Aquifer Thermal Energy Storage (ATES) and direct use of groundwater for heating and cooling – Norwegian experiences

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Agenda

ATES = Aquifer thermal energy storage
- What, where, how and how much?
- Iron precipitation

Experiences in Norway
- Regulations
- Potential
- Research
- Documentation
- Some examples

Summary

ATES = Aquifer thermal energy storage

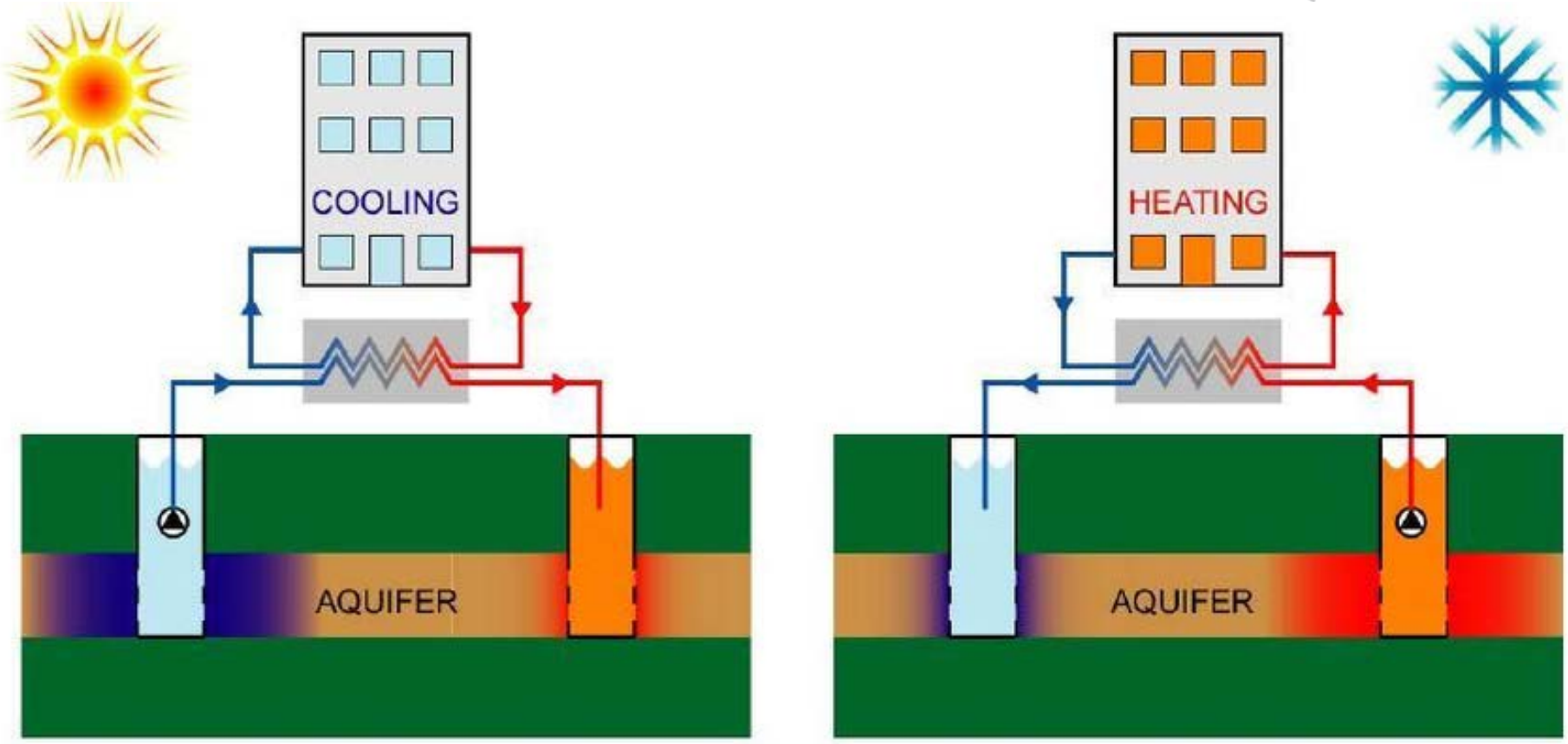
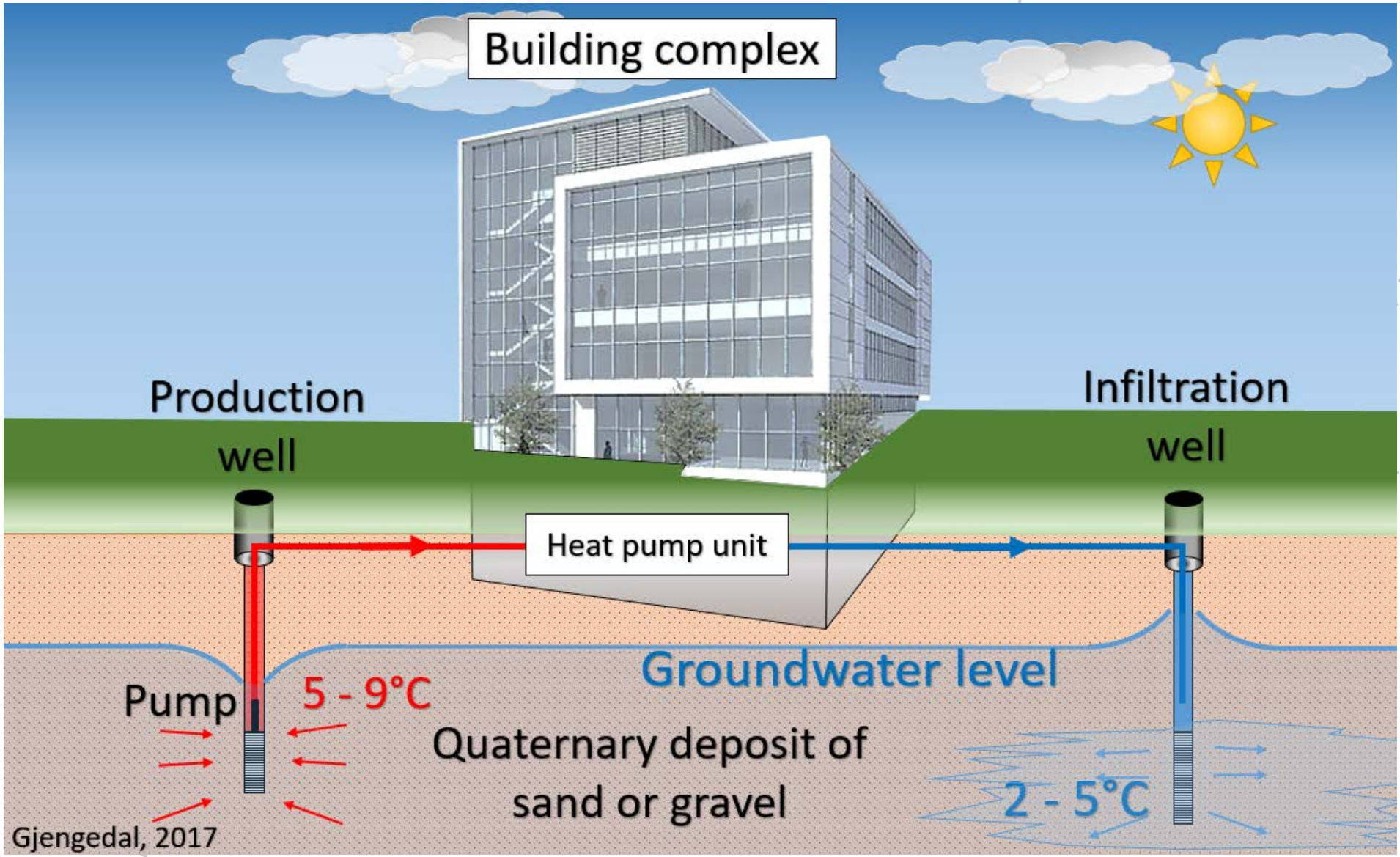


Illustration: IEA Heat pump centre

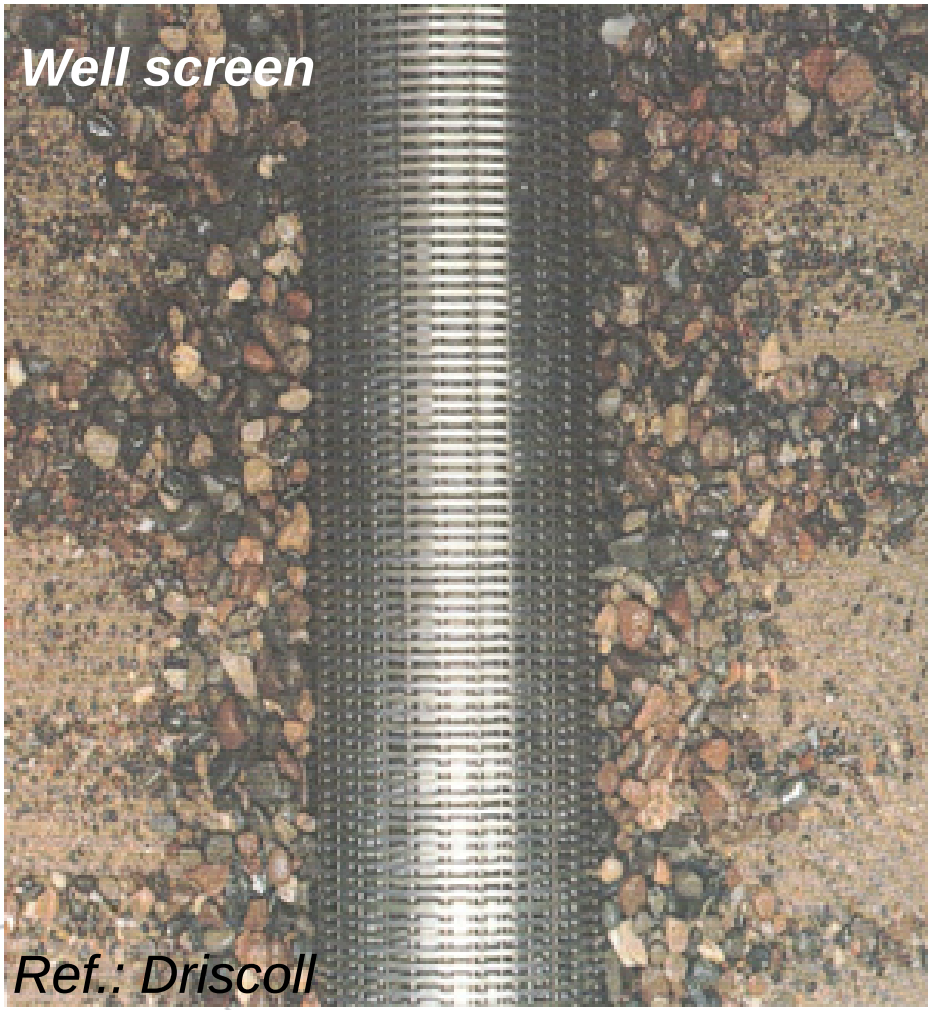

Building complex
Production well
Infiltration well
Heat pump unit
Groundwater level
Pump
5 - 9°C
Quaternary deposit of sand or gravel
2 - 5°C
Gjengedal, 2017

The groundwater well

Typical in Norway:

- Sand and gravel of glacial or fluvial origin
- Con-slot well screens
- Producing 10-30 liters/second per well (sometimes more)
- Stable groundwater temperatur, but must be above freezing level
- Water chemistry - especially iron and manganeese can be a challenge

The groundwater well cont.



Energy and power from water

Power (kW) = $Q \times \Delta T \times C_{H2O}$

- Q: Extraction rate of groundwater (m^3/h)
- ΔT: Extraction rate of temperature (^oC)
- C_{H2O}: Specific heat capacity of water, 1,17 ($kWh/m^3,^oC$)

Example:

- 20 l/s=72 m^3/h, ΔT= 4 ^oC ➔ ≈ 340 kW from the groundwater

➔ 2/3 from the groundwater, and 1/3 from electricity to run the heat pump. Heat delivered from the heat pump is around 500 kW.

➔ Assuming 3000 operating hours per year, gives a production of heat corresponding to 1,5 GWh/year.

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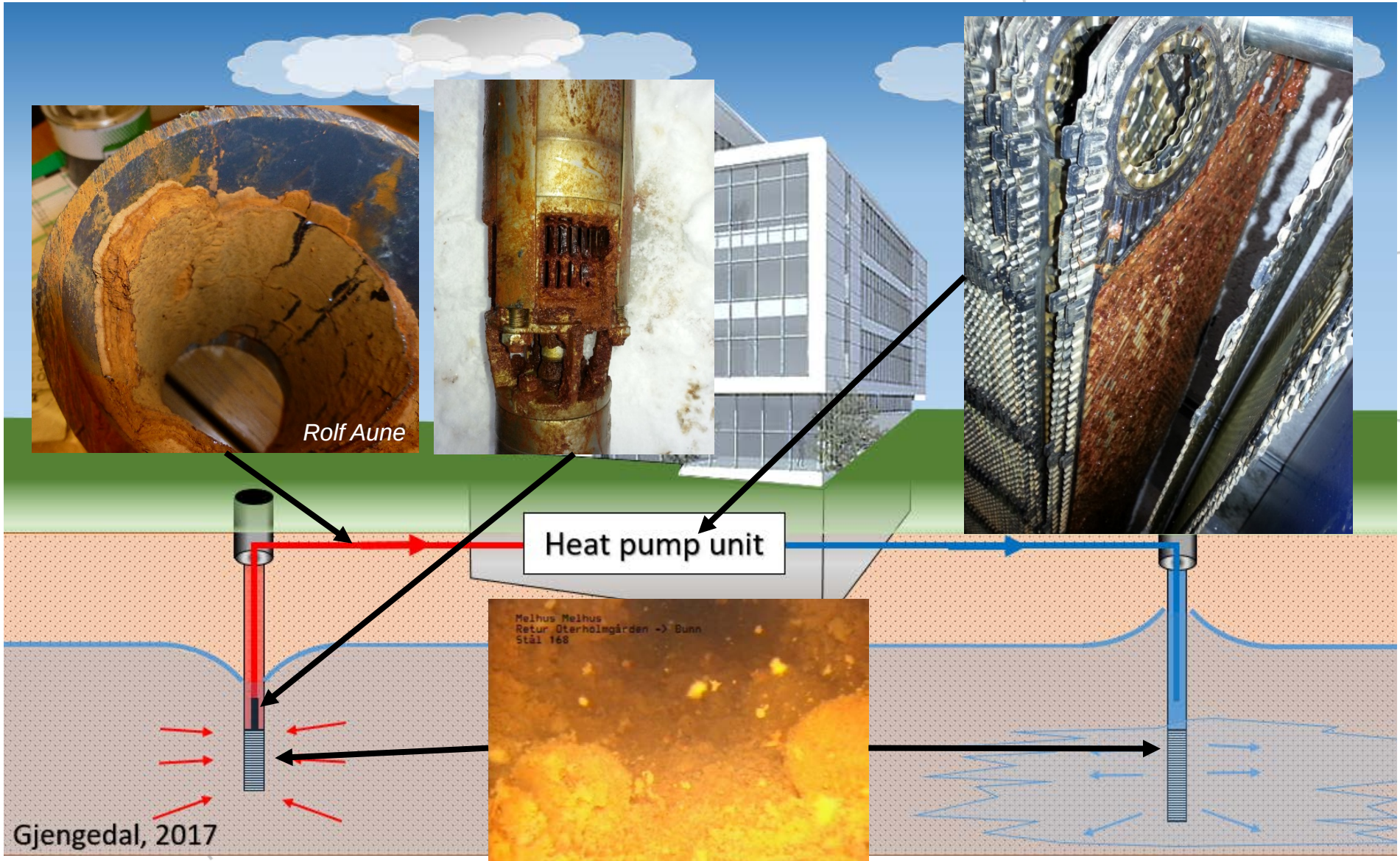
Iron precipitation



Water resources legislation – groundwater regulations

- Some new changes by 1.1.2018:
  - § 43a: Duty of *general care* for the groundwater
  - § 45: Duty to report if the extraction of groundwater is higher than 100 m^3/day (4,2 m^3/h) and request of an evaluation for groundwater extraction licence
  - A property owner can extract groundwater for household and farm animals at the property without licence for groundwater extraction.
- Drilled wells must be reported to the Geological Survey of Norway and the welldatabase GRANADA
- Groundwater wells for energy: Some confusion, but probably «*duty of report» to evaluate the need for licence.*

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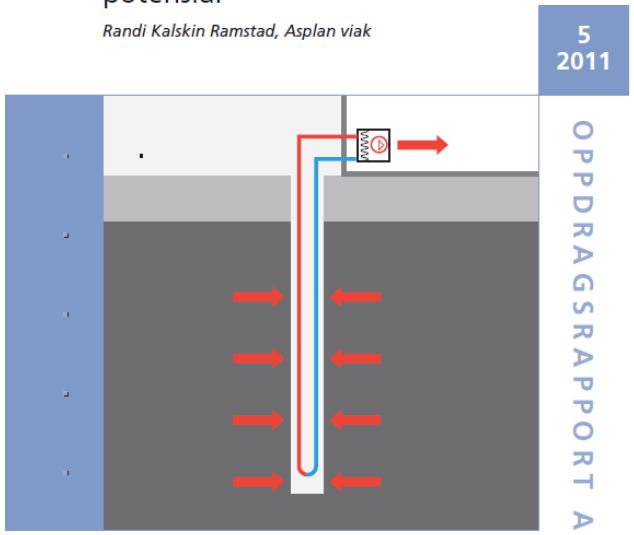
Geoenergy in Norway – mapping economical potential

Theoretical potential for ATES and extraction of groundwater for heating and cooling is approximately 6 TWh/yr

Based on mapped glasifluvial and fluvial deposits in areas with buildings having a heating and cooling demand.



Research on ATES - ORMEL

- ORMEL = optimal resource utilization of groundwater for heating and cooling in the municipality of Melhus and Elverum
- Main goal: To provide a solid and sustainable basis for an optimal use and management of the groundwater resources for heating and cooling purposes in the central part of Melhus and Elverum
  - Mapping the capacity and character of the groundwater resource
  - Iron and manganese challenges
  - Follow up and monitoring of plants
- Partners: Melhus and Elverum municipality, NTNU IGP and EPT, Geological Survey of Norway (NGU) and Asplan Viak AS
- Project period: 2015-2018
- Financing:
  - 6 MNOK from Regional Research Fund Mid-Norway (RFFMN)
  - 2 MNOK from partners
  - PhD-funding from NTNU IVT
- PhD-student Sondre Gjengedal

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Documentation of well installations

Why documentation is smart:

- Verifying ok installations, and as described (and payed for).
- As-built documentation to be used in operation of the plant.
- Easier to find causes and solving eventual challenges.
- Documentation of before and after situations

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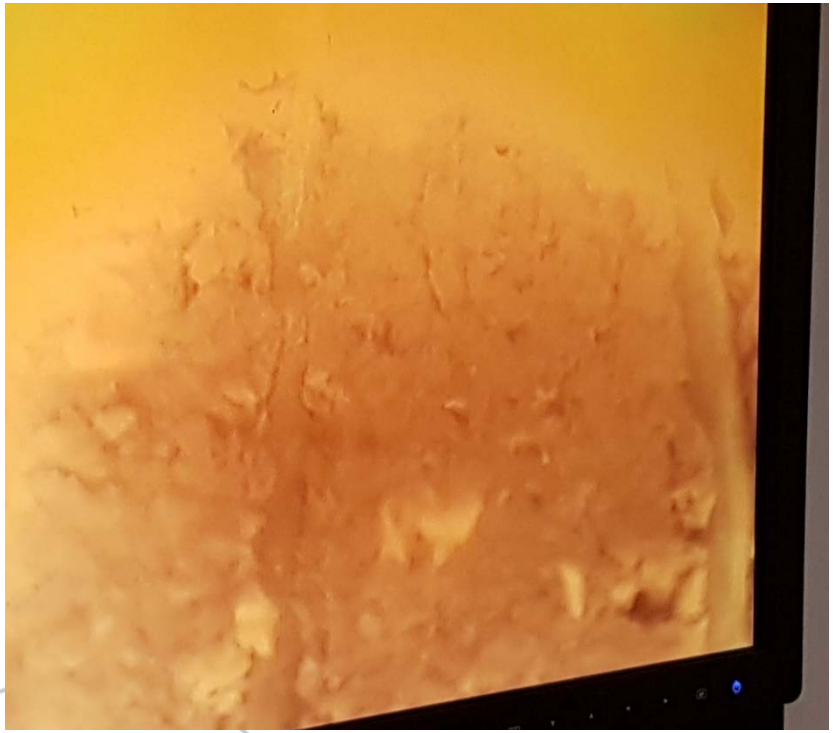
Documentation of well installations cont.

- *new con-slot screen*

Pictures by Gjøvaag AS

Documentation of well installations cont.
- not so new well…

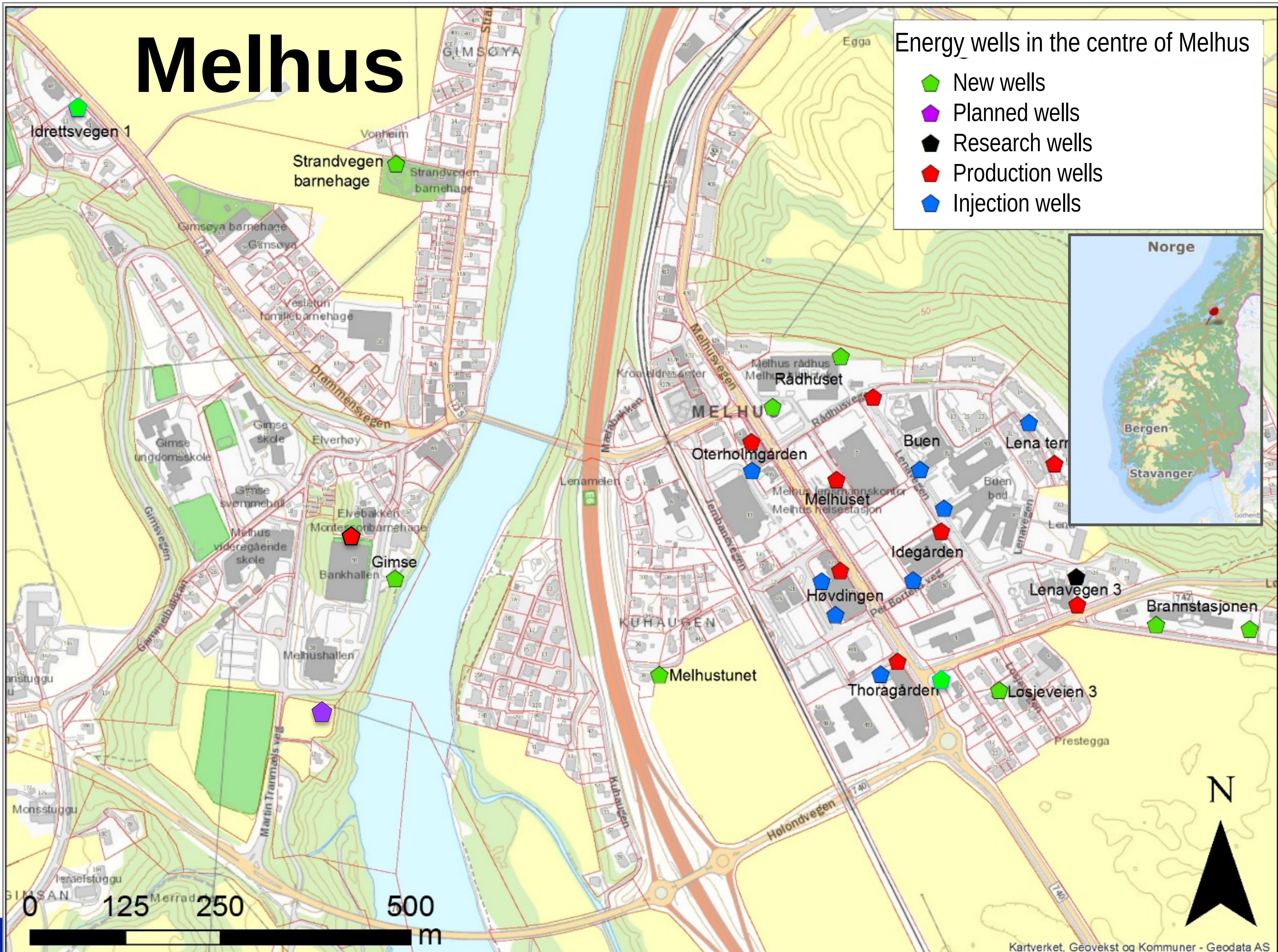


Gardermoen Oslo Airport

- ATES from 1998
- 9 MW cooling and 7.5 MW heating
- 9 varm and 9 cold wells to 45 m depth
- Groundwater temperature:
  - Cold wells 4.1 – 4.5 ºC
  - Varm wells 4.5 – 20 º C
- Investment ATES system
  - 17 mill NOK
  - Pay back time 2 years

- Major problems with iron precipitation and iron bacterias
- Yearly maintenance is needed

Foto: Oslo Lufthavn AS



Melhus
Energy wells in the centre of Melhus
New wells
Planned wells
Research wells
Production wells
Injection wells
Norge
Bergen
Stavanger
Idrettsvegen 1
Strandvegen barnehage
Rådhuset
Oterholmgården
Buen
Lena terr
Melhuset
Idegården
Høvdingen
Lenavegen 3
Brannstasjonen
Gimse
Melhustunet
Thoragården
Losjeveien 3
0
125
250
500
m
N
Kartverket, Geovekst og Kommuner - Geodata AS

Summary

- Large potential for ATES
- Medium to large installations
- Need for hydrogeological and heat pump knowledge in pre-studies, operation and regular maintenance.
- Be aware of iron precipitation. Keep the system free of oxygen!
- Documentation is smart (and cheap).

Thank you!

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