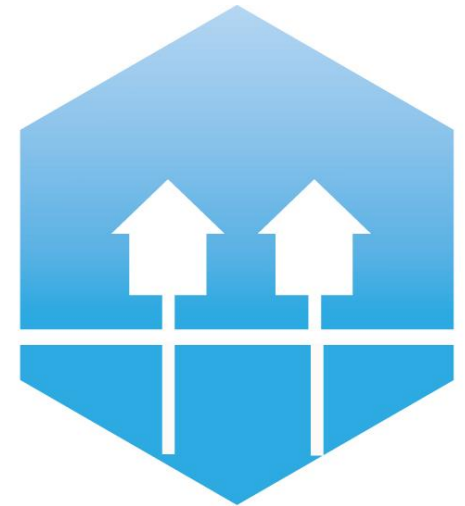
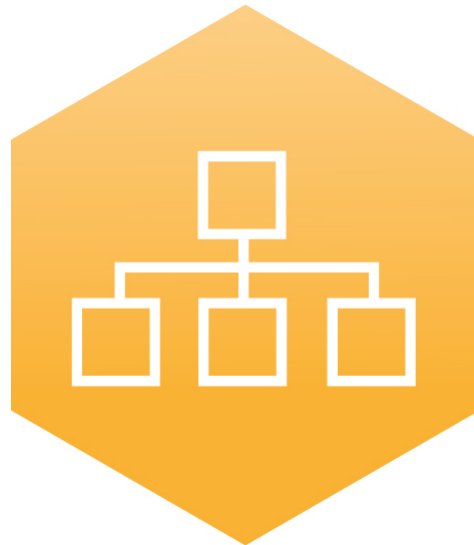


2nd International Conference on Smart Energy Systems and 4th Generation District Heating
Aalborg, 27-28 September 2016



AALBORG UNIVERSITY
DENMARK

4DH

**4th Generation District Heating
Technologies and Systems**

Industrial Waste Heat Utilization for Low Temperature District Heating



AALBORG UNIVERSITY
DENMARK

2nd International Conference on Smart Energy Systems and
4th Generation District Heating, Aalborg, 27-28 September 2016

Who are we?



- **Kristian Christoffersen and Allan Bjerg**
- **7th Semester at the Department of Energy Technology at AAU**
- **Thermal Energy and Process Engineering**



Agenda



- **Background**
- **What has been investigated?**
- **Results from models**
- **Economy**
- **Conclusion**
- **Questions**



Background of project

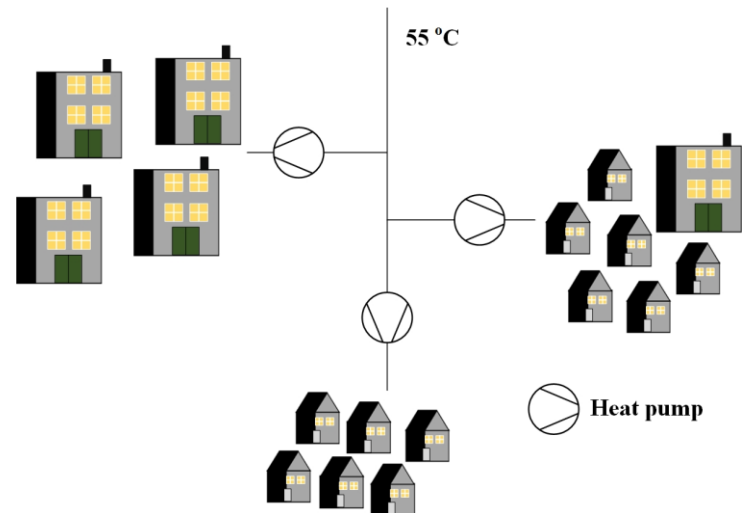


- **Present district heating in Viborg: natural gas**
- **Apple Data Centre**
 - 166,000 m²
 - Enough heat to cover Viborg's demands
 - Finished in 2026
 - First part finished in 2018
- **Supply water at 25°C**



Background of project

- **Past and present district heating in Viborg**
 - 2002 – 75°C
 - 2013 – 65°C
- **The future...**

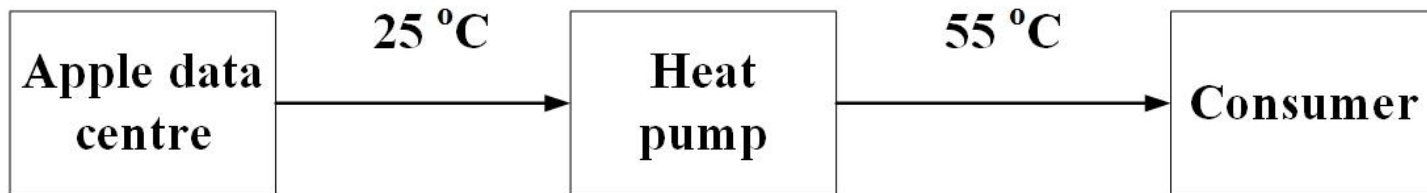


- **How can we utilize the heat from Apple?**

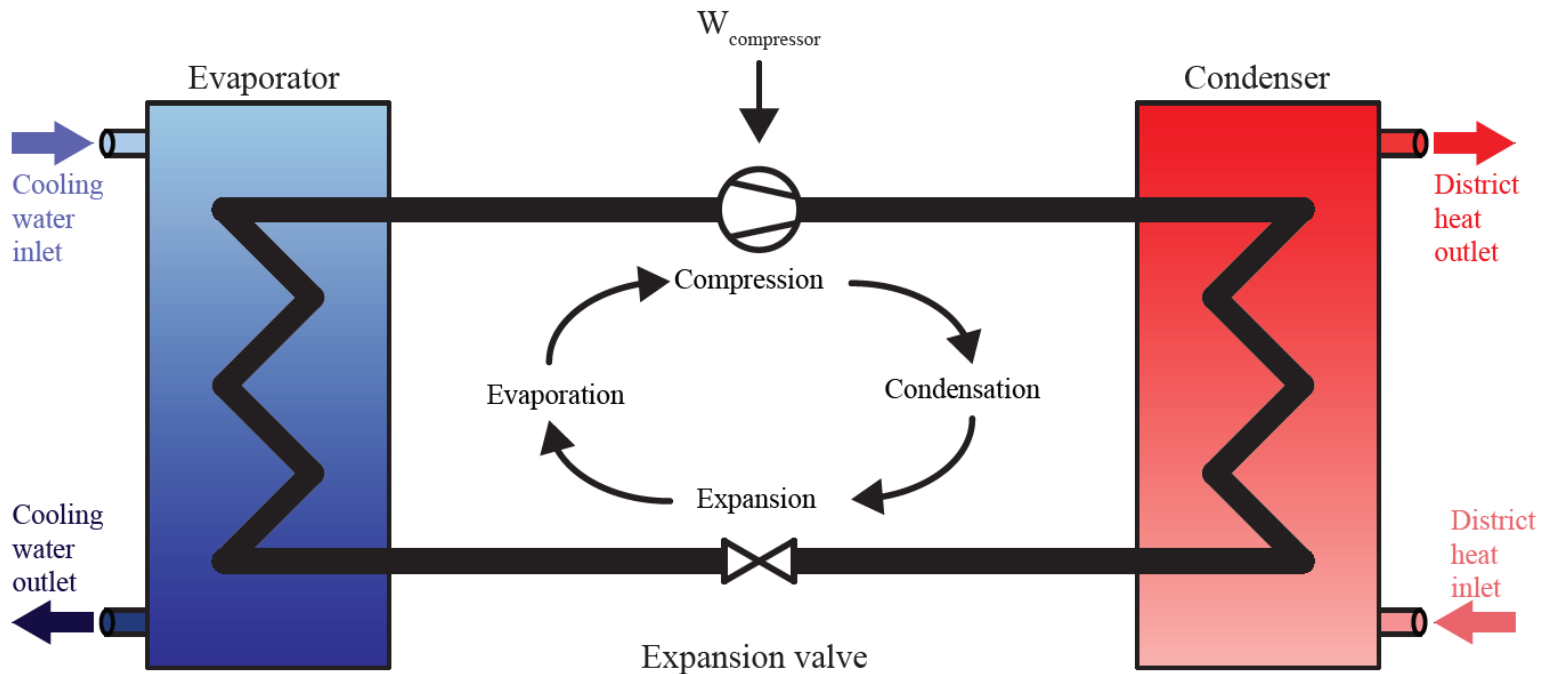


What has been investigated?

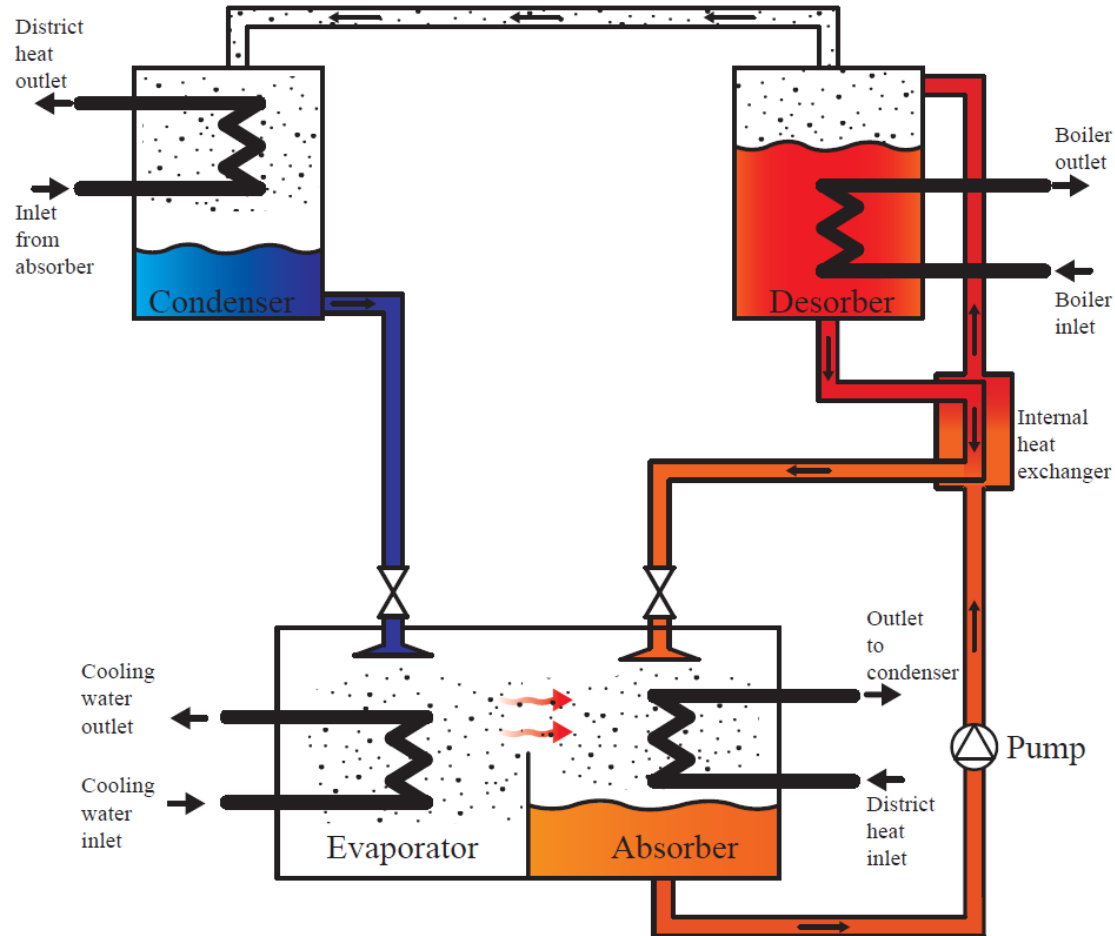
- **Energi Viborg and Viborg Fjernvarme**
- **“Which type of heat pump is best suited for district heating in Viborg?”**



Mechanical heat pump



Absorption heat pump



Results from heat pump models



- **Two scenarios**

District heating temperature	65°C (3. gen)	55°C (4. gen)
Mechanical heat pump (COP)	4.2	5.4
Absorption heat pump (COP)	1.5	1.6

- **Assumption: Return temp. to Apple is 25°C**



Economy

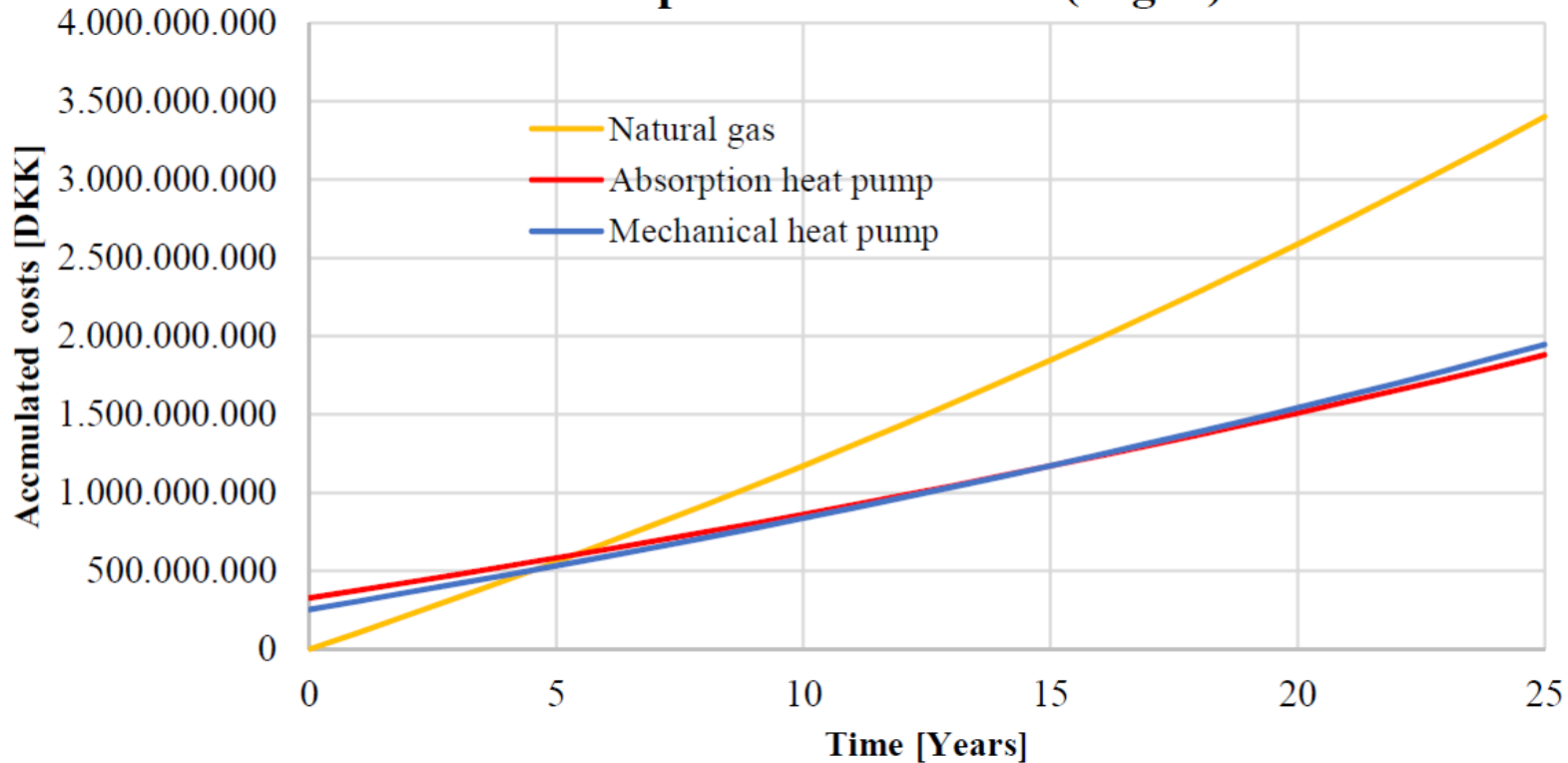


- **Fuel costs**
 - Electricity
 - Biomass (Straw)
 - Taxes (WHT: 180 DKK/MWh)
- **Installation costs**
- **Operating and maintenance costs**
- **Inflation**



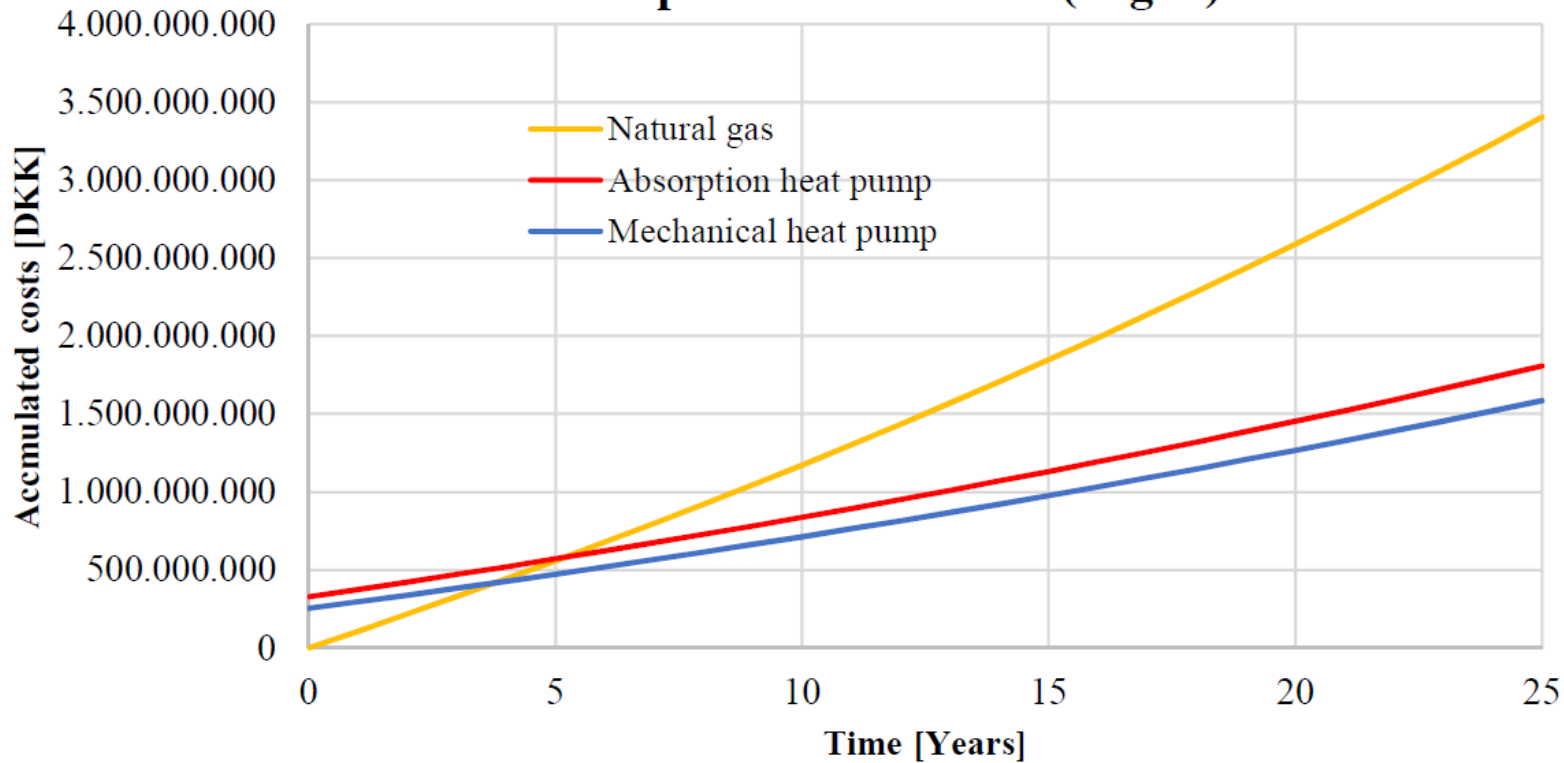
Overall results (no WHT)

Accumulated Expenses in 25 Years (3. gen)



Overall results (no WHT)

Accumulated Expenses in 25 Years (4. gen)



Conclusion



- **Mechanical heat pump proved cheapest**
- **But...**
 - **Future fuel and tax prices have great impact**
 - **Big differences since the project was made**
 - **PSO tariff removed**
 - **Natural gas price calculated has proven to be too high**



Questions?

