large and growing infrastructures
- drilled in a star-shaped deflected pattern
- minimal area requirement and low impairment of existing infrastructure



source: Fraunhofer IEG

# Thank you for your attention

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Sources:

[1] OECD/IEA, The Future of Cooling | Opportunities for energy- efficient air conditioning (2018).
[2] LBNL (Lawrence Berkeley National Laboratory), Heat Island Group, http://heatisland.lbl.gov/, (2013).
[3] VDMA, Forschungsrat Kältetechnik e. V., Energiebedarf für Kältetechnik in Deutschland | Eine Abschätzung des Energiebedarfs von Kältetechnik in Deutschland nach Einsatzgebieten 2017 (2019).
[4] The New York Times, https://www.nytimes.com/2021/05/03/climate/heat-climate-health-risks.html, (2021).
[5] Fraunhofer IEG, ROADMAP OBERFLÄCHENNAHE GEOTHERMIE | Erdwärmepumpen für die Energiewende – Potenziale, Hemmnisse und Handlungsempfehlungen, https://www.ieg.fraunhofer.de/de/presse/pressemitteilungen/2022/oberflaechennahe-geothermie.html, (2022).
[6] Finalreport, Energienetz Berlin Adlershof, https://www.energienetz-berlin-adlershof.de/, (2019).
[7] Fraunhofer IEG, GeoCool | Geothermally driven heat pump system combined with a borehole storage system for the energy efficient supply of cooling and heating, https://www.ieg.fraunhofer.de/en/references/geocool.html, (2023).
[8] René Verhoeven et al, Minewater 2.0 project in Heerlen the Netherlands: transformation of a geothermal mine water pilot project into a full scale hybrid sustainable energy infrastructure for heating and cooling, Energy Procedia 46 (2014) 58–67.
[9] SMART ENERGY REGIONS, René Verhoeven, Minewater 2.0, p. 174-180, ISBN - 978-1-899895-14-4, (2014).
[10] Kübert, Markus (2020): Heizen und Kühlen mit Geothermie. Quartier am Henninger Turm, Frankfurt. https://www.buergerforum-energiewendehessen.de/BFEH/faktencheck_geothermie/FG_F2_Kuebert.pdf, (2020).