



Thermal and geothermal storage



Kirsti Midttømme & Jan Kocbach

21.10.2014

Geothermal energy and including Underground Thermal Energy Storage (UTES)

<u>Country</u>	<u>GWh/yr</u>	<u>MWt</u>	<u>Main Use</u>
China	20,932	8,898	bathing/district heating
USA	15,710	12,611	GHP
Sweden	12,585	4,460	GHP
Turkey	10,247	2,084	district heating
Japan	7,139	2,100	bathing (onsens)
Iceland	6,768	1,826	district heating
France	3,592	1,345	district heating
Germany	3,546	2,485	bathing/district heating
Netherlands	2,972	1,410	GHP
Canada	2,465	1,126	GHP
Norway	2,300	1,300	GHP
Switzerland	2,143	1,061	GHP



Geothermal Heat Pumps

Ice exported from Norway - Underground cold storage, London



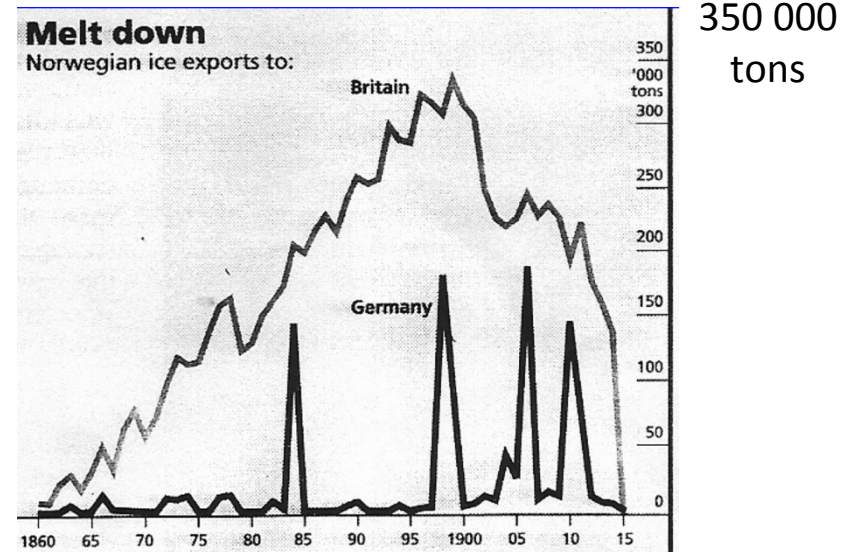
Ice production, Notodden, Norway



Building by the riverside,
Regents Canal, London



Underground ice storage,
Syon Park, West London



Norwegian ice exports to Britain and
Germany, 1860-1915

— eCool —
"red verden"
— én jordkølet øl ad gangen

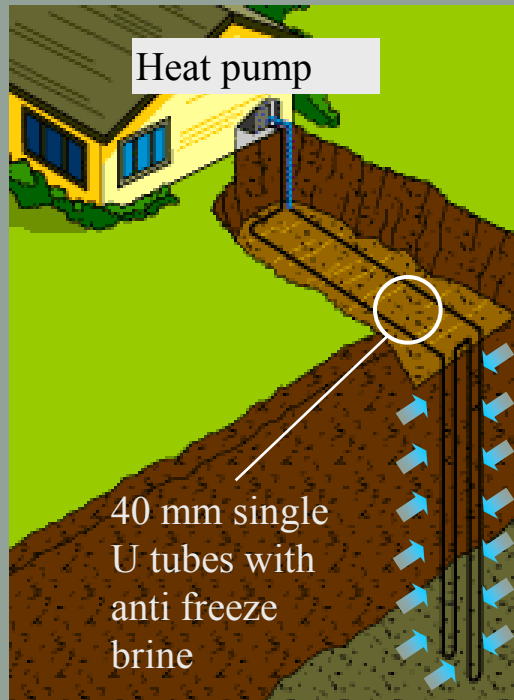
Kølle øl
året rundt

Ingen
brug af
elektricitet

Frostfri
om vinteren



Underground (Borehole) Thermal Energy Storage (UTES/*BTES*)



Heating



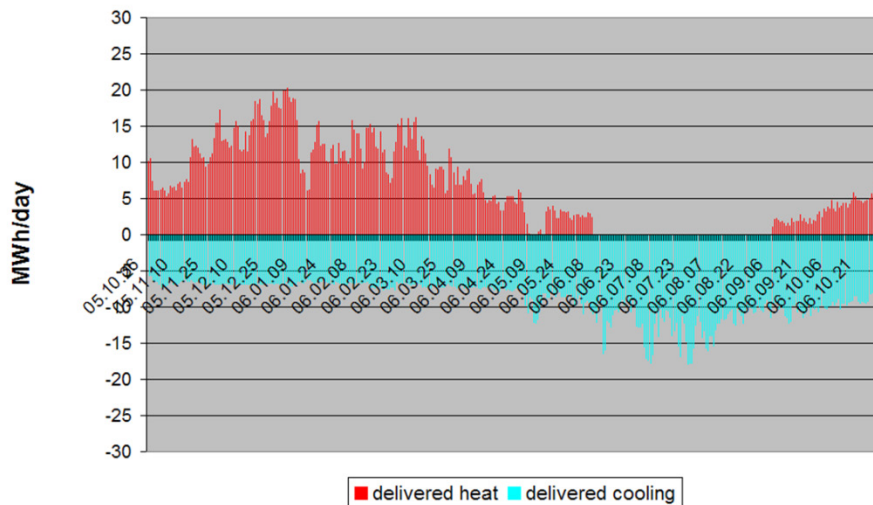
Cooling

Borehole Thermal Storage System (BTES)

Alnafossen office building, Oslo



BTES with 52 boreholes
to 150 m depth



Delivered heat/cooling from
the BTES to the building
throughout the year

2013

2011

2010

2013

2001

2010



Sartor mall
165 x 200m



Kleppestø school
19 x 180m



Clamper school
5 x 180m



COOP Åsane
112 x 212m



Åsane
50m



Olav Grevstad AS
6 x 190m



4 apartment
houses Varden
12 x 160m



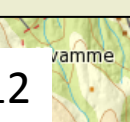
University College
Bergen
80 x 220m



Haukeland
75 x 250m



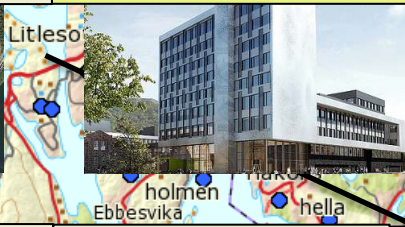
Kolstien
11 x 200m



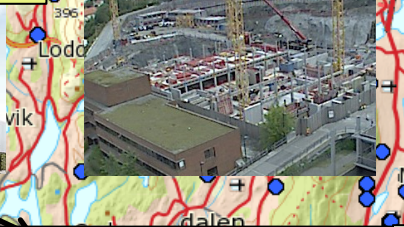
Ådnemarka school
14 x 190



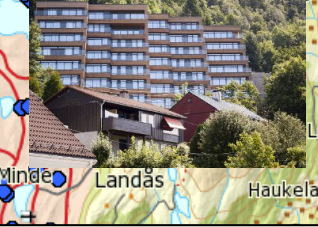
Spar Kjøp Kokstad
18 x 170m



Sælenveien 91
18 x 170m



Chr M Vestreheim
7 x 170m



Espehaugen 45
6 x 200m



Apeltun school
10 boreholes



2010



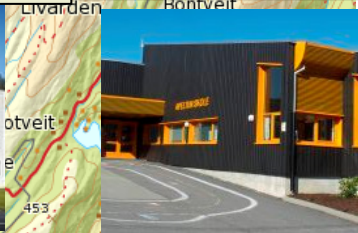
2012



2010



2012



2003

2009

BTES New Akershus University hospital (Ahus), Norway

- Operation from 2008
- 137 000 m²
- 228 boreholes of 200 m depth
- Heat pump, 8 MW
- Energy production
 - Heat 26 GWh
 - Cooling incl. free cooling 8 GWh
- Investment cost BTES
 - 100mill NOK



Foto: Båsum boring AS

Gardermoen airport, Oslo, 1998

Building area: 150 000 m²

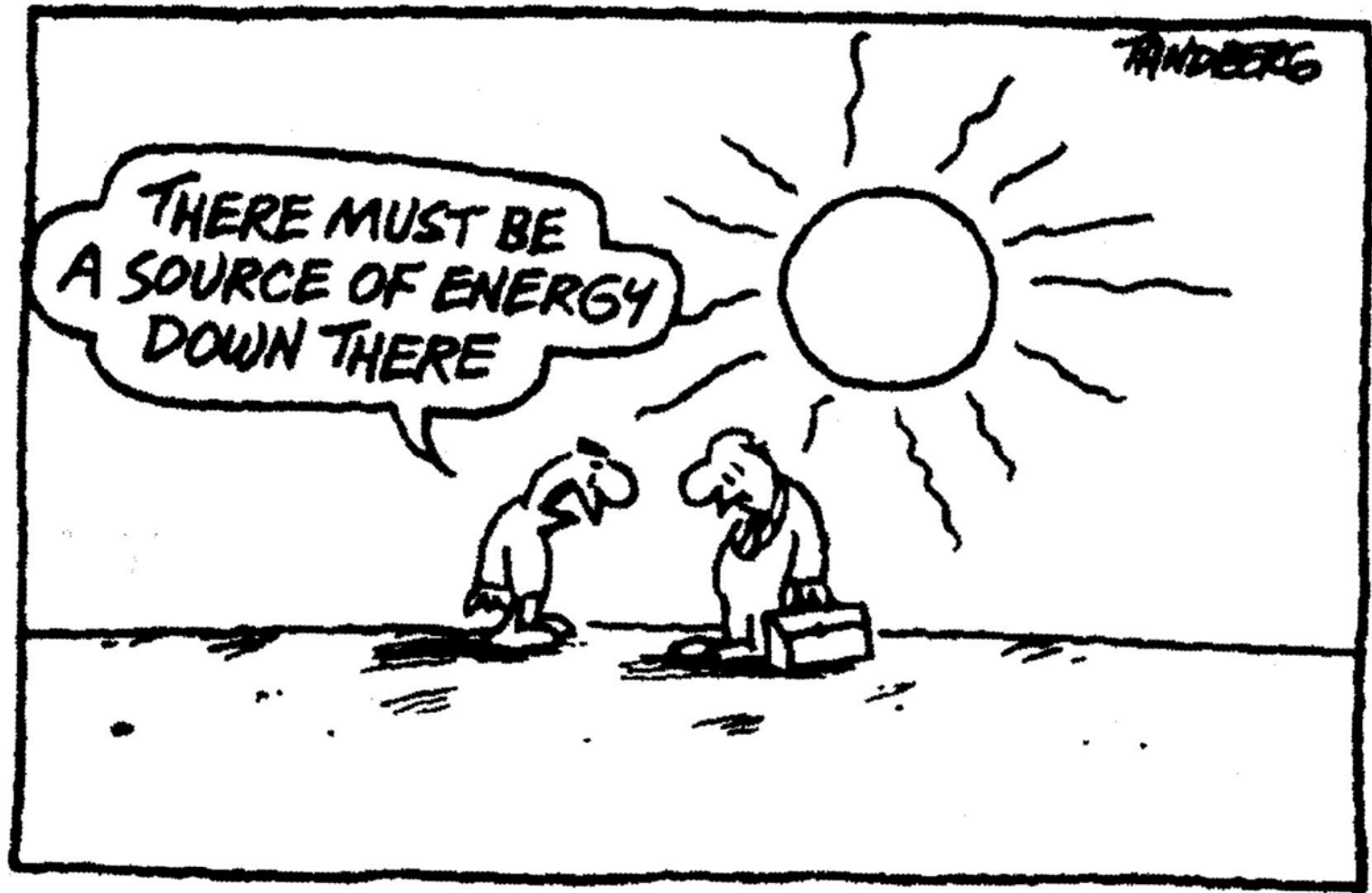
- **Aquifer Thermal Energy Storage (ATES) system**
 - 9 MW cooling
 - 7.5 MW heating
- 9 warm and 9 cold wells
 - 45 m depth
- **Groundwater temperatures**
 - Cold wells 4.1 – 4.5 °C
 - Warm wells 4.5 – 20 °C
- **Energy production 2004**
 - Heat 11 GWh
 - Cooling incl passive cooling 11GWh
- **Investment ATES system**
 - 17 mill NOK
 - Payback time <4 years



Foto: Oslo Lufthavn AS

Energy Storage

- utilizing of local available energy



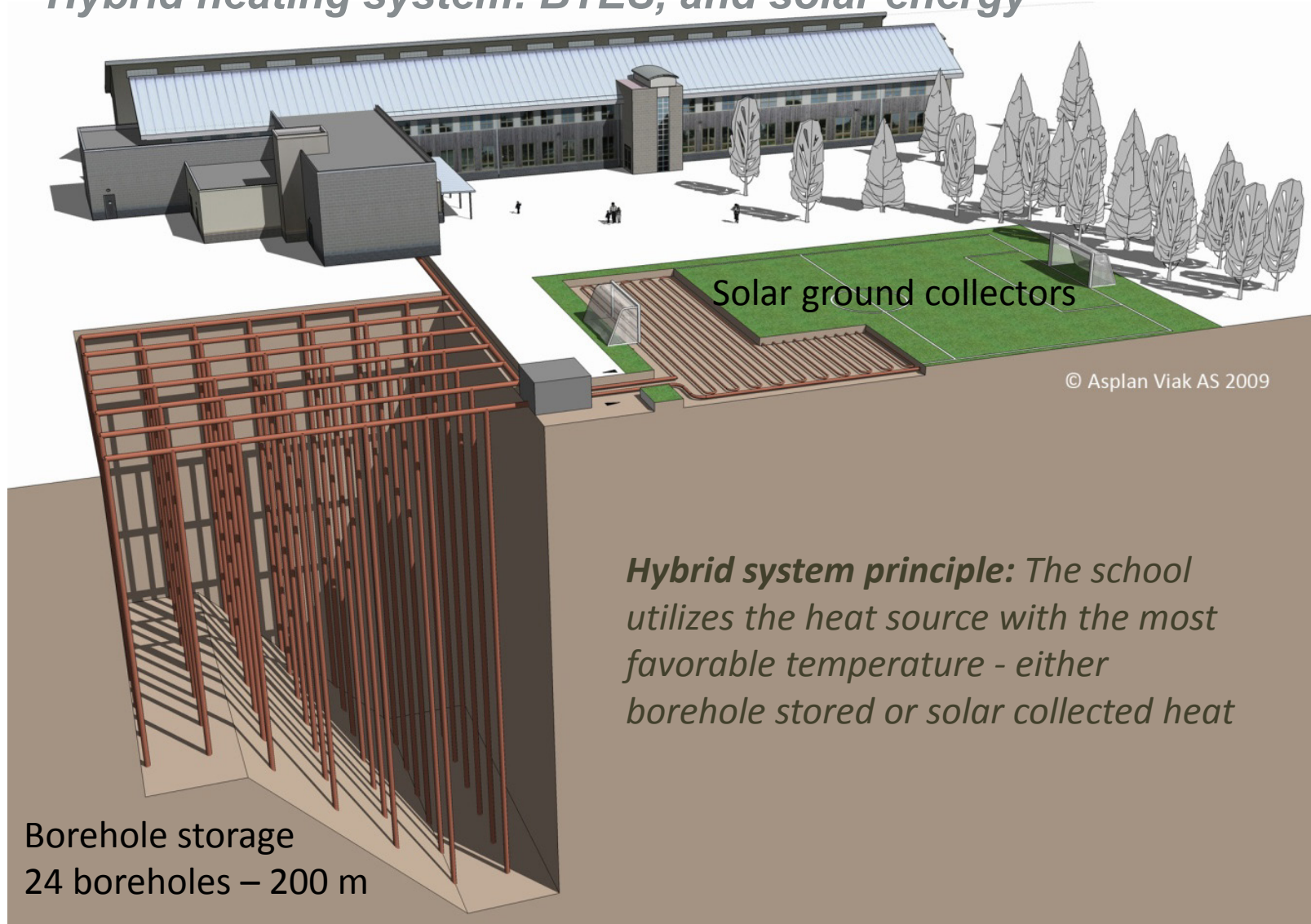
High Temperature BTES, Emmaboden, Sweden

- Seasonal storage of waste heat from the foundry in the summer - to be recovered for space heating during winter
- 140 boreholes, 150 m depth
- Borehole spacing; 4 m
- In operation since Summer 2010
- Designed for charging 3800 MWh of which 2600 MWh is predicted to be recovered for space heating
- Working temperature 60 /40 °C



Ljan school, Oslo

Hybrid heating system: BTES, and solar energy



Bergen University College

BTES and ice storage tanks



81 BHE to 220 m depth
heat 1 700 kW
cooling 1400 kW

4 ice storage tanks 250 m³
diurnal storage
11200 kWh = 7 timer á 1600 kW
-Freezing temperature 10 C



Heat to power – VDG Craftengine

CRAFTENGINE

PROVIDING RENEWABLE ENERGY AT A LOW COST



CRAFTENGINE™ POWERPACK – WASTE HEAT TO ELECTRICITY

- Waste Heat Recovery System with Power Output up to 40 kW_e
- Industrial Engine Design by Viking Heat Engines and AVL Schrick
- Low Cost and High Reliability
- Heavy Duty Expander Design – Low Maintenance and Long Lifetime
- Cost-Effective – Competitive Energy Costs (typ. €5-8 cents/kWh)

The **CRAFTENGINE™ POWERPACK** accepts any available waste heat source with temperatures from ~90 °C (190 °F) and upwards to generate electricity, without the need to burn fuel. If sufficiently low cooling temperatures are provided, usage of even lower feed temperatures are possible.

The **CRAFTENGINE™ POWERPACK** can effectively utilize a variety of waste heat sources (exhaust, off-gases, steam and hot water) from diesel engines, gas engines, turbines, waste incinerators, metal smelters, food plants, dairy plants, chemical plants and more.



Some waste heat sources:

UTES applications

- Temperature 2-17C (60C)
- Power <10 MW
- Capacity: 50 -85 %
- Efficiency: 10 –50 kWh/t
- Storage time: day – years
- Operation cost: low



Nydalen Næringspark