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# GEO ENeRGY

## Integrated use of the underground: new research, development and national policies are needed

In October 2014 EU Heads of State and Government agreed the headline targets and the architecture for the EU framework on climate and energy for 2030. The agreed targets include a cut in greenhouse gas emissions by at least 40% by 2030 compared to 1990 levels, an EU-wide binding target for renewable energy of at least 27% and an indicative energy efficiency target of at least 27%. The decision underlines the European Union's position as a world leader in the fight against climate change. The agreed greenhouse gas target will be the EU's contribution to the global climate change agreement due to be concluded in Paris next year. The renewables and energy efficiency targets will increase the security of the EU's energy supplies and help reduce its dependency on imported fossil fuels.

In November 2014 the UN IPCC published Press Release 'Concluding instalment of the Fifth Assessments Report: Climate change threathens irreversible and dangerous impacts, but options exist to limit its effect'. „We have little time before the window of opportunity to stay below 2°C of warming closes. To keep a good chance of staying below 2°C and at manageable costs, our emissions (Fig.1) should drop by 40 to 70 percent globally between 2010 and 2050, and falling to zero or below by 2100“, said R. K. Pachauri, Chair of the IPCC.

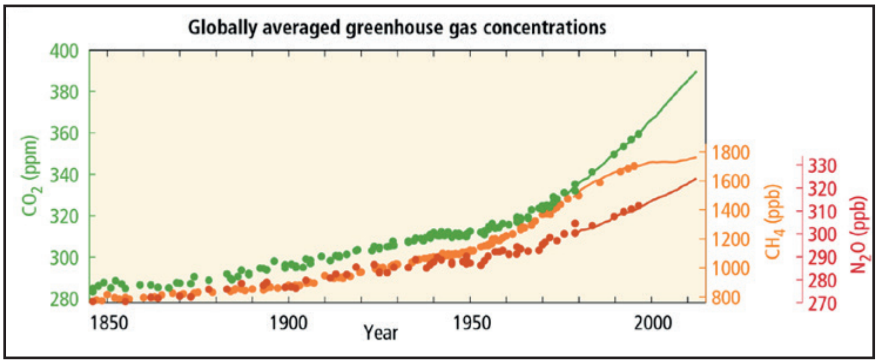


*Fig.1 Atmospheric concentrations of the greenhouse gases carbon dioxide ($CO_2$, green), methane ($CH_4$, orange), and nitrous oxide ($N_2O$, red) determined from ice core data (dots) and from direct atmospheric measurements (lines) (Climate Change 2014, IPCC Fifth Assessment Synthesis Report, Approved Summary for Policymakers)*

Europe could be on track to deliver a 100% renewably powered energy system by 2050. Many of the green-energy and low-emission technologies exist today but need to be developed and expanded further. Besides cutting the vast majority of its emissions, Europe could also reduce its use of key resources like oil and gas, raw materials, land and water. Integrated use of the underground supports these future European targets.

The purpose of the new ENeRG Position Paper (attached inside) is to give guidance on new research needed for integrated and sustainable use of the underground in relation to geothermal energy, energy storage, natural gas (shale gas, coal-bed methane, gas hydrates), shale oil (kerogen oil), $CO_2$ capture and storage (CCS), $CO_2$ capture, utilization and storage (CCUS), nuclear energy and waste disposal, while preserving groundwater.

In order to meet EU 2030 targets the following research is advised by ENeRG network in energy-related fields.

**Geothermal energy:** *Research is needed to catalyse the development of geothermal energy all over Europe, from shallow heat pumps to deep enhanced geothermal systems.*

**Fossil fuels:** *Natural gas exploitation of all kinds of deposits including unconventional resources requires much more research and development efforts in Europe.*

**Shale gas:** *Research for better understanding of the fundamental processes and risks, monitoring and mitigation of impacts posed by hydraulic fracturing is needed.*

**Coal bed methane:** *The most critical research areas for coal bed methane with CCS are environmental issues, potential groundwater contamination and conflict of interest in the use of the underground.*

**Natural gas hydrates:** *Research on the capacity estimation of reserves, cost effective production technologies and risks of instability of sea basin is needed.*

**Shale oil:** *The future research should be targeted on the most environmentally friendly technologies for ex-situ and in-situ use of the oil shale.*

**$CO_2$ storage and use:** *Research is needed to collect newer data to create the European $CO_2$ Storage Atlas, for integration of $CO_2$ utilization with $CO_2$ storage and synergies with geothermal energy exploitation.*

**Nuclear energy and waste disposal:** *Research contributing to the secure and environmentally safe uranium mining and safe disposal of radioactive or other waste in geological repositories will be essential to social acceptance of future use of nuclear energy.*

**Energy storage:** *Mapping of all possible underground energy storage sites, estimation of their storage capacity, techno-economic feasibility and the short and long term market perspectives are important future research areas.*

**Integrated use of the underground:** *Detailed exploration of the underground structures, properties of the reservoir and sealing rocks, 3D models of the studied underground space, estimation of its production and/or storage capacity, and integrated atlas are needed to take decision about the most economic, multiple or integrated use of the underground. New national policies need to be developed for secure and sustainable use of the underground.*

In the Netherlands, the country with one of the highest intensity of subsurface exploitation among European countries, the Dutch Government is already developing an additional set of policies for the spatial planning of the entire subsurface (see page 3 in Newsletter 29 and page 2 in this Newsletter 30). This plan focuses on a sustainable and efficient use of subsurface space and resources, while preserving a balance between exploitation and protection of the subsurface. With the development of the structure plan, the Dutch government strives to incorporate all governmental levels and institutions involved in the subsurface governance. The first version of the plan is expected to be presented to the national government next year; the new policies will come into effect in coming years.

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# Multiple use of the underground - the Dutch approach

The Netherlands is renowned for its spatial planning and man-made design of its densely populated and often vulnerable living environment. Now this planning is being extended to the subsurface domain; a challenge that has been initiated by the Ministry of Infrastructure and Environment and the Ministry of Economic Affairs in 2011.

The intensity of subsurface exploitation in the Netherlands is probably one of the highest among European countries. Within the upper 30 meters below urban areas there is a struggle for space between cables, pipelines, subsurface building and heat pump applications, whereas in more rural regions the wellbeing of agricultural and nature areas relies on a coordinated ground- and wastewater management. Up to a depth of a few hundred meters the subsurface is exploited among others for drinking water supply, shallow geothermal systems and the storage of brine filtrates. At the deepest levels, the subsurface is extensively utilized for the exploration and production of hydrocarbons and to a lesser extent rock salt and coal (the latter ceased in 1974). More recently these applications have been complimented by deep geothermal development and underground gas storage, while shale gas exploration and storage of $CO_2$ could be considered as potential prospects for the future (Fig.2).

Issues related to the intensification and diversification of subsurface activities increasingly confront the Dutch society. Some well-known examples are subsidence and induced seismicity due to gas production, interference between production of deep geothermal energy and hydrocarbons and last but not least health, safety and environmental concerns related to potential development of shale gas production and $CO_2$ storage. At the same time considerable challenges for security of supply of energy, drinking water and mineral resources, climate and the transition towards sustainable energy sources exist. For each of these challenges, the subsurface represents an essential factor to be taken into account.

The governance for safe and effective exploitation of the subsurface is well established under the Dutch Mining Act and associated regulations. In many cases however, the current policies rely on the principle of “who comes first, wins”. This may result in discarding essential opportunities for future development and suboptimal matching of subsurface and surface development. Last but not least many subsurface developments and their necessity are increasingly criticized by the public and there is a growing demand for transparent assessments of alternative options and associated benefits and societal costs.

In order to address these issues, the Dutch Government currently develops an additional set of policies for the spatial planning of the entire subsurface (the so-called “Structuurvisie Ondergrond”). This plan focuses on a sustainable and efficient use of subsurface space and resources therein, while preserving a good balance between exploitation and protection of subsurface capital. Cross-border implications of subsurface use are taken into consideration as well. In this context TNO delivers fundamental geotechnical information and national scale assessments of subsurface exploration and development potential, including associated effects and risks. These assessments are based on state of the art 3D geological models incorporating information on the structuration and properties of prospective intervals within a ~5km depth range. The models are subsequently matched with geological boundary conditions and criteria for technical feasibility and performance. At various levels the assessed applications are further analysed for potential interference and risks.

With the collected information from TNO, other stakeholders and in-house assessments, The Ministry of Infrastructure and Environment analyses strategic and/or synergetic development options, and identifies potential bottlenecks. This analysis will form the basis for a robust and flexible decision methodology which incorporates multiple weighing factors and links to important societal challenges and trends such as climate and the consumption and supply of energy and other essential resources. In special cases reservations may be considered, for example the preservation of strategic drinking water reserves and space for subsurface storage.

With the development of the structure plan, the Dutch government strives to incorporate all governmental levels and institutions involved in subsurface governance. A broad consensus on the fundamental principles of the required decision model is envisioned and stakeholders are invited to provide their input and views. Information is publicly shared as much as possible in order to increase transparency with regard to future decisions and to maintain a shared knowledge base among stakeholders.

The first version of the structure plan is expected to be presented to the national government in 2015. Depending on further decisions the new policies will come into effect in coming years.

Serge van Gessel
TNO

TNO innovation for life

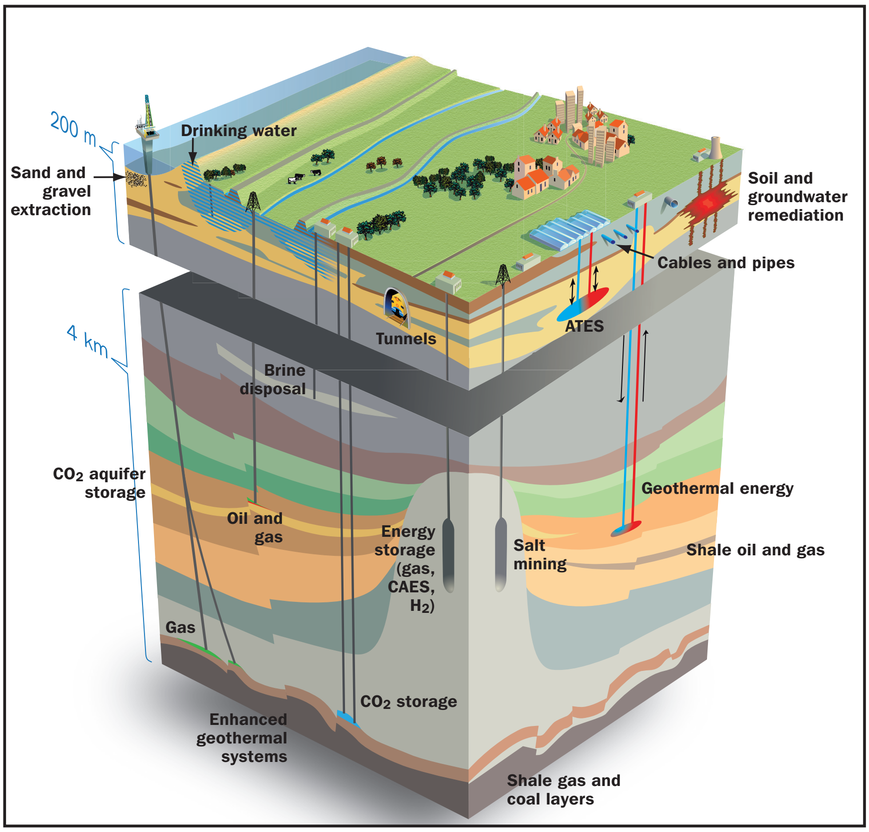


*Fig. 2 Schematic overview of energy related applications assessed for the deep subsurface of the Netherlands*

# Insight into shallow geothermal energy research in Finland

Designing a reliable, efficient and lasting borehole heat exchanger (BHE) system requires understanding of the thermophysical properties of the bedrock surrounding the boreholes. The two most important factors are the thermal conductivity and the temperature of the ground. Both of these vary notably, not only regionally and depending on the rock type, but also very locally, so although bedrock maps offer useful information at the beginning of the project, in situ measurements are needed.

The properties of the heat exchanger itself affect the efficiency of the system in creating thermal resistance between the heat carrier fluid and the borehole wall. The thermal resistance of the borehole is a complex factor that cannot be reliably calculated, but also needs to be measured. The Geological Survey of Finland (GTK) has evaluated actively the usability of the Distributed Thermal Response Test (DTRT) method in order to determine the thermal parameters of the bedrock and the borehole by layers. A Thermal Response Test (TRT) combined with temperature measurements along the borehole heat exchanger (BHE) depth with optical fiber thermometers is called the Distributed Thermal Response test (DTRT). The DTRT is merely a modification of the conventional TRT and is based on all the same principles, but it offers a more detailed examination of the subsurface surrounding a borehole.

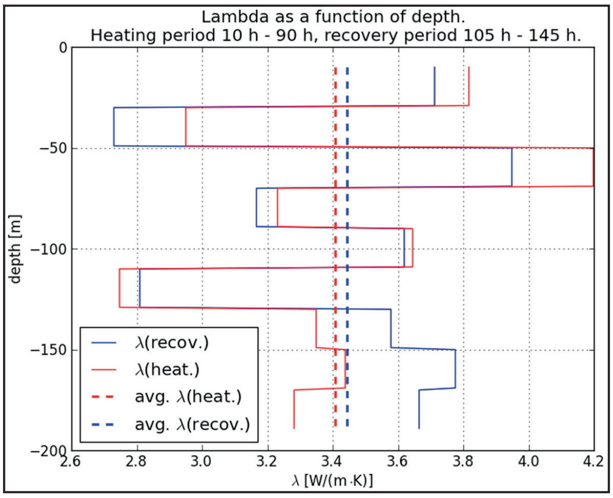


*Fig.3 The layered thermal conductivities achieved from the recovery and heat injection data. The thermal conductivity calculated from the recovery period is represented by the blue solid line and the layered thermal conductivity calculated from the heating period by the red solid line. The dashed lines correspondingly indicate the averaged value of all layers (Figure ©GTK)*

To determine the layered thermal conductivity (Fig.3) and borehole thermal resistance, the temperature of the heat carrier fluid can be logged with optical fiber cables along the borehole length during different phases of the TRT. Particular interest is paid to borehole recovery after the conventional TRT (Fig. 4). The borehole can be divided

*Fig.4 The boreholes in Sipoo are monitored online by optical fiber measurements (©GTK)*

into sections, each of 1- 20 meters in length. Then, the infinite line source method combined with the superposition technique (i.e. variable heat rate) can be applied to each section, fitting the calculated fluid temperatures to the measured ones and minimizing the error between them. Thus, the layered thermal conductivity and the borehole thermal resistance can be assessed.

The DTRT method clearly provides a more detailed overview along the borehole, which is significant in a heterogeneous and anisotropic environment. In future work, GTK's goal is to improve the interpretation methods related to TRT and DTRT. Collector testing and usability studies of bentonite filling material will also be included.

**The Sipoo Massif**

GTK still focuses on large scale commercial geoenergy projects, like office buildings, shopping centers and industrial buildings, and energy storage systems. GTK acts in close cooperation with private companies from designers and financiers to manufactures of equipments as well as with the governmental and other public authorities. Showcase for shallow geothermal energy utilization in Finland and maybe Europe's largest closed-loop borehole field locates in Sipoo, 30 kilometers north from the Helsinki city centre. The site consists of two massive logistics centers. The second one is being built at the moment and will be in operation by 2016. The shallow geothermal energy reservoir consists of two borehole fields which both include 150 boreholes, each 300 meters deep. The ground-coupled loads are characterized by an excess heat requirement. In order to avoid a heat deficit which can't be replenished by surplus heat, GTK monitors the temperature levels in separate observation wells and also in active wells. In reality, the annual heating and cooling loads are not exactly balanced and constant so it's vital to observe and predict the thermal behavior of the fields. The surveillance done in Sipoo provides valuable data for other schemes to come.

**Research for city and regional planning**

Shallow geothermal energy offers nowadays a competitive alternative to traditional combustion based district heating in Finland. Not only one family houses but also bigger residential buildings, office buildings and public buildings like hospitals have chosen geoenergy. Ground source heat pumps can form the basis, or at least a part of the district heating network. City of Oulu in northern Finland was the first to evaluate the potential of geoenergy in city planning. One major issue in Oulu is the large variation of soil depth which affects the efficiency and construction costs of BHE's. As the result, a map for Oulu geoenergy potential was created, delivering critical information on areal suitability for geoenergy production.

Next GTK will evaluate the geothermal potential of Central Finland, which consists of 23 municipalities. The study will be used for regional land use planning, and it will be the first step towards the national geoenergy potential evaluation.

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and
Samu Elias Valpola

GTK

## ENeRG – European Network for Research in Geo-Energy

**ENeRG – European Network for Research in Geo-Energy** is an informal contact network open to all European organisations with a primary mission and objective to conduct basic and applied research and technological activities related to the exploration and production of energy sources derived from the Earth's crust.
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# Sustainable Earth Sciences Conference & Exhibition 2015

## 13-15 October 2015 | Celle, Germany

The Third Sustainable Earth Science Conference & Exhibition, which will take place from 13-15 October 2015 in Celle, Germany, will be organized by EAGE in cooperation with CO2GeoNet and ENeRG. Building on the success of the first SES conference in Valencia, Spain (2011) and the second SES conference in Pau, France (2013), this conference aims to create a platform for geoscientists to meet, learn and discuss 'Use of the Deep Subsurface to serve the Energy Transition'.

SES 2015 will be linked with the Second EAGE Workshop on Geomechanics and Energy, and the participants will have the opportunity to visit both events. For more information about the Second EAGE Workshop on Geomechanics and Energy please visit www.eage.org/event/geomechanics-energy-2015.

### Conference themes

To meet the challenges of present and future energy demand, the geosciences play an increasingly important role in the sustainable use of the Earth and its resources and in the conservation of our environment. As an association representing a large group of geoscientists, EAGE wishes to promote the development of applied geosciences and technology with regard to the sustainable use of the Earth and its limited resources.

### Important Dates

| | |
|---|---|
| Call for Papers open | 1 October 2014 |
| Deadline for Call for Papers | 15 March 2015 |
| Early Registration Deadline | 15 August 2015 |
| Late Registration Deadline | 1 October 2015 |
| Conference & Exhibition | 13-15 October 2015 |

This Conference & Exhibition will bring together multi-disciplinary scientists working on different aspects of Sustainable Earth Sciences. The main conference themes will be $CO_2$ Storage, Geothermal Energy and Deep-Earth Storage. Cross-disciplinary session themes will be encouraged, including monitoring technology, coupled Earth systems modeling, long-term storage integrity, combining renewables, geothermal and CCS and risk and environmental impact analysis.

### Short courses & Field trips

Preceding and following the Third Sustainable Earth Sciences Conference & Exhibition in Celle, we will offer two field trips and two short courses. The short courses will cover Reservoir Model Design and Microseismicity. The field trips will visit Lautenthals Glück Silver Mine, Devil's Wall and the Compressed Air Energy Storage facility at Huntorf.

### Contact

Please visit EAGE at www.eage.org for the latest updates and the downloadable version of the SES 2015 announcement and sponsor guide. For any questions about SES 2015, please contact EAGE via ses@eage.org.

SES Sustainable Earth Sciences

EAGE European Association of Geoscientists & Engineers

CO2 GeoNet

ENeRG

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