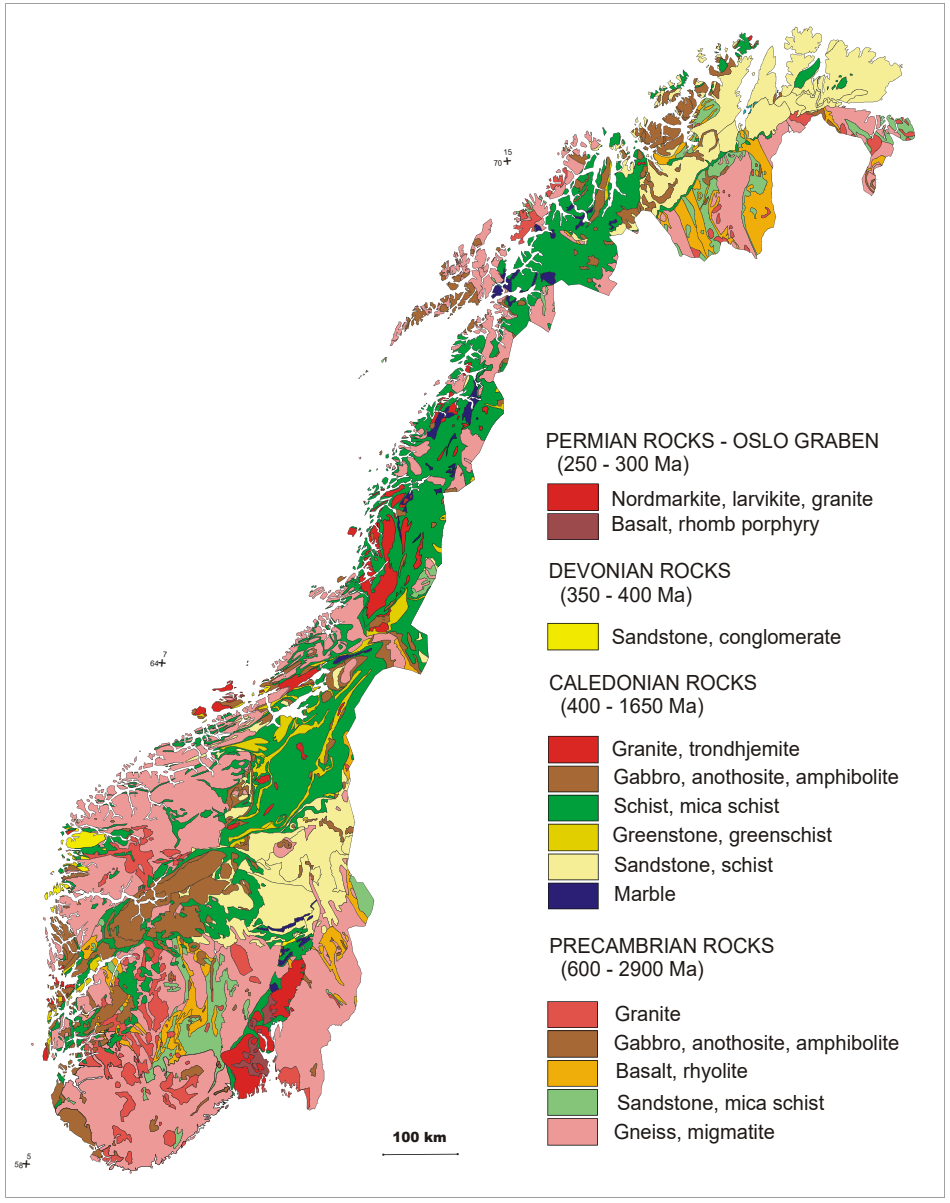
Present state, best practices and future developments of geothermal activities in Norway

Kirsti Midttømme

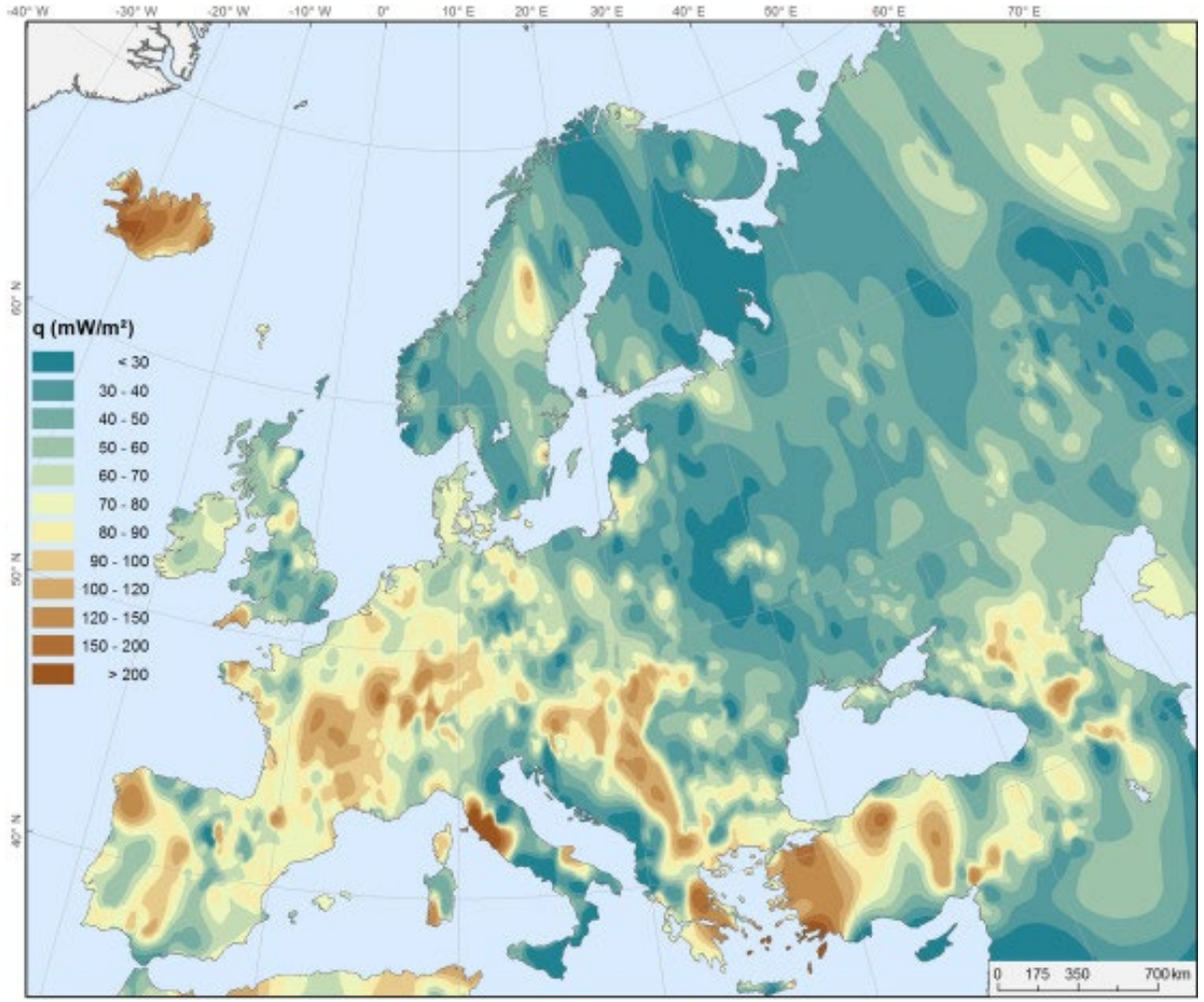
NORCE Norwegian Research Centre

17. JUNI 2022

Bedrock map of Norway



Heat flow map of Europe



S. Hurter, R. Haenel Atlas of geothermal resources in Europe (2002)

IEA Key World Energy Statistic 2021

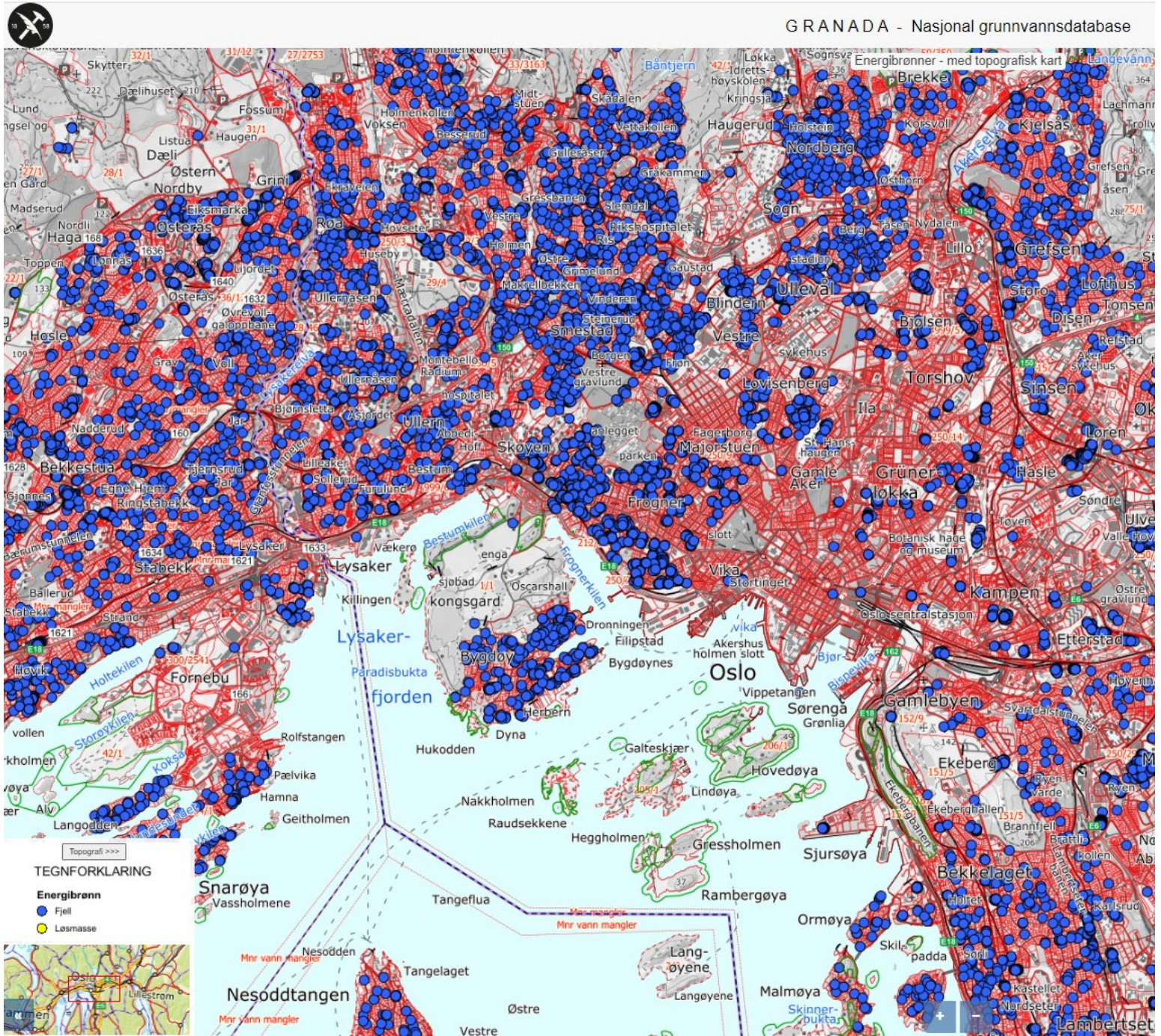
	Population (Million)	Total Energy Supply / population (GJ /capita)	Electric consumption/ population kWh / capita	CO_2 / population tCO_2 /capita
Estonia	1.3	166	6998	7.46
Finland	5.5	253	15568	7.27
Norway	5.3	215	23762	6.52
Sweden	10.3	200	12787	3.27

*CO_2 emissions from fuel combustion only. Emissions are calculated using the IEA World Energy Balances and the Revised 2006

Geothermal utilization in Norway

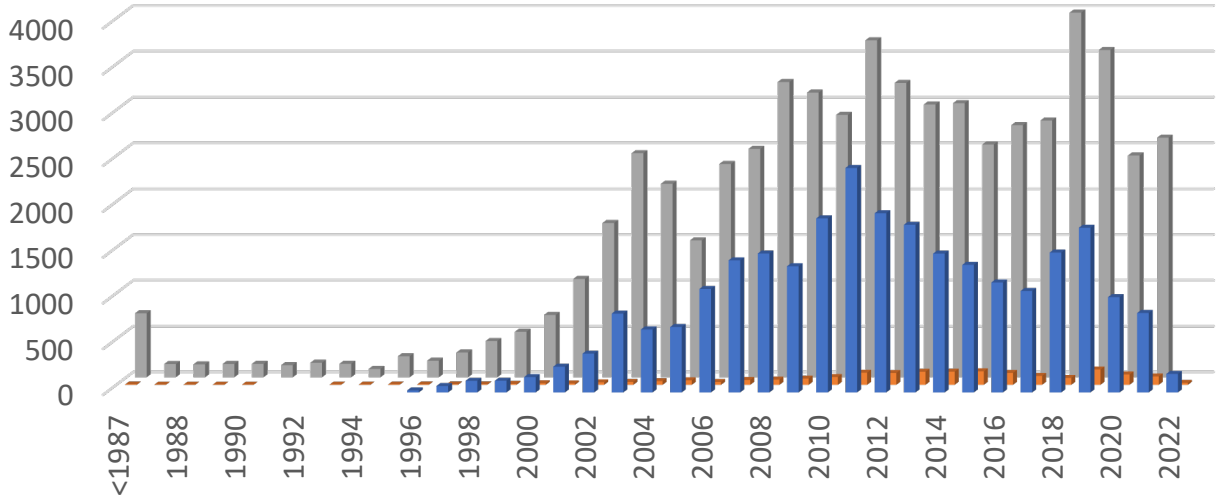
	MW	GWh/yr
GSHP	1150	3500
Direct Use	< 1	<1
Power	0	0
Total	**1150**	**3500**

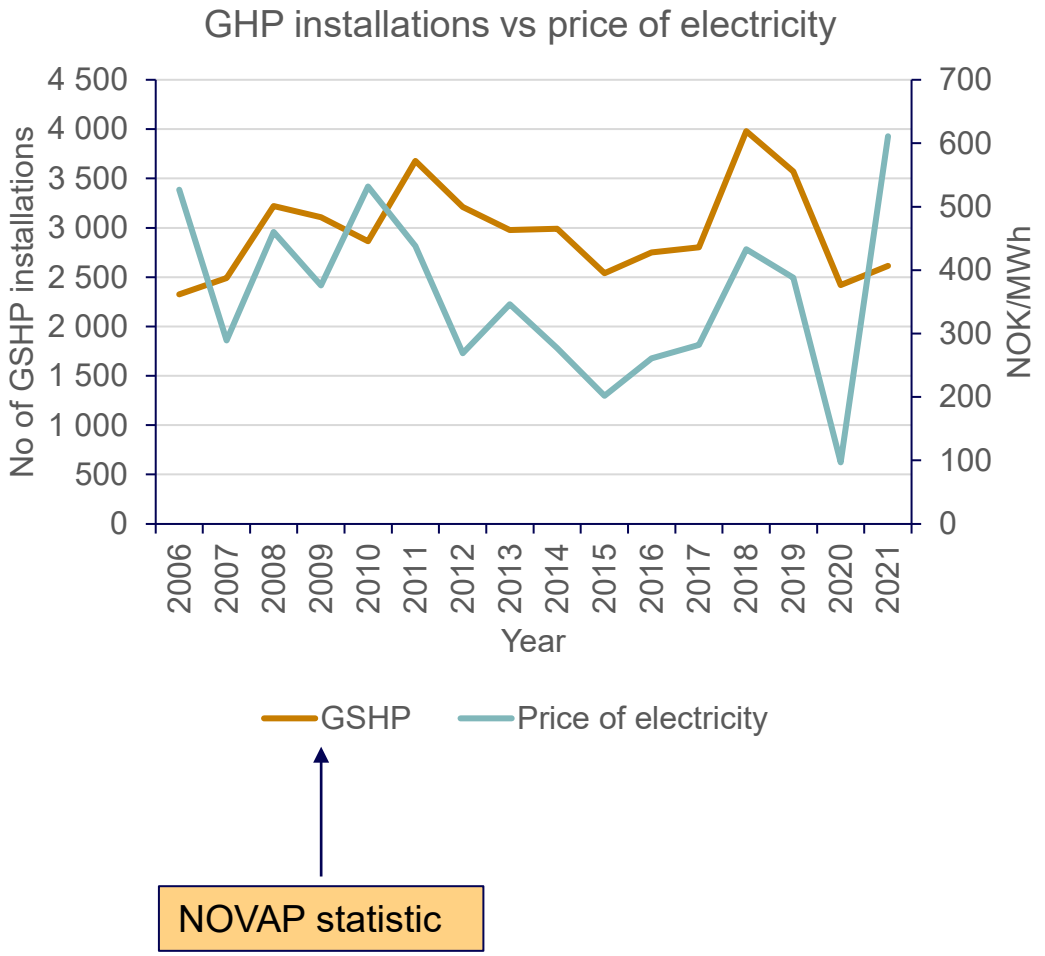
National well and borehole database: Boreholes for energy use, Oslo



Ground Source Heat Pump installations

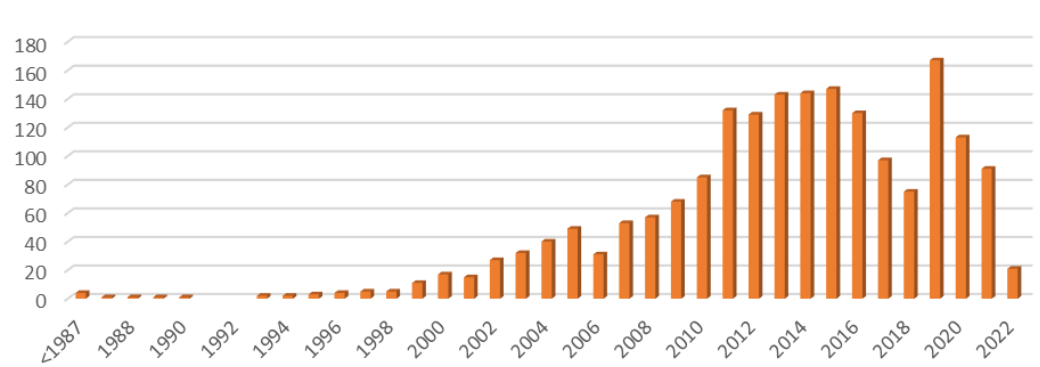
- Installed capacity 1150 MW
- Energy use (energy saving) 3.5 TWh
- Ca 70 000 installations incl 2000 large installations >4 BHE (25 kW)

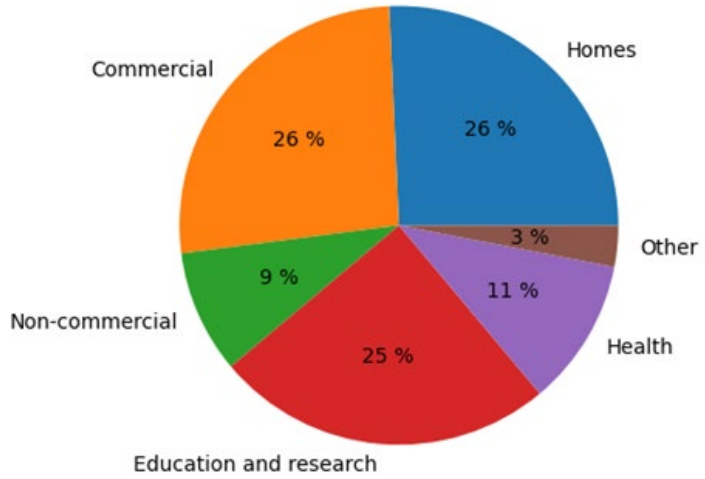




Large GSHP installations

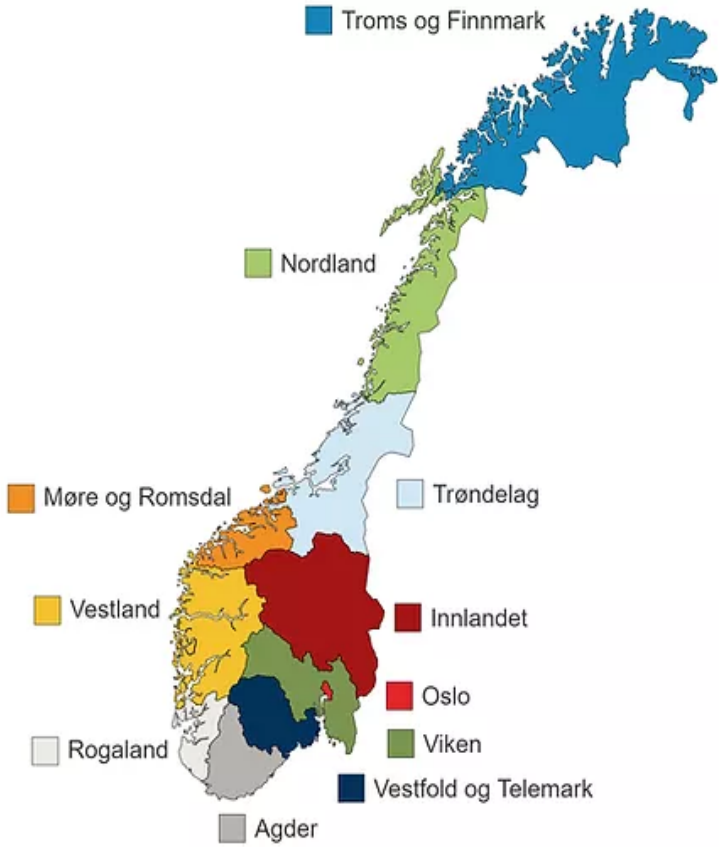
- >4 boreholes (BHEs) (25 kW)





Installation	Building type	No of BHEs	Total length of boreholes -m	Year
Ahus	Hospital	228	45600	2007
Avantor- Nydalen syd	Business	180	42500	2004
Sartor senter	Mercantile	167	33268	2013
Idrettshøgskolen	Educational	97	29100	2016
Ulven borettslag	**Residential**	**88**	**27698**	**2019**
Arcus	Industrial	91	27300	2012
Sykehuset Østfold	Hospital	100	24429	2013
Stavanger universitetssykehus	**Hospital**	**96**	**24000**	**2020**
Ullevål stadion	Sport/Business	120	24000	2009
Coop Åsane	Mercantile	114	23874	2013
Marikollen ungdomsskole	Educational	85	23327	2017
Stavanger Forum	Exhibitions	85	21250	2011
Maridalsveien borettslag	**Residential**	**59**	**20727**	**2019**
Manglerudjordet borettslag	**Residential**	**67**	**20033**	**2018**
Vulkan kontorbygg	Business	68	19000	2010
Haukeland sykehus barne avd	Hospital	77	18730	2012
Ørlandet flyplass	Airport	72	18000	2016
Thon Sørlandssenteret	Mercantile	90	18000	2011
Postterminalbygget	Business	90	18000	2010
Diakonhjemmet	**Hospital**	**60**	**17865**	**2019**
IKEA Slependen	Mercantile	86	17200	2009
Universitetet i Sør Øst Norge	Educational	70	17110	2009
Vestre Billingstad, borettslag	**Residential**	**52**	**17045**	**2021**
Rælingen videregående skole	**Educational**	**51**	**16320**	**2021**
Høgskolen i Bergen	Educational	80	16000	2012
St.Hansberget borettslag	**Residential**	**45**	**15720**	**2021**

Regional variations of GSHP



Regions	Population		Single family houses		Large installations	
Inland region	**2765142**	**51 %**	**20481**	**73 %**	**1284**	**67 %**
Viken	1269230	23 %	9972	36 %	619	32 %
Oslo	699827	13 %	4177	15 %	349	18 %
Innlandet	371253	7 %	4746	17 %	167	9 %
Vestfold og Telemark	424832	8 %	1586	6 %	149	8 %
Costal regions	**1704071**	**31 %**	**4026**	**14 %**	**400**	**21 %**
Agder	311134	6 %	471	2 %	44	2 %
Rogaland	485797	9 %	1083	4 %	124	6 %
Vestland	641292	12 %	1969	7 %	144	8 %
Møre og Romsdal	265848	5 %	503	2 %	88	5 %
Middle region	**474131**	**9 %**	**2632**	**9 %**	**95**	**5 %**
Trøndelag	474131	9 %	2632	9 %	95	5 %
Northern regions	**481926**	**9 %**	**873**	**3 %**	**131**	**7 %**
Nordland	240190	4 %	501	2 %	61	3 %
Troms og Finnmark	241736	4 %	372	1 %	70	4 %
Total	**5425270**	**100 %**	**28012**	**100 %**	**1910**	**100 %**

- Norway has several climate zones with combinations of costal, inland, polar and mountain climate
- The distance to Sweden seems to be a factor in the prevalence of GHPs

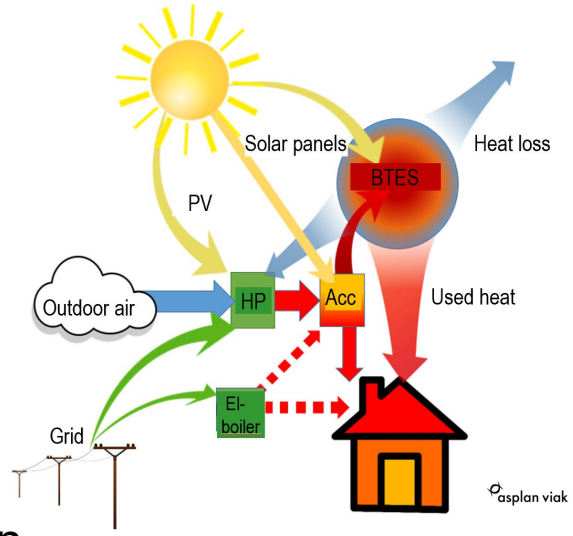
Ref. National well database

HT-BTES, GeoTermos, Fjell 2020, Norway

Energy system Fjell school (2020)

- High temperature BTES
- Injection of solar energy by use of air source heat pump and PVs
- Direct heating of the school, by 30°C water-based underfloor heating system

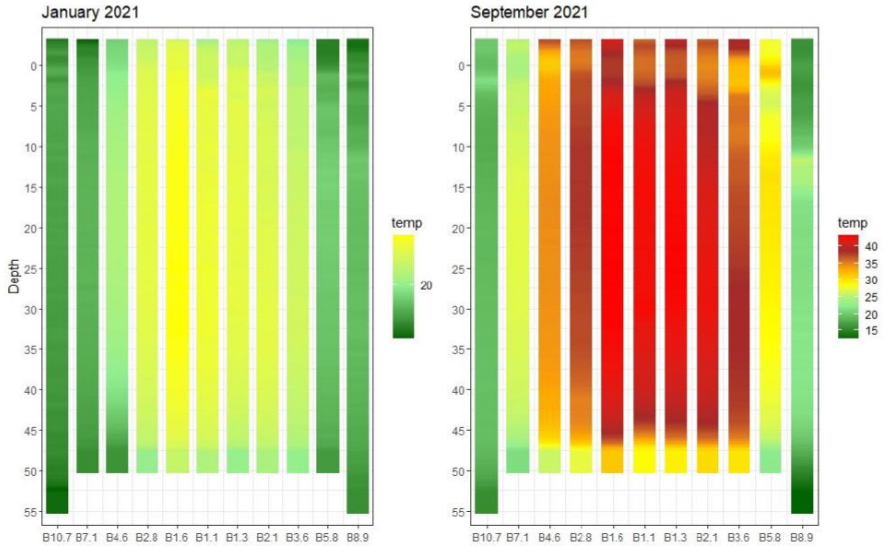


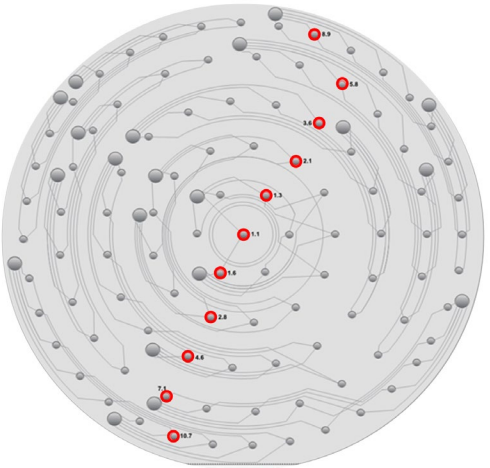




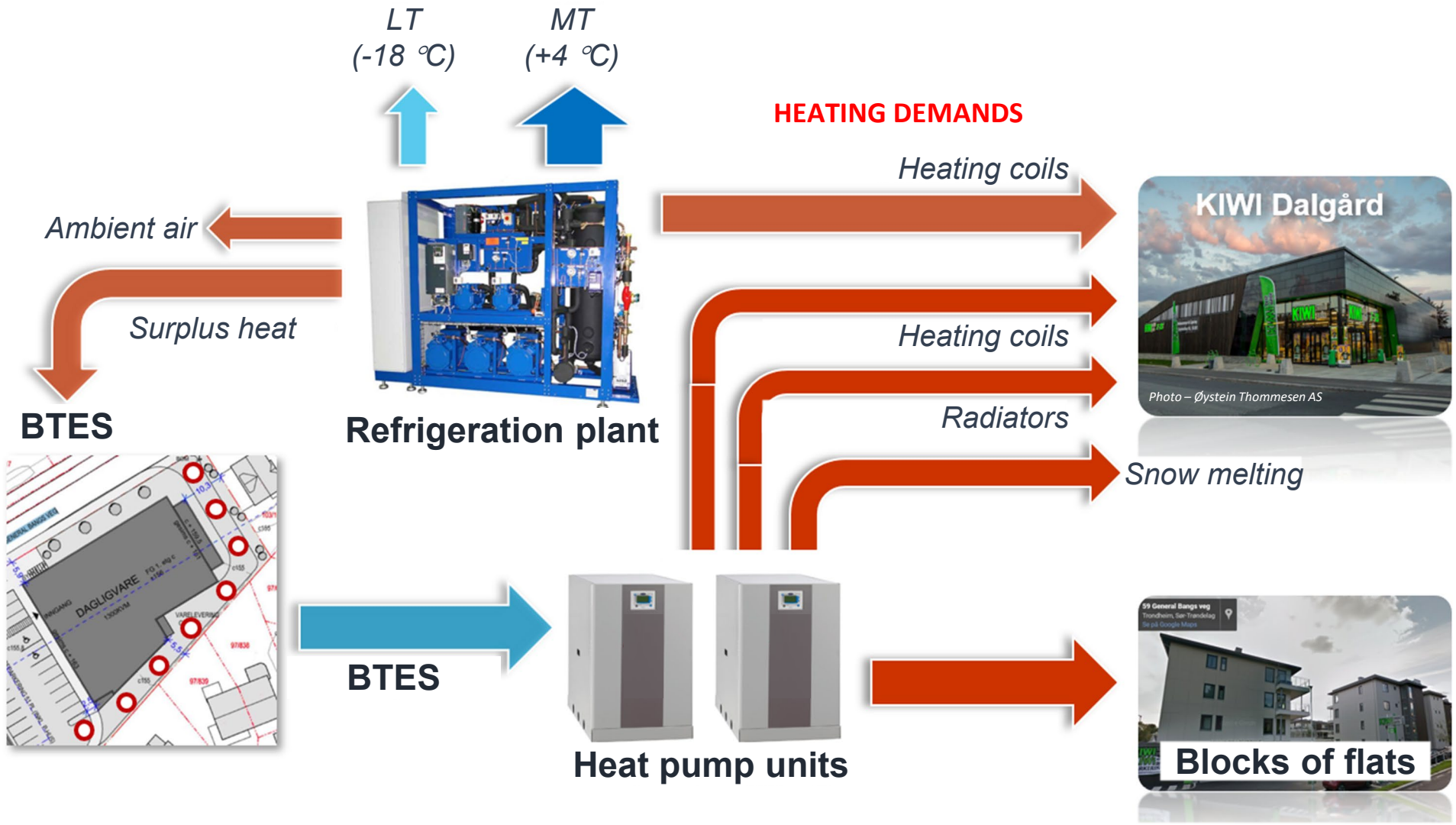
HT- BTES

- 100 BHEs a 50 m in a circle configuration.
- Fiber for distributed temperature sensing installed in 11 of the BHEs
- Granite, no/low groundwater flow
- Injection of heat started April 2020
- Temperature Sept 2021 19-43 °C





Integrated energy systems with BTES



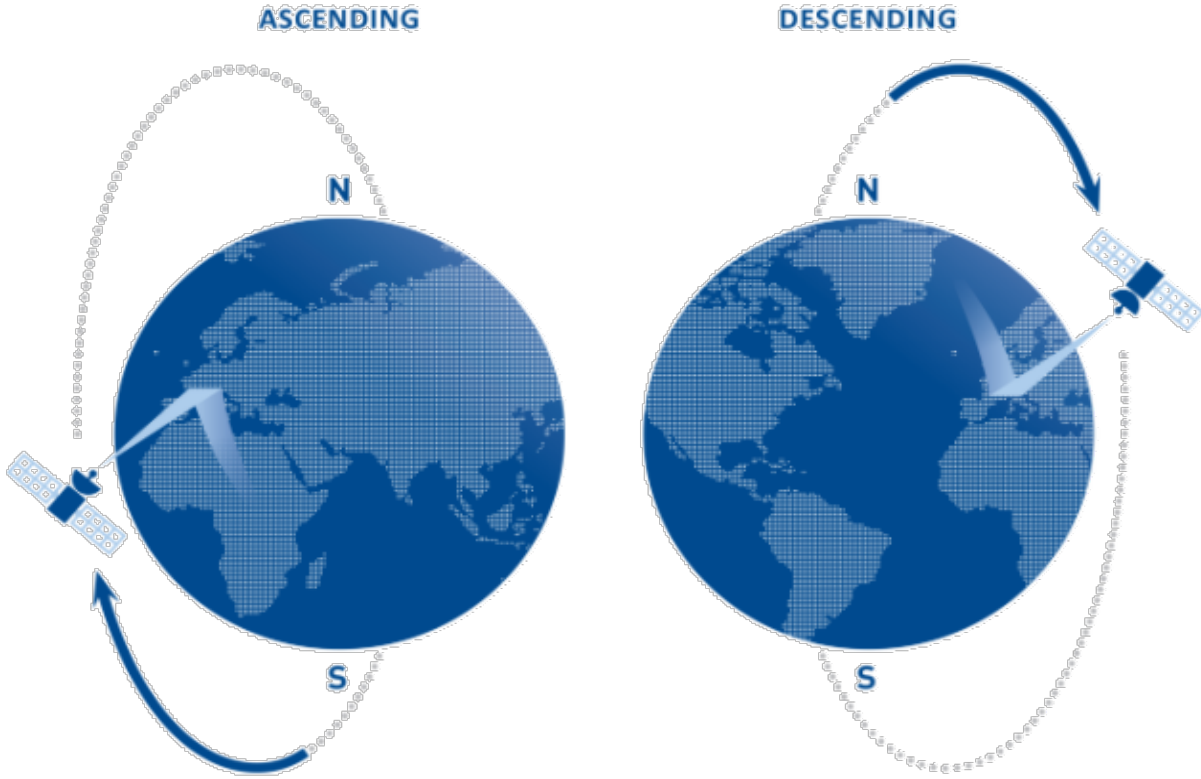
Ref Jørn Stene Cowi

Satellite synthetic aperture radar remote sensing InSAR

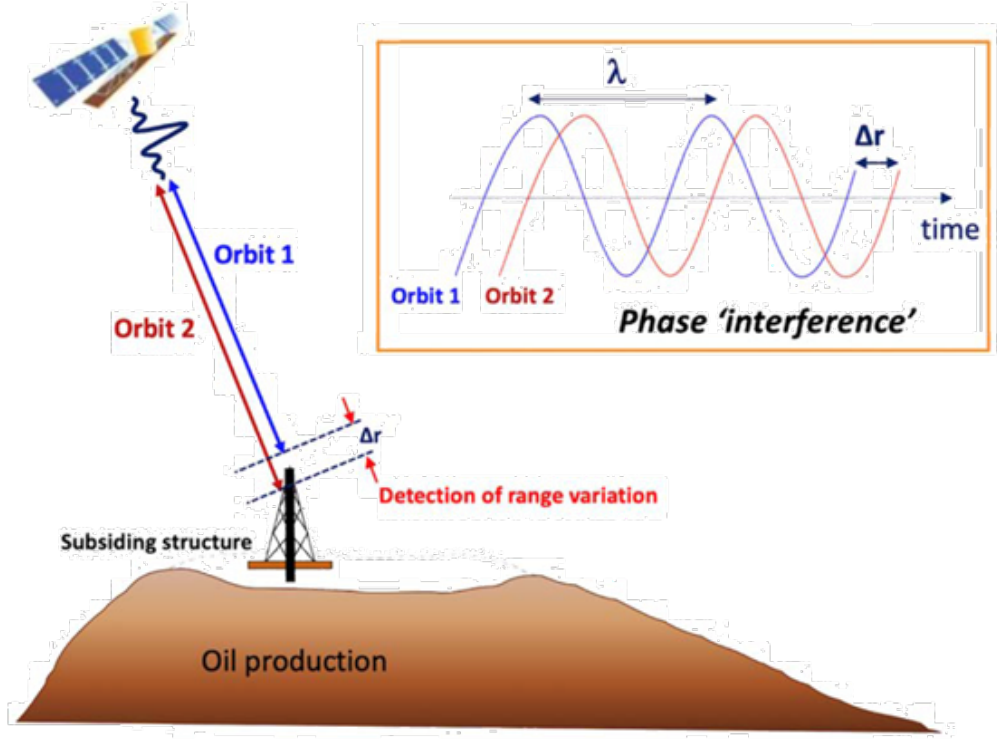
No need for external illumination

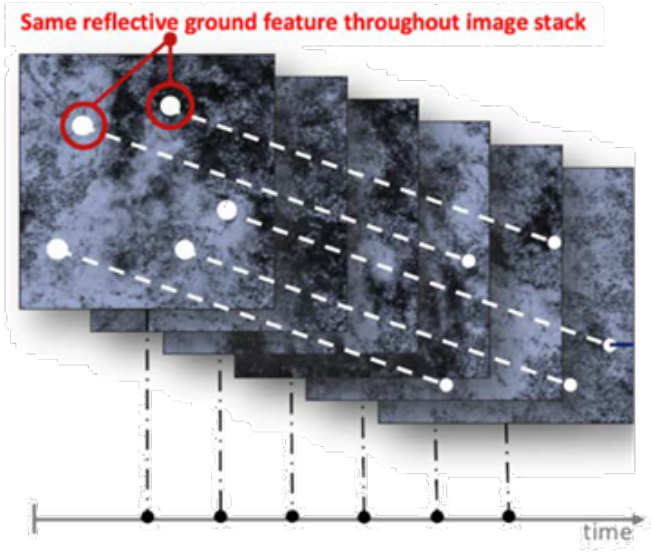
Penetrates clouds, vegetation

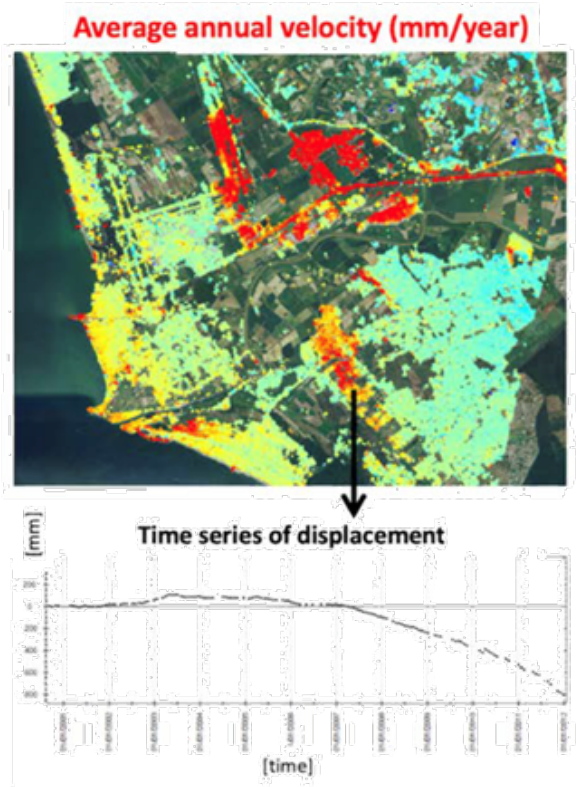
Continuous spatial and temporal coverage



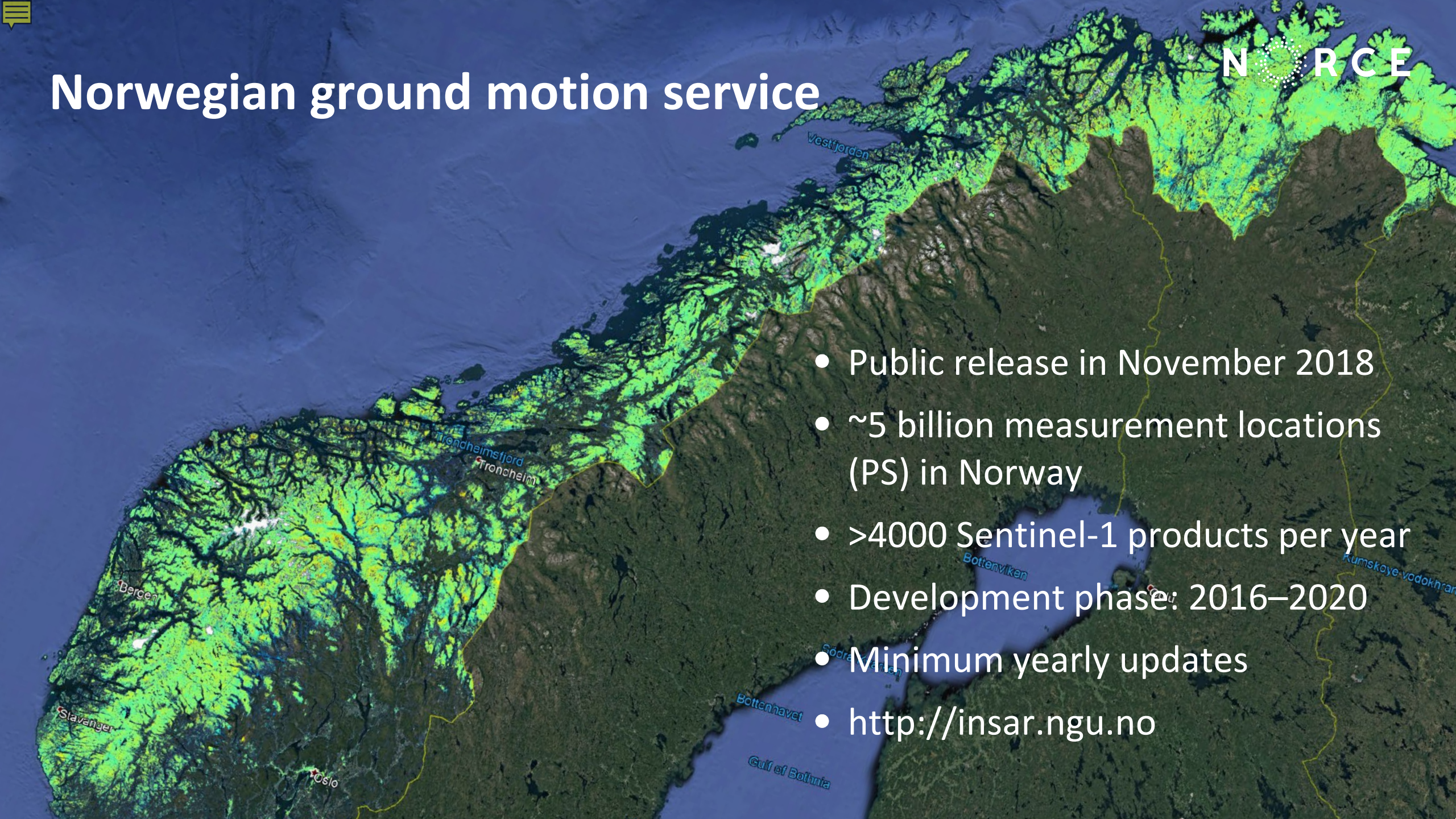
InSAR studies phase difference between different SAR images







Norwegian ground motion service



- Public release in November 2018
- ~5 billion measurement locations (PS) in Norway
- >4000 Sentinel-1 products per year
- Development phase: 2016–2020
- Minimum yearly updates
- http://insar.ngu.no

The European Ground Motion Service

- EGMS is the newest addition to the Copernicus Land Monitoring Service, managed by European Environmental Agency (EEA)
- EGMS will provide continental-scale, homogeneous maps of **ground motion**
- Millimetre-per-year precision with full time-series included



Ground motion in Oslo observed by InSAR

NORCE

NIBE PRODUKTER FORHANDLERE REFERANSER KUNNSKAPSBANK SUPPORT OM NIBE KONTAKT

- BERGVARME ER FREMTIDEN
- AVTREKKSVARMEPUMPE SØRGER FOR VARME, VARMTVANN OG VENTILASJON
- BERGVARME EN SELVFØLGE I PLUSSHUS-BARNEHAGE
- FRA KALDT TIL KOMFORTABELT I EKHOLT KIRKE
- SAMEIET SPARTE OVER 60% STRØM MED VARMEPUMPEN
- DEILIG MED GULVVARME
- 12 KM ENERGIBRØNN MIDT I BYEN
- BERGVARME DEN BESTE INVESTERINGEN GJORT

12 km energibrønn midt i byen byen



Varmepumpene henter fornybar varme fra energibrønner her inne i bakgården og bak blokkene til høyre.

Åtte solide varmepumper koblet til 36 energibrønner skal spare 65 % på fyringskostnadene i Engelsborg borettslag. – Det har fungert trolig flott, fastslår vaktmester Alf Mikalsen.

Ground motion in Oslo observed by InSAR

InSAR data accessible from InSAR Norway (http://insar.ngu.no)

Significant ground movement starting ~2019

Complex deformation

Horizontal/vertical and seasonal component



Summary

- The prevalence of GHP is steadily increasing. A larger increase is expected due to increased electricity prices.
- Environmental monitoring by Satelite (InSAR) can detect subsidence caused by construction and operation of geothermal installations
- Legislation and regulations on the use of geothermal energy need to be improved.
- Need for better monitoring and improved competence in the operation of the GSHP installations

Thank you. Takk. Merci. Gracias. Obrigado.

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NORCE