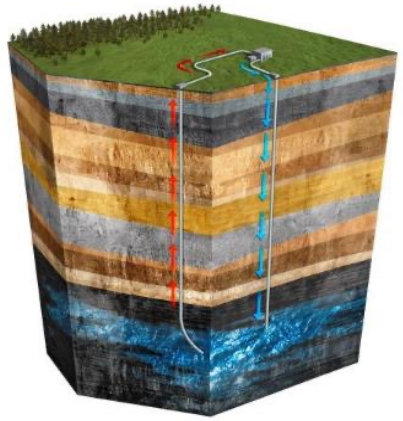
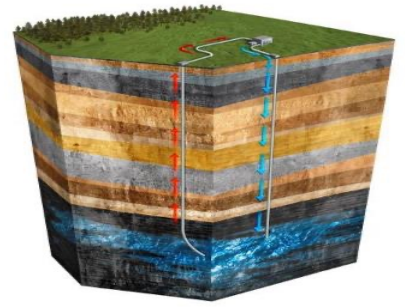


Geotermi – erfarenheter av DjupGeo och tankar om framtiden

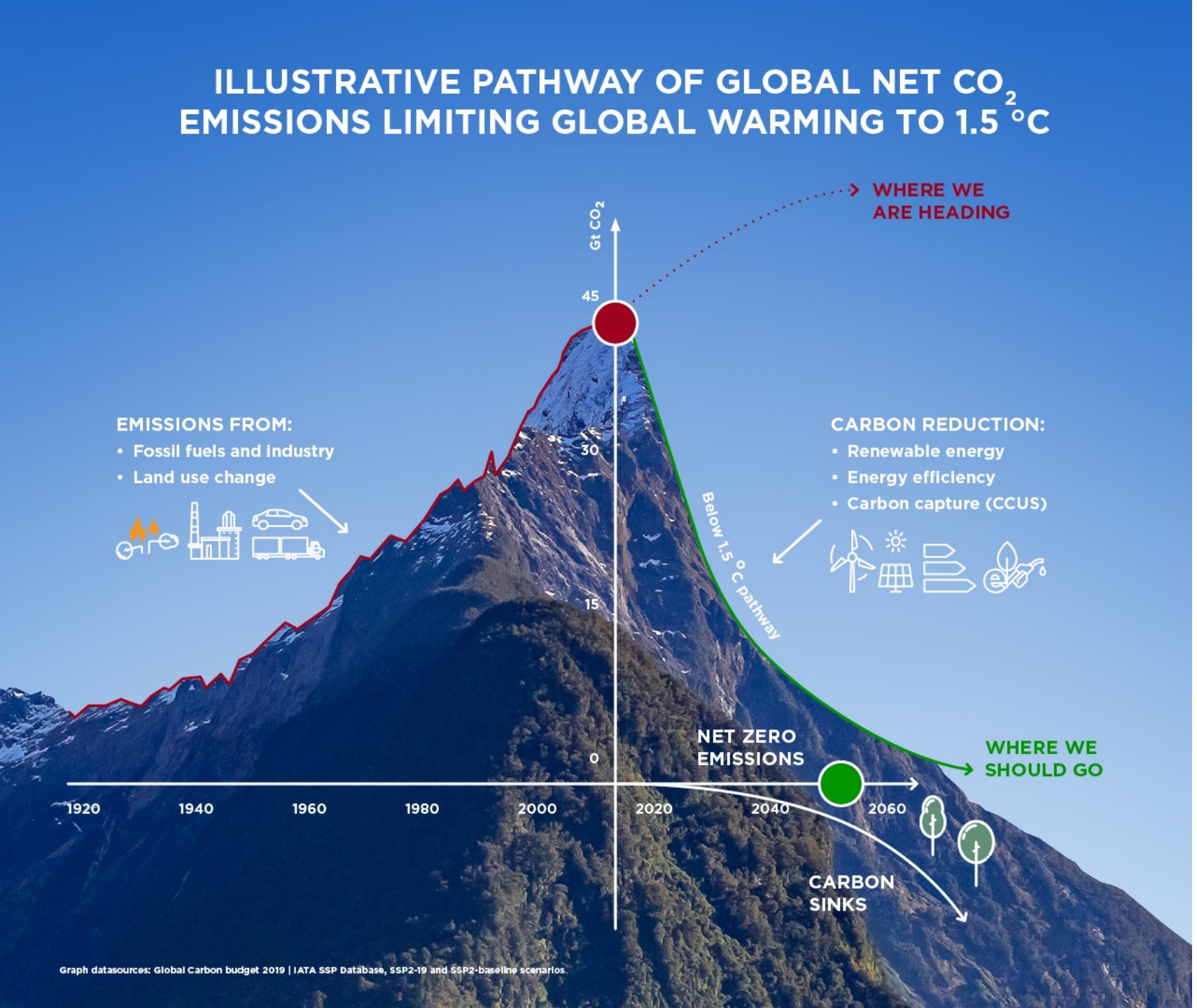
Per-Arne Karlsson 2022-05-05

Sett från ovansidan!



St1 strengthens waste feedstock business by acquiring Brocklesby Ltd in the UK

st1 Biogas



Business as usual doesn't cut it.

We must balance our carbon debt by *removing* the already emitted CO_2 from the *atmosphere*.

Vad vill/måste vi då ändra?
Inse att vi är i en nödvändig ENERGIOMSTÄLLNING!

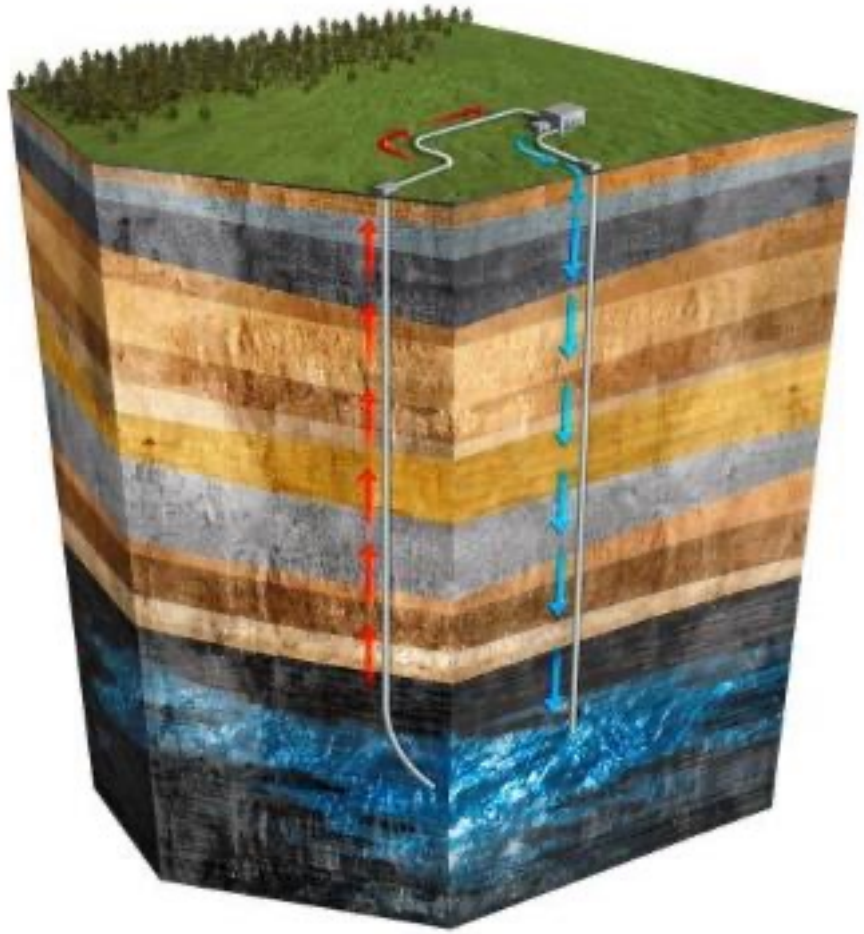
Tankemodeller och tankeprocess!

SLUTA att ställa olika alternativ MOT varandra!

Samverkan för att komma igång och börja skala upp.

Biomassan räcker till det vi vill att den ska räcka till?

Teknikneutralt kanske ska kallas klimatneutralt?



St1 Geothermal heat - production pilot

1st industrial-scale geothermal pilot heat plant in Finland with up to 40 MW capacity
Ready to start end 2020(did not happen!)

Key objective to develop and test technically and financially profitable solutions for all work phases of the geothermal business concept to make it commercial.

Output, up to 10 % of the district heat needs in the Espoo region, sold to Fortum.

Letter of Intent with EoN for new projects in Malmö
Testhole drilling ongoing during 2020

Project goals

1.Test waterflow in the reservoir rock

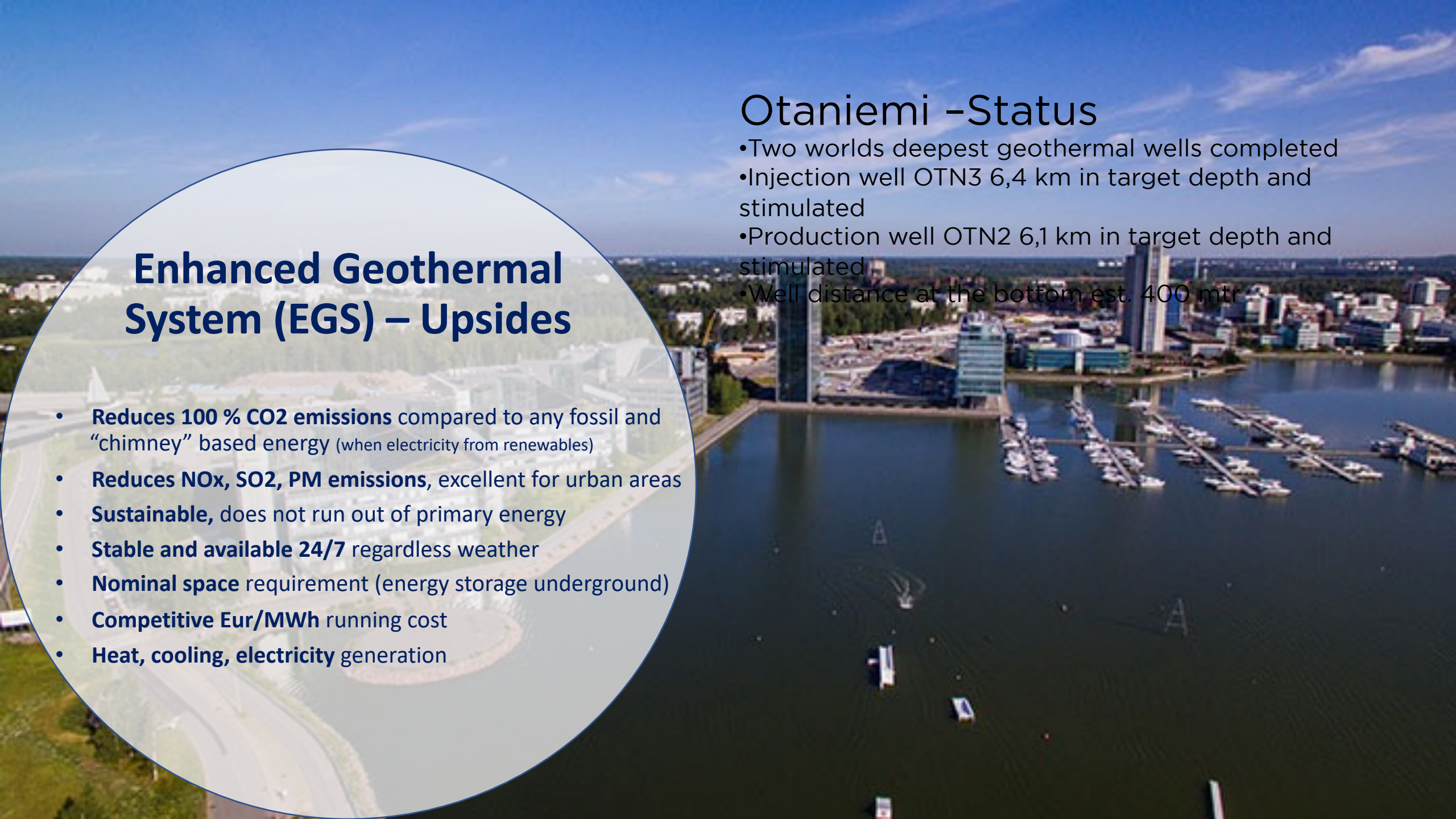
- Goal number one is to test the watermassflow that we can achieve in the reservoir
- Second goal is to test how vastsurface area of rock we can get into contact with the water

2.Select and develop a drilling tool(s) for hardrock

- We needto beable to drill the future projects costefficiently(<1500 €/m) from start to finish
- Develop a weapon of choicetools for Scandivian crustal drilling

3.Test the plant performance

- To verify the productioncost €/MWh for all the energyflows that a plant produces
- To verify the realistic project time schedule
- To verify the equipment and material selections that giveus the optimum plant performance and reliability



Enhanced Geothermal System (EGS) – Upsides

- **Reduces 100 % CO2 emissions** compared to any fossil and “chimney” based energy (when electricity from renewables)
- **Reduces NOx, SO2, PM emissions**, excellent for urban areas
- **Sustainable,** does not run out of primary energy
- **Stable and available 24/7** regardless weather
- **Nominal space** requirement (energy storage underground)
- **Competitive Eur/MWh** running cost
- **Heat, cooling, electricity** generation

Otaniemi –Status

- Two worlds deepest geothermal wells completed
- Injection well OTN3 6,4 km in target depth and stimulated
- Production well OTN2 6,1 km in target depth and stimulated
- Well distance at the bottom est. 400 mtr

Geoscience –

Learnings from stimulation and seismic data

Structural seismic studies during drilling revealed a major fracture system (VSP reflector)
•VSP structure was chosen to become the **EGS reservoir** (hydraulically conductive rock)
•Drill bit seismicsimportant in surveying structures at 1-3 km
•Vertical seismic profiling (VSP) revealed a fractured volume of rock at 4 –6 km

Stimulation successfully and safely carried out in crystalline rock at the depth of 5-6 km
• Seismicity did not exceed magnitude limits set by authorities
•Traffic light system (TLS) and seismic real-time monitoring were successful

Estimation of the thermal power of the EGS
•Temperature in Otaniemiat 6 km is 100-110 °C (as predicted)
•It allows to inject only ~ 100 L/min(because of the 400 Bar overpressure limiting the hydraulic conductivity)
•Thermal power of the EGS remains very low, unless we can increase the injection rate
•F.ex. 10 MW would require injection rate of 3000 L/min
•Problem: Such rates probably lead to seismicity exceeding the M2.1 limit

Otaniemi –Lesson learned

•Drilling-	> Done, but with 4x the anticipated cost
•Temperature -	> Goal achieved
•Stress field in the bedrock-	> Data obtained,(explains EQ mechanism at this location)
•Stimulation & induced seismicity-	> Traffic Light System proven
•EGS water reservoir -	> Created and defined, but limited volume
•Pressure connection btw the wells -	> Confirmed
•Hydraulic conductivity-	> Low


St1 Geothermal
concept

St1's Otaniemi geothermal heating plant pilot project investigates heat production methods

RELEASE 24.11.21

The pilot project of St1's Otaniemi geothermal heating plant explores the technical implementation options for the heating plant. The Engineered Geothermal System (EGS) technology, which was originally planned, **has proved to be very challenging from a techno-economic** point of view, and the current mapping phase aims to **define the connection of the boreholes and above-the-ground production technologies to achieve the best possible thermal output.**

During the design phase of the cross-flow test scheduled for fall 2021, detailed data from 2018 and 2020 stimulations were analyzed to provide information on the water flows in the deep bedrock fractures and how it can be intensified if necessary. As a result of the analysis, **it was concluded that the new cross-flow test between wells does not provide any additional information** that would support to run the test and the time spent on it.

An important sub-goal of St1's Otaniemi geothermal heating plant pilot project has been to develop and test technically and economically viable solutions for all work phases of the geothermal business concept**. The pilot project has provided valuable information on the conditions under which future projects must be evaluated.** In recent years, heat pump technology has developed by leaps and bounds, **enabling to reach sufficiently high temperatures in geothermal heat plants already with shallower heat well solutions.** Advanced geothermal power plants will play an important role in the transition to zero-emission heat production, and St1 will utilize the lessons learned from the Otaniemi project in the following geothermal projects.

Första anläggningen i Finland

St1 är det bolag som kommit längst av de tre pågående projekten i Sverige och Finland. Utanför Helsingfors har St1 borrat 6,5 km. Det är det första anläggningen för geotermisk energi i industriell skala i Finland och den är placerad vid Fortums värmeverk i Otaniemi. Projektet skulle ha tagits i drift inför den gångna driftsäsongen, men är försenat då St1 vill genomföra tester och öka kunskapen om hur de kan förbättra vattenflödena i en berggrund med smala sprickor. Detta sker bäst innan man startar upp anläggningen.

– När vi har bättre kunskap kring hur man förbättrar flödet kommer det att minska osäkerheten kring vad den termiska effekten kan bli för vårt och framtida projekt, säger Per-Arne Karlsson, chef för förnybar energi på St1 Sverige.

– Detta har aldrig tidigare blivit testat på det sätt vi nu planerar att genomföra och kan man lära sig hur detta fungerar i en av världens tuffaste berggrunder, nämligen den i Outaniemi, så kommer det att vara till stor nytta i framtida projekt på andra platser.

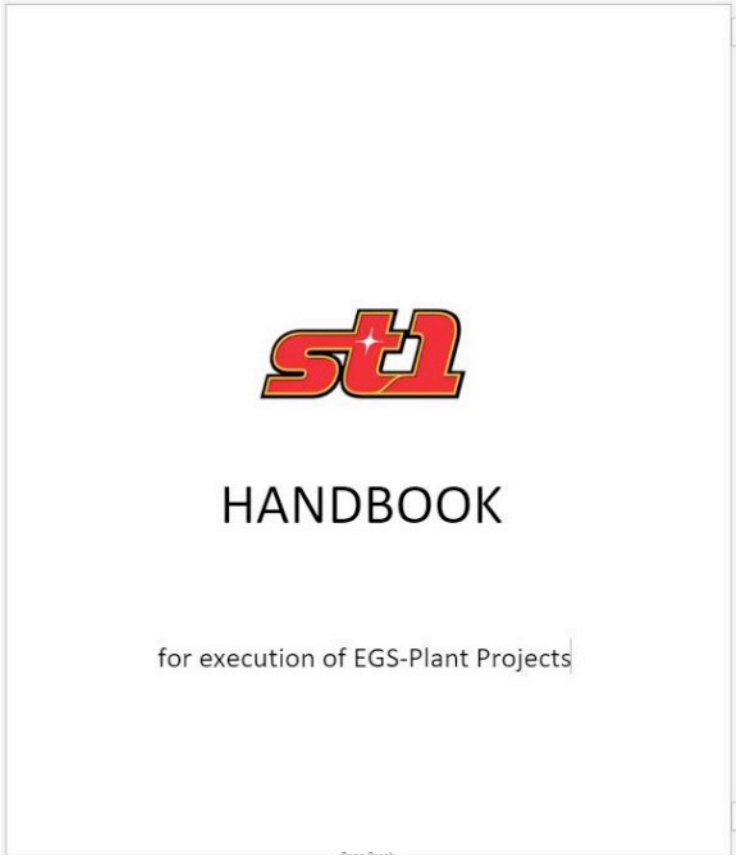
St1 ser djupgeotermisk värme som en framtida affär där de är producenter och säljare av förnybar energi.

– **Men tekniken behöver utvecklas inte minst för att kapa tiden för borrning och att det blir en mer kostnadseffektiv lösning. Vi har mycket kvar att lära**, säger Per-Arne Karlsson och avslutar:

– Vi behöver helt enkelt upptäcka hur vi kan använda denna värme smartare, säkrare och effektivare. Nu är det fortfarande ibland onödigt kostsamt, men vi tror absolut att det kan bli en riktigt intressant lösning i energisystemet framöver.

concept

“Our take on how it should be done….”

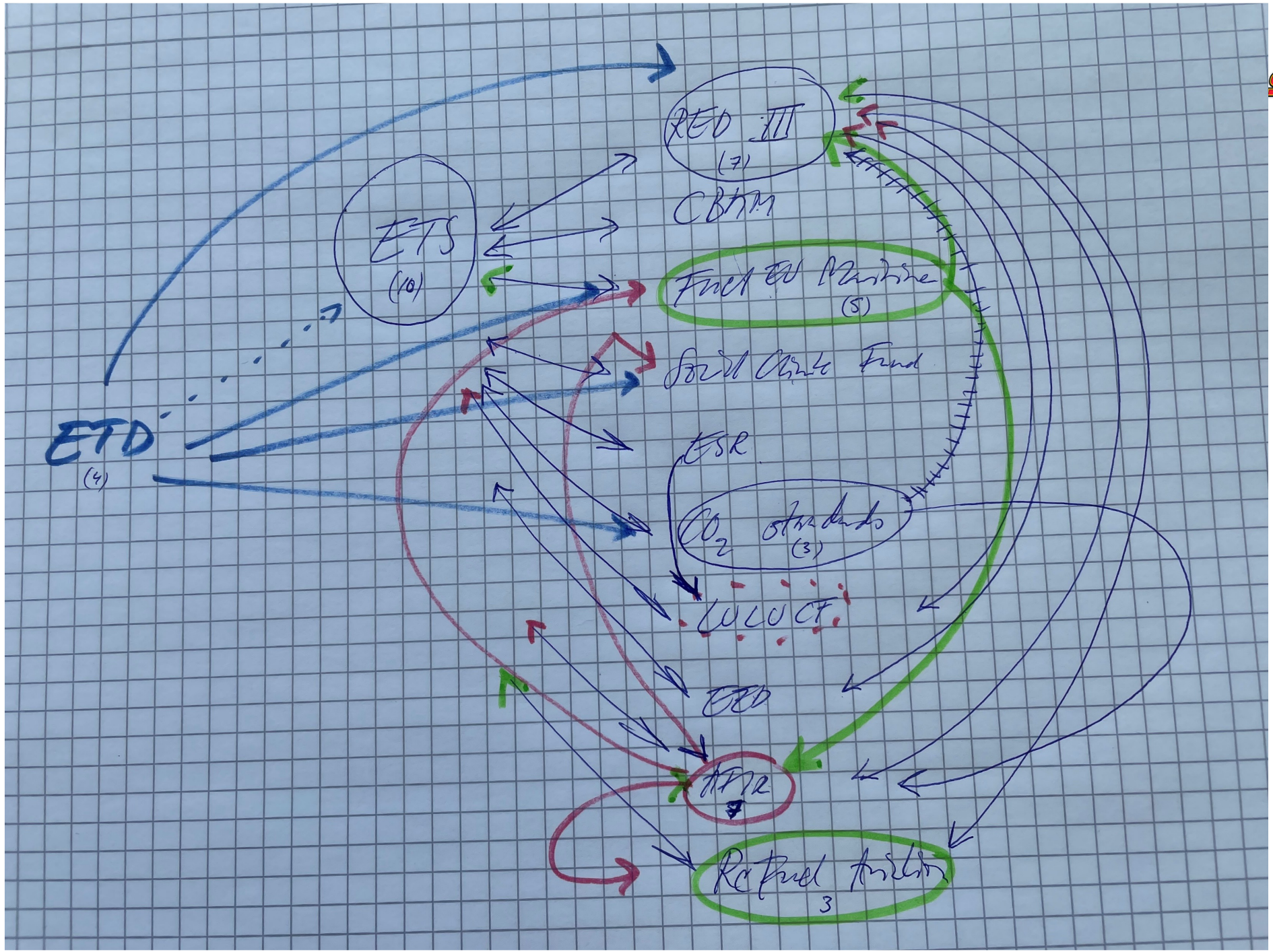


ST1 geothermal concept

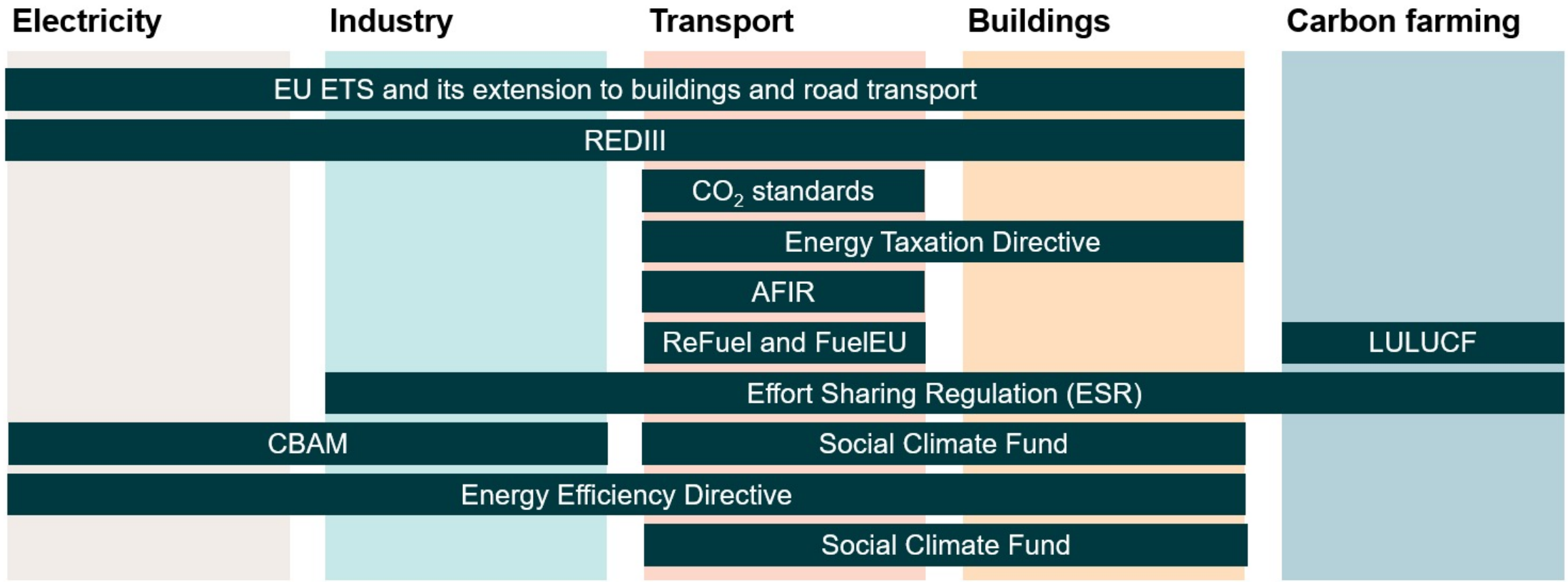
- ❑Project handbook for execution of medium deep geothermal plants
- ❑Evolving technology book presenting the state of art practices in each key technical entity
- ❑Plant design and design standard for medium deep geothermal plant
- ❑Data library, including the complete data file from Otaniemi
- ❑IP-evaluation in process

Opportunities are created by regulation

Interlinkages;



Fit for 55 package



EU Fit for 55

Implications on St1 business

What to think about FF55? What about RePower EU?

Our societies have two important objectives:

Mitigating climate change and halting global warming as well as preventing the loss of biodiversity.

The EU's climate package is taking steps in the right direction - great! It provides a framework for long-term rules. The best solutions must be promoted in a technology-neutral way.

In addition, functioning markets of negative emissions and incentives must be created for carbon sequestration. They are pivotal, alongside with transitioning the energy sector towards zero emissions.

How to get into the boardroom with a confidence to come out with a YES!

- Legislation
- Cooperation/Partnership
  - Timing & scalability
- Valuechain(s)
  - Our own, combined and others
  - Business models – Techniques (raw material/ vehicle)
- Investment risk(s)
  - Media
  - Political
  - Economic