Experience with Design, Commissioning and Operation of Sustainable Ground-Source Heat Pumps for Heating and Cooling

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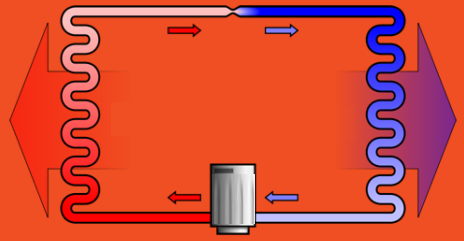

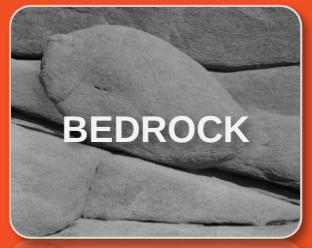

Sustainable GHSP Plants

- Minimum resource/material use
  - High-quality components and unit – long lifetime
- Environmentally friendly fluids
  - Refrigerants – anti-freeze fluids – PCM etc.
    - Biodegradable – excellent thermophysical properties
- Energy-efficient operation
  - Energy-efficient components, units and systems
    - Minimum electricity use (kg CO_2/kWh) during operation
  - Regular maintenance
    - Long lifetime – maintained energy efficiency

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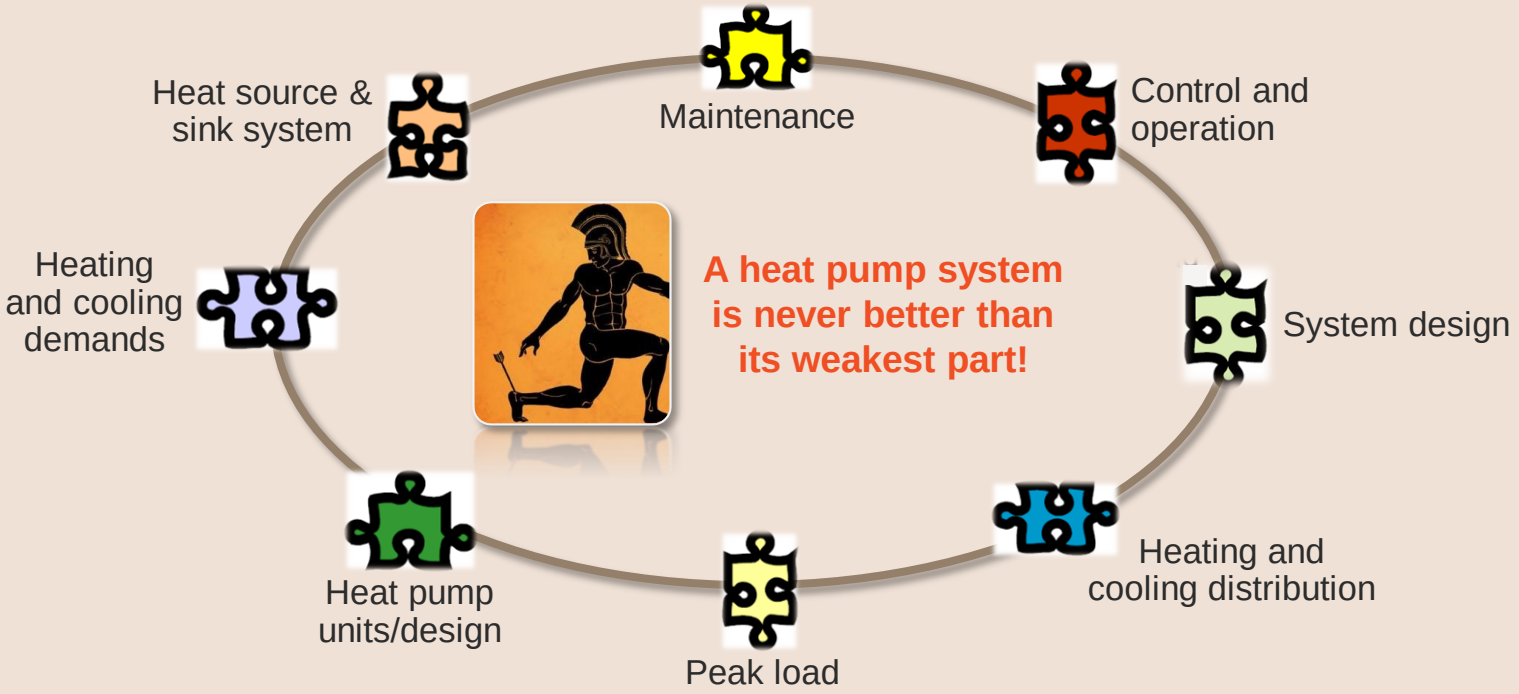
ErP Eco-design

Sustainability – Total Quality from Design to Operation



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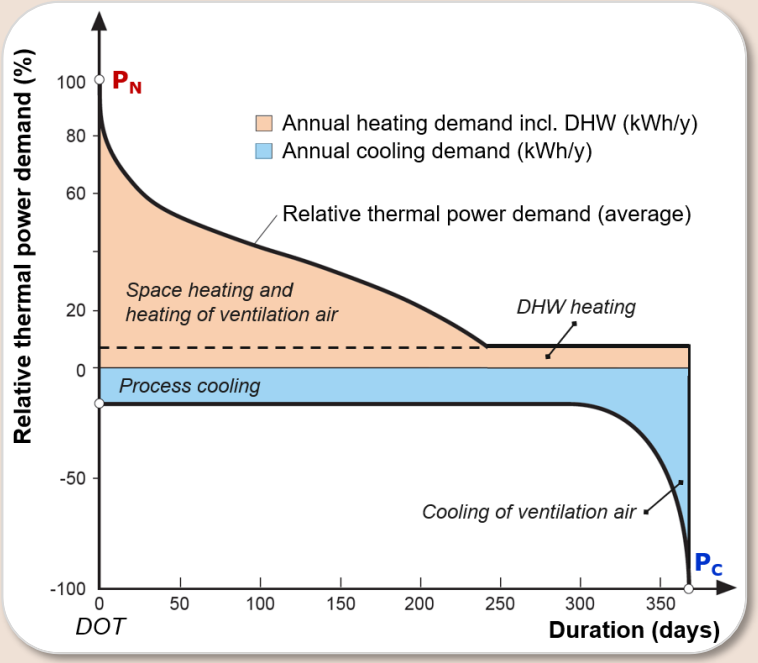
Calculation of Heating and Cooling Demands

- Power demand (kW) & energy demand (kWh/year)
  - Space heating
  - Heating of ventilation air (after heat recovery unit)
  - DHW heating
  - Space cooling and process cooling
- Power duration diagram (load visualisation) →
- Essential for correct design of:
  - Heat pump system
  - Borehole system (BTES)
  - Distribution systems for heating & cooling



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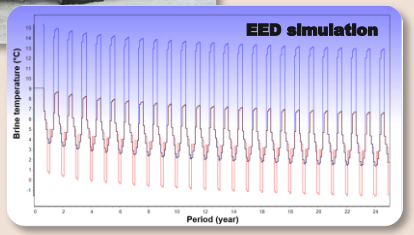
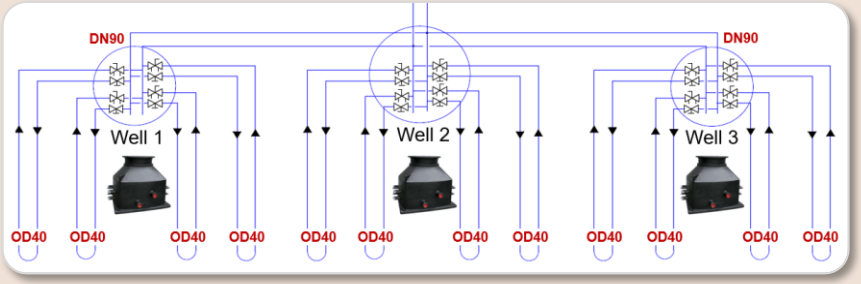
Design of the Borehole System (BTES)

- Annual thermal energy balance
  - Heating/cooling loads for heat pump system (kW, kWh/year)
  - Ground properties (NGU or TRT)
  - Possibly thermal charging (space limitations, ground-conditions etc.)
- Computer tools for design – e.g. EED or IDA ICE
  - Total borehole depth
  - Borehole geometry
- Ground-source system – components/fluid
  - Borehole heat exchanger (BHE) system
  - High-quality anti-freeze fluid
  - Pumps, heat exchangers, valves, deaerator etc.



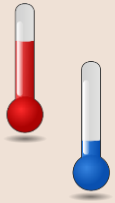


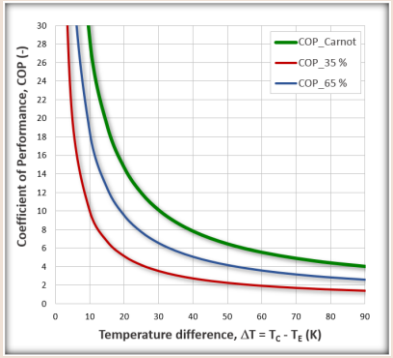
Design of Heat Pump Plant and Secondary Systems

- Heat pump units
  - Natural working fluid (propane, ammonia, CO_2)
  - High quality components – ErP min. A^+ or Eurovent min. A
  - Risk assessment and safety systems for propane/ammonia

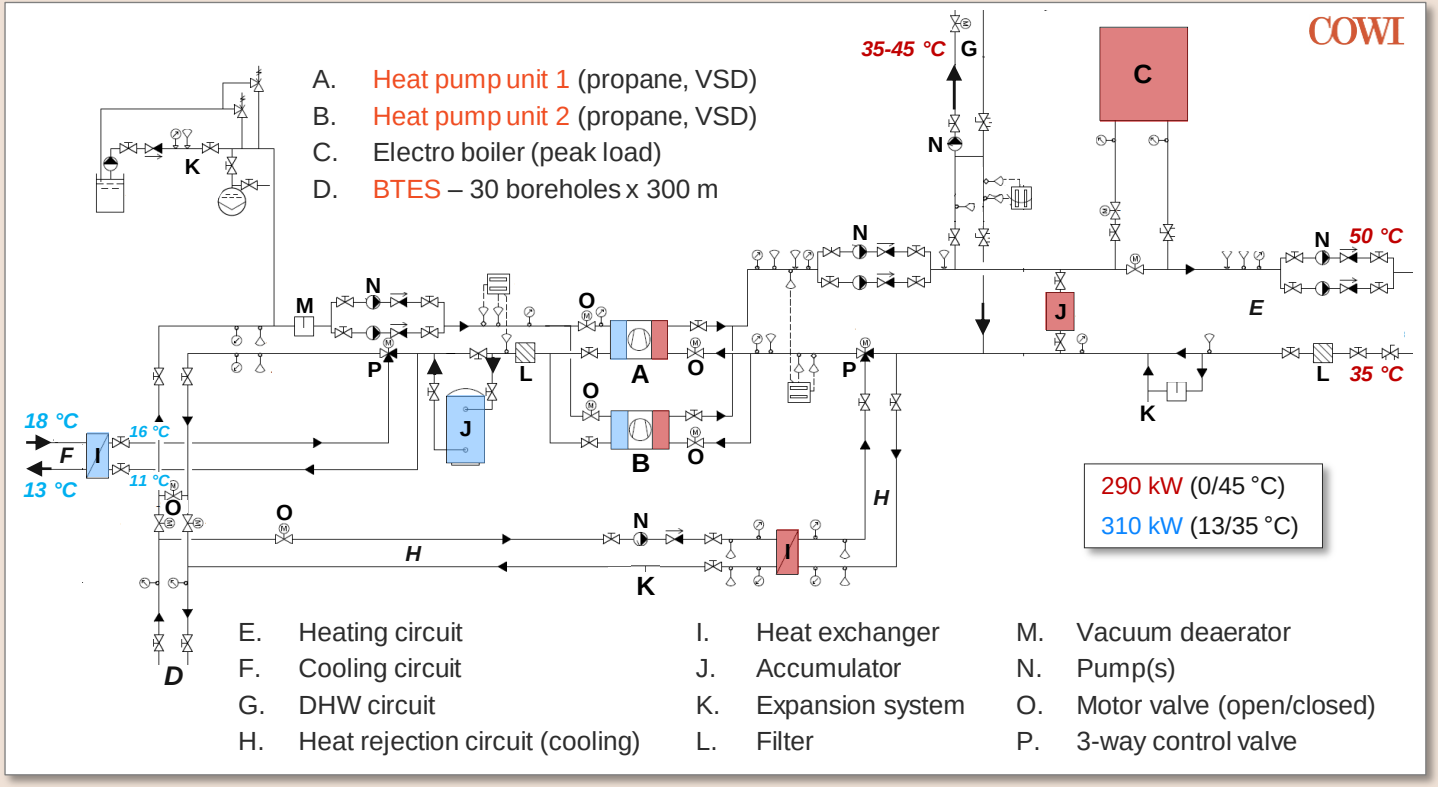
- Optimized system design and operation for minimum energy use
  - Maximize SCOP, minimize peak load and minimize parasitic losses

- Secondary systems – SCOP vs. temperature level
  - Heating – rel. low distribution temperature
    - Outdoor temp. compensated supply temperature
    - Retrofit – measures to reduce supply temperature in existing buildings
  - Cooling – rel. high distribution temperature





Example – GSHP System for Heating, DHW & Cooling



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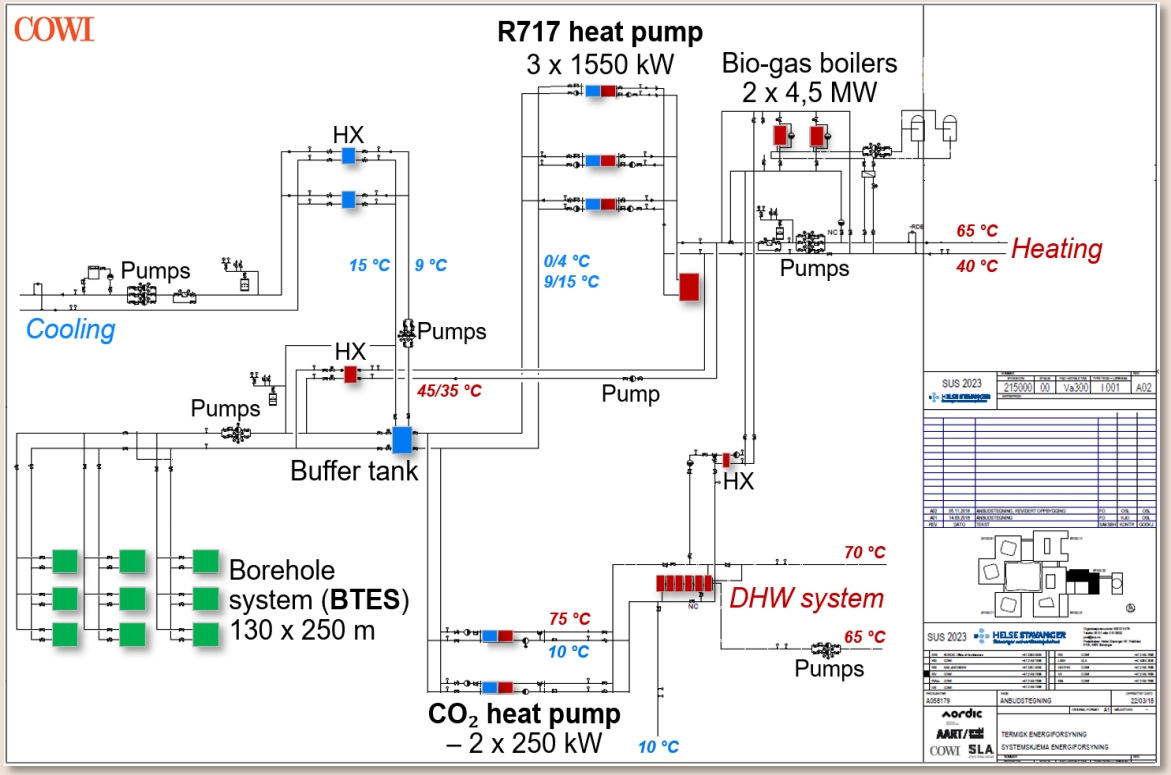
New Stavanger University Hospital

- Stage 1 – 120,000 m²
- To be completed 2024
- World class GSHP system
  - 130 boreholes x 250 m
  - Ammonia (R717) heat pumps
    - High-efficiency units (VSD)
  - CO_2 heat pumps – DHW
    - Optimized for DHW heating
- Peak load – bio-gas boilers



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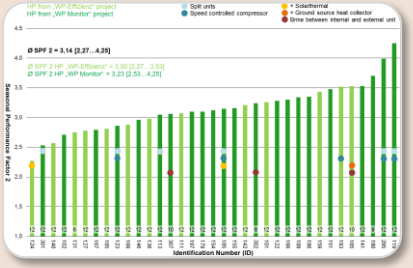
Sustainability – Real Quality vs. Designed Quality

- Project design → tender documents
  - Design-build contract – technical description with quality req. + system diagram
  - Assessment of tenders – equipment, system design, performance, price offer (LCC)
- Detailed design – installation period
  - Continuous quality control (QC)
- Commissioning
  - Extensive functional testing – components, sub-systems and total system
  - Performance testing – SAT (Site Acceptance Test)
- Trial operating period (min. 12 months) with plant tuning → hand-over
- Plant monitoring → optimized operation – regular maintenance



Thank you for your attention!