



Hybrid ground source heat pumps for cold climates
NTNU, Trondheim | September 11, 2025

GSHP + PVT

*State-of-the-art and
perspectives*

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KTH: Sweden's largest tech university



1 
(19 EU)

17k
students

4k
staff

In Engineering 

School of Industrial
Engineering & Management

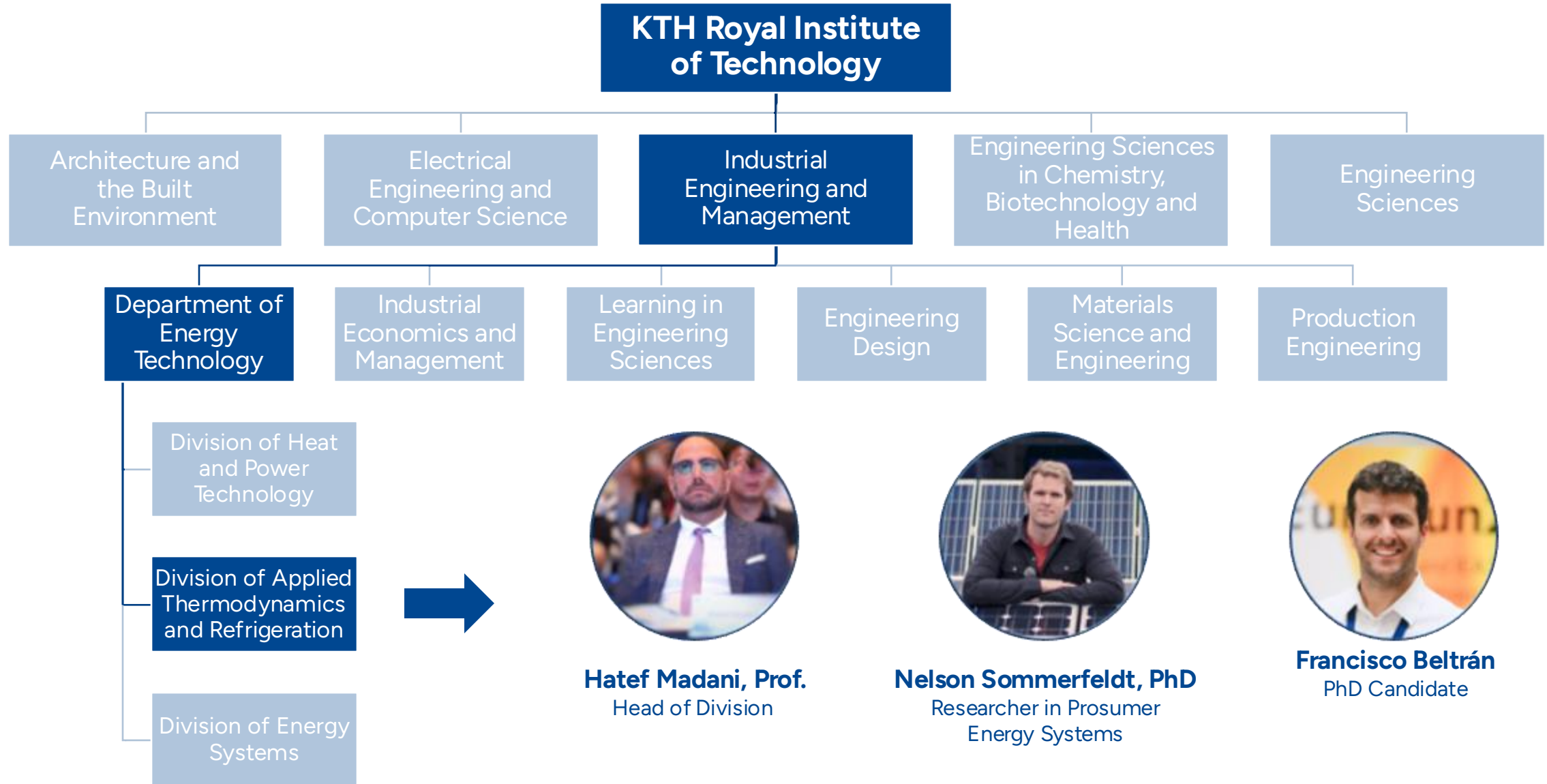
Department of
Energy Technology

3 Divisions

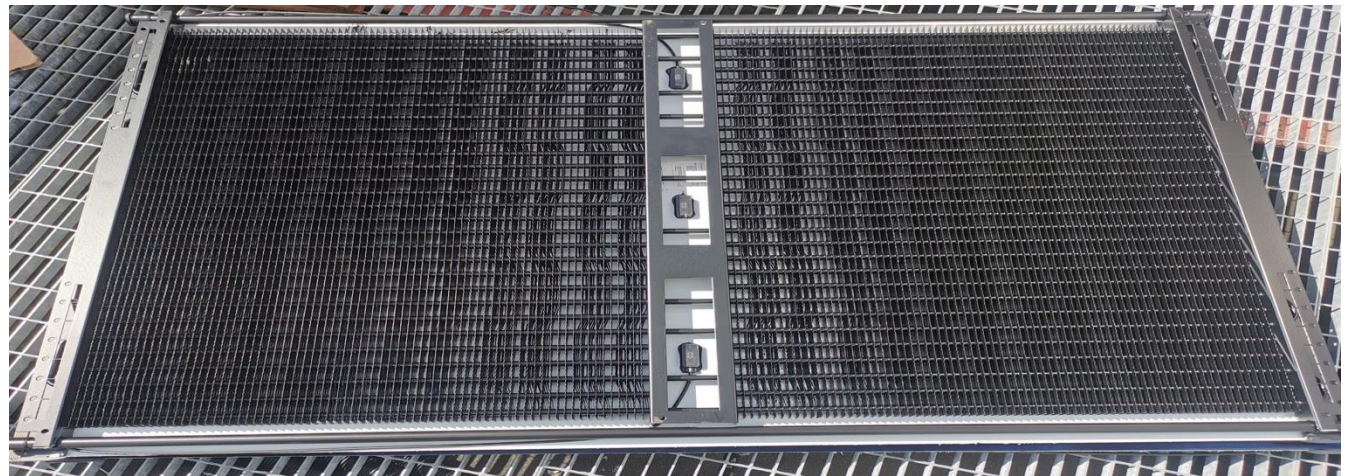
50 Faculty and 40 PhD stud



PVT+GSHP Research Team

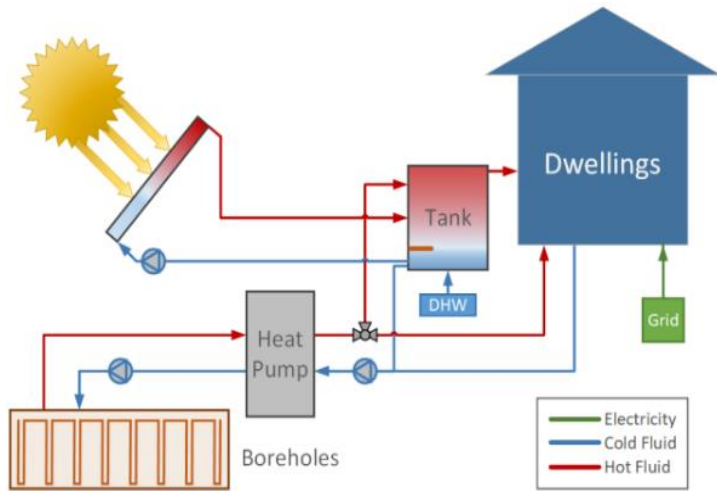


What is solar PVT?



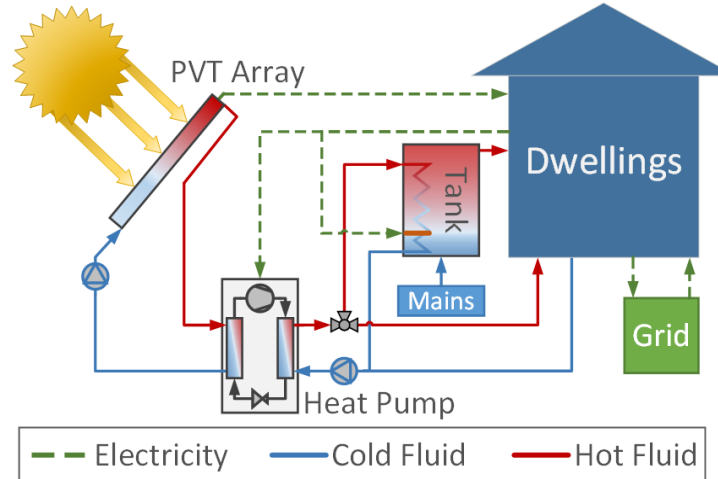
How can we connect the PVTs to a heat pump?

Parallel

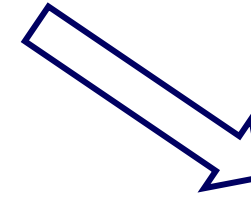


PVT as supplementary heating supply technology

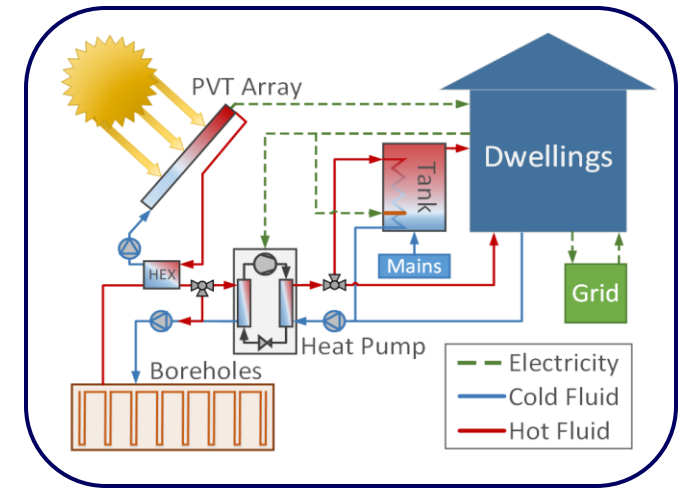
Series



PVT as the primary (or supplementary) heat source of heat pump

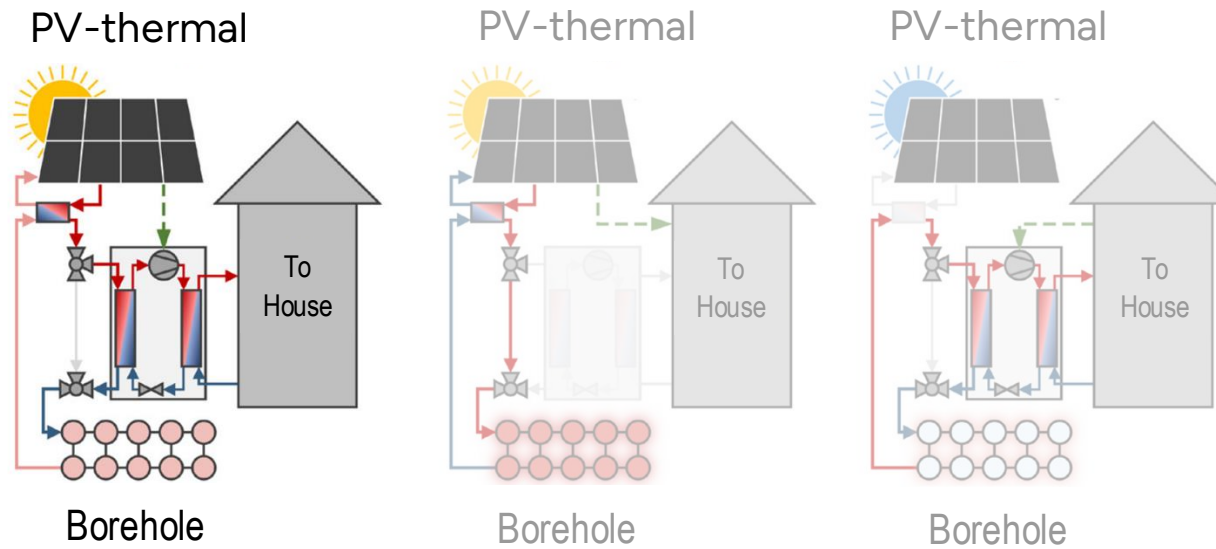


Series/Regenerative



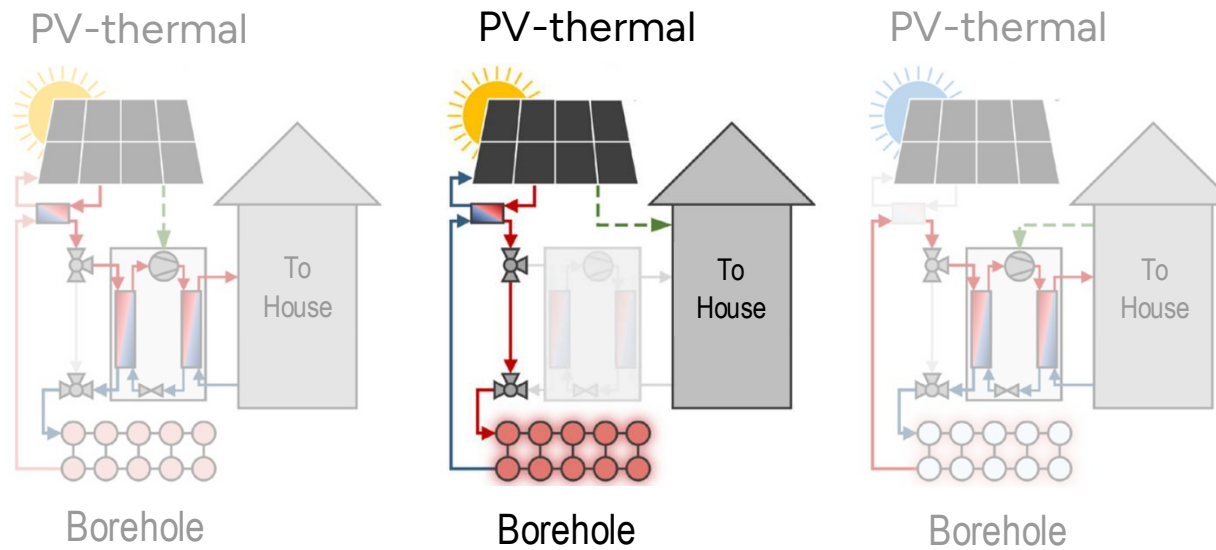
PVT as heat source with borehole regeneration

Operation modes of PVT + GSHP



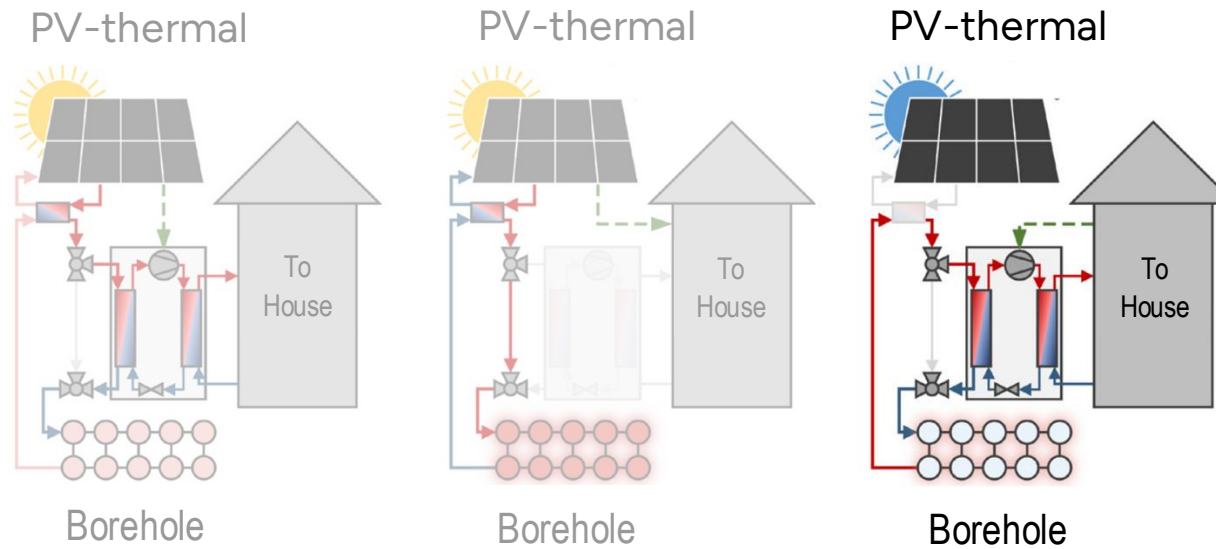
PVT as a boost

Operation modes of PVT + GSHP



Borehole regeneration

Operation modes of PVT + GSHP



Borehole as a source

Why series/regenerative PVT + GSHP systems?



NEW

Benefits for New Systems:

- Smaller borehole field, particularly for densely populated area



OLD

Benefits for Old Systems:

- Supports undersized borehole fields
- Avoids costly (and sometimes messy) upgrades



NEW

+



OLD

Shared Benefits:

- Seasonal solar energy storage
- Higher heat pump efficiency
- 4-6x solar energy capture
- Helps reduce peak loads
- Improved PV cell efficiency

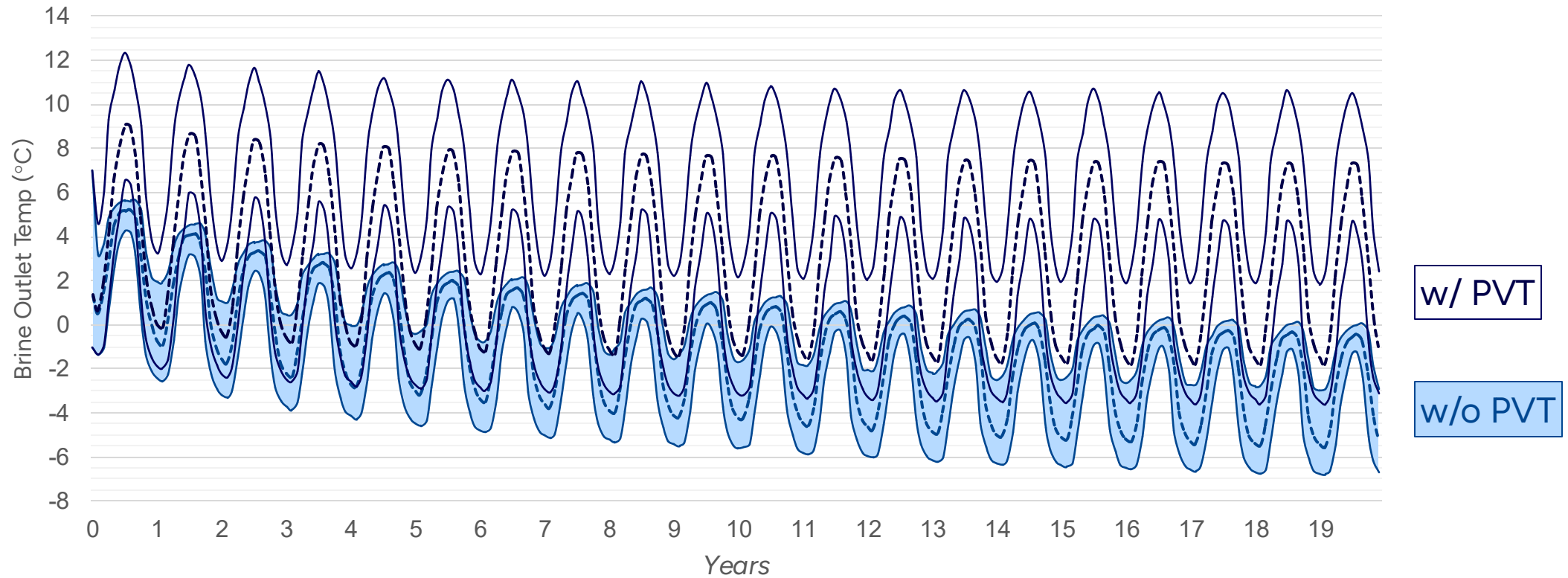
**Around 600.000 GSHP systems in Sweden
20.000+ new installed systems per year**



**Huge market
potential for PVT!**

What have we learned?

- **PVT collectors enable GSHP installation in space-limited buildings or thermally-imbalanced systems by supporting ground temperatures**

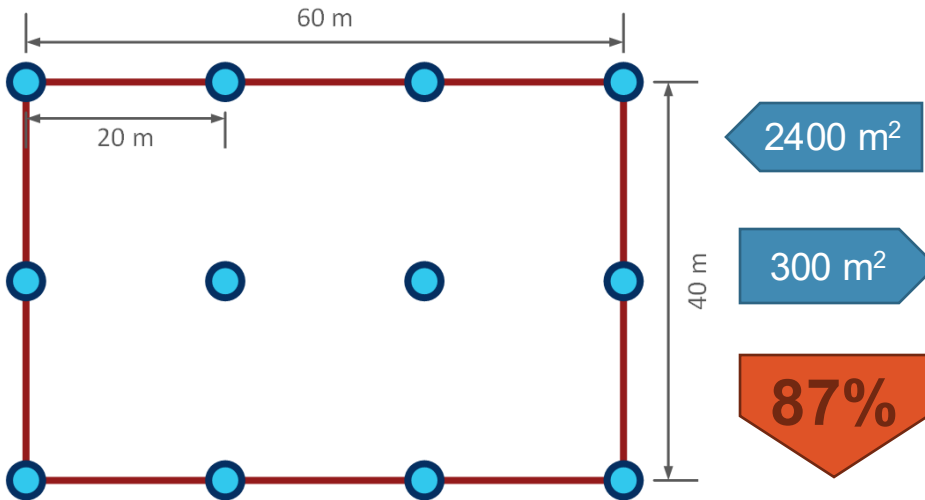


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- **PVT collectors enable GSHP installation in space-limited buildings by supporting ground temperatures**

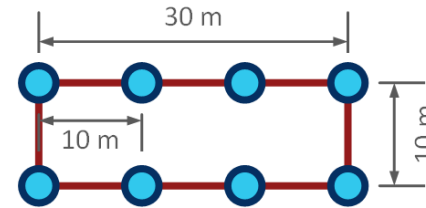
Sommerfeldt & Madani (2019)

- 2000 m² MFH in Stockholm
- Full roof coverage with PVT (236 m²)



0.8% length reduction or 0.5 m spacing reduction for each 10 m² of PVT collector (while maintaining the same seasonal performance factor!

Considerable gain from electrical auxiliary heater!



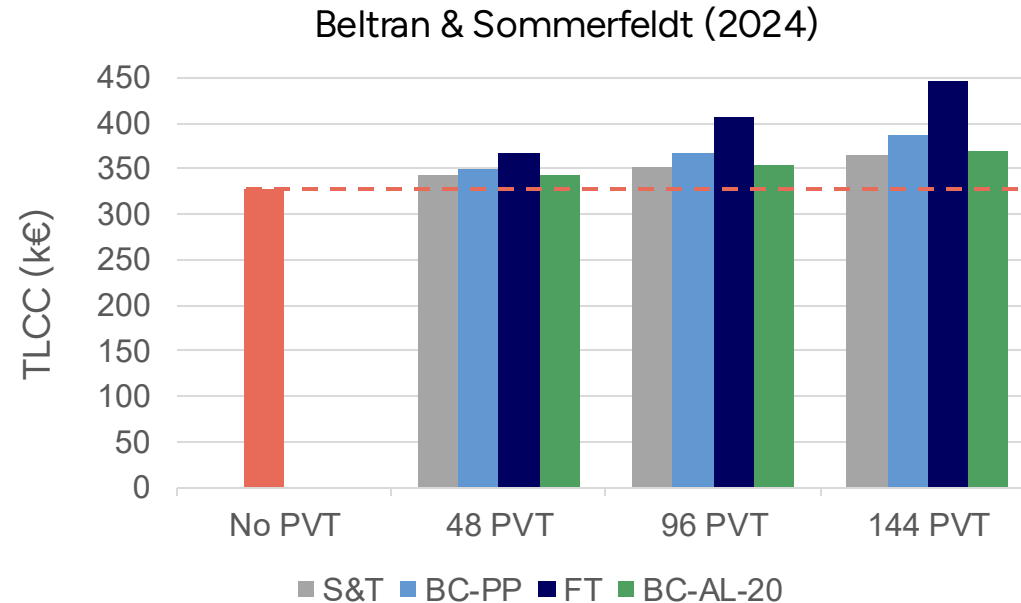
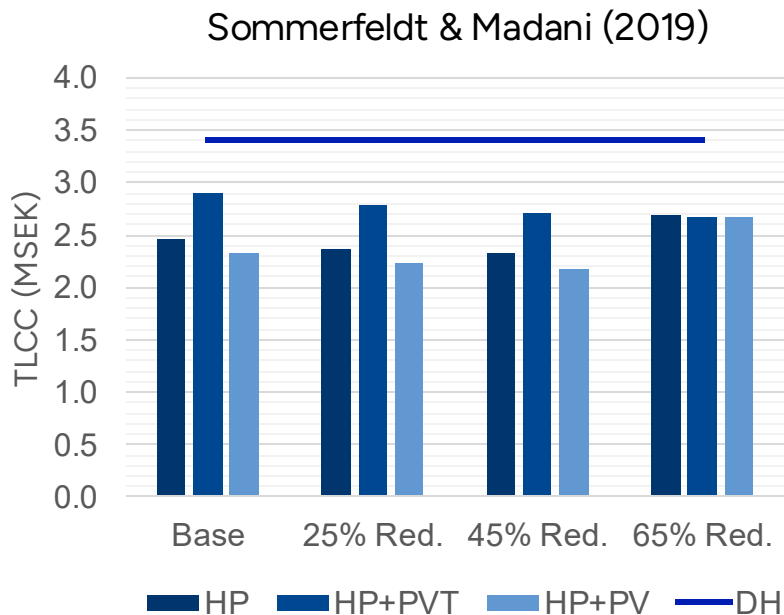
Supported by Liravi et al (2024)

- 1656 m² multi-family house in Oslo and Røros
- ~2 m² PVT/kW_{th} HP capacity

95%

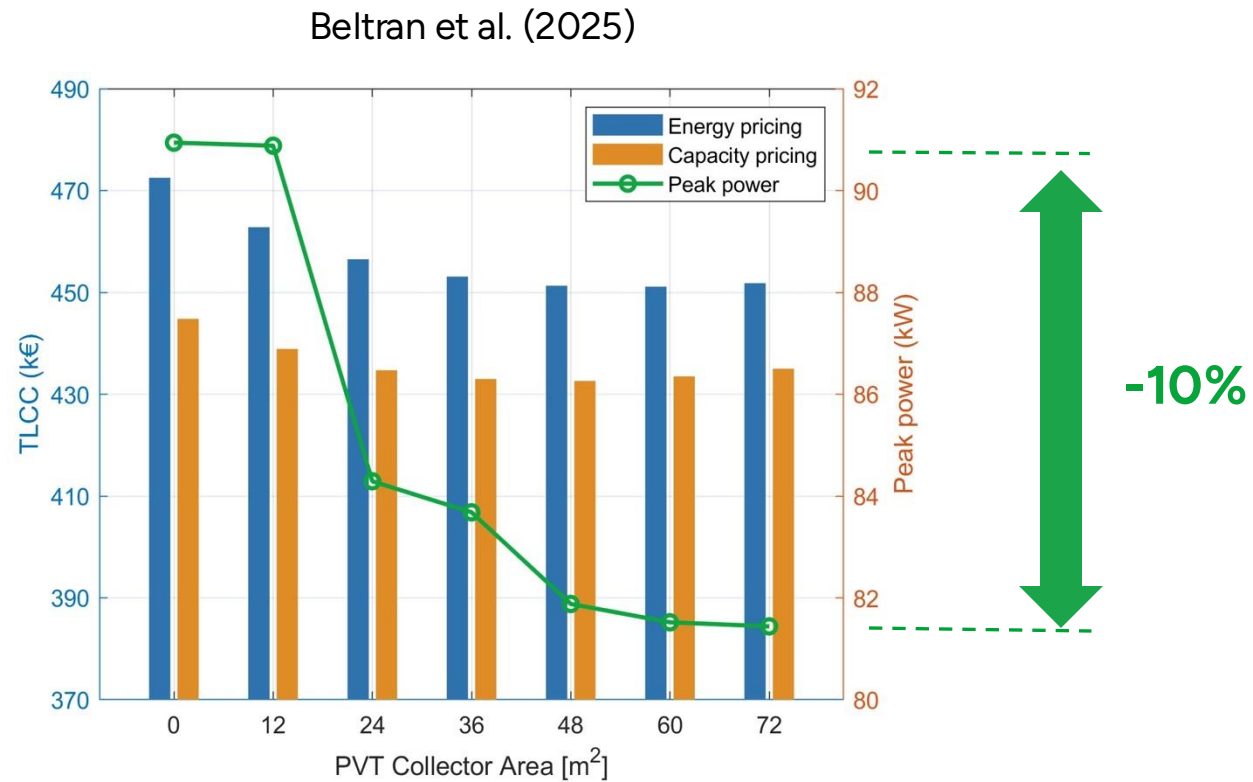
What have we learned?

- In buildings with sufficient land, traditional GSHP-only or GSHP with PV systems remain the most cost-effective option.
- Only marginal gain in seasonal performance factor regardless of design of PVT (for a well-dimensioned GSHP system).
- *a trade-off between improved thermal performance, manufacturability, and material cost (as well as energy vs. exergy)*



What have we learned?

- When integrated with an undersized borehole field, PVT can cut the peak power demand of the GSHP by 10%

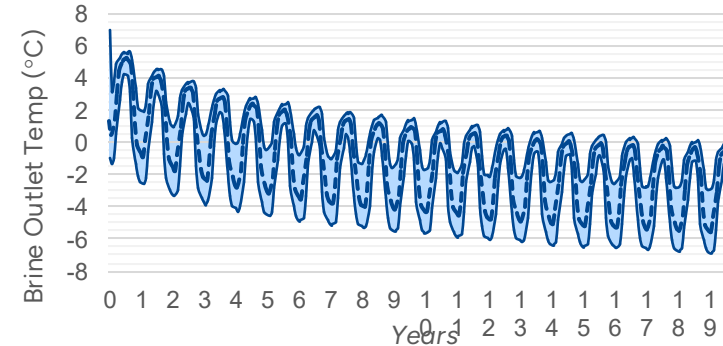


Where do we see the biggest potential for PVT+GSHP?

Replacement market of GSHP



Even if the borehole field has been properly dimensioned, temperature has declined over time



Imagine now that the heat pump owner decides to change the heat pump for a modern, more efficient model



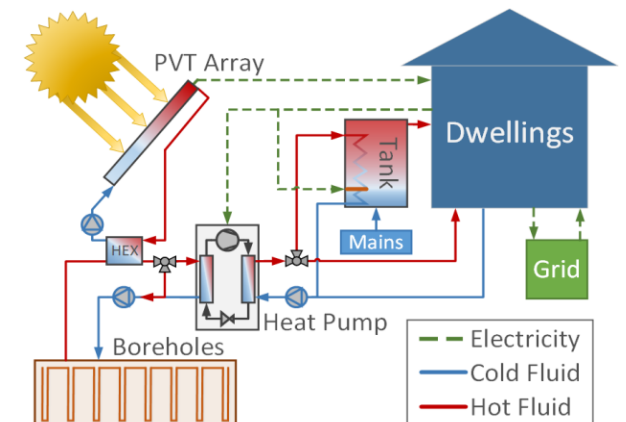
The already degraded borehole field will become undersized



Higher electricity consumption, higher peak power demand, higher electricity bills



How do we solve this problem?





Ongoing Research Project – Smart Reno SE



Smart Renovation Strategies for Sustainable Electrification

Partners:



Research Leader



PVT + GSHP Solutions



Geoenergy Consultancy



Behavioral Analysis Expert

Goal:

Deliver a smart, holistic renovation strategy for existing buildings with GSHPs considering a **range of prosumer technologies** and the **needs and preferences of decision-makers**.

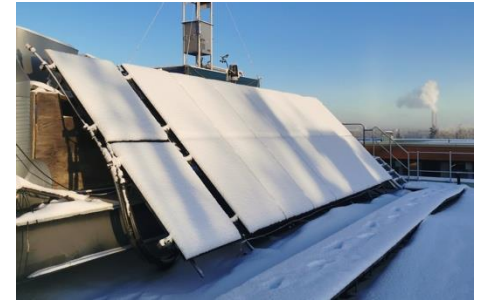
Potential Solutions:

- Adding boreholes to existing GHE
- Thermal renovation to building envelope
- Borehole regeneration with PVT
- Thermal storage
- Electricity storage via batteries / EVs
- Demand response

Perspectives: other ongoing and future directions

Component level:

- Reduce material and manufacturing costs of the PVT collector
- Characterize performance of PVT collectors under condensation, frost, rainfall and snowfall



System level:

- Integration of PVT into low-temperature district heating networks
- Business models: integrated PVT+GSHP solution
- Long-term monitoring of real PVT+GSHP installations
- Advanced control strategies considering variable energy and power prices
-



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