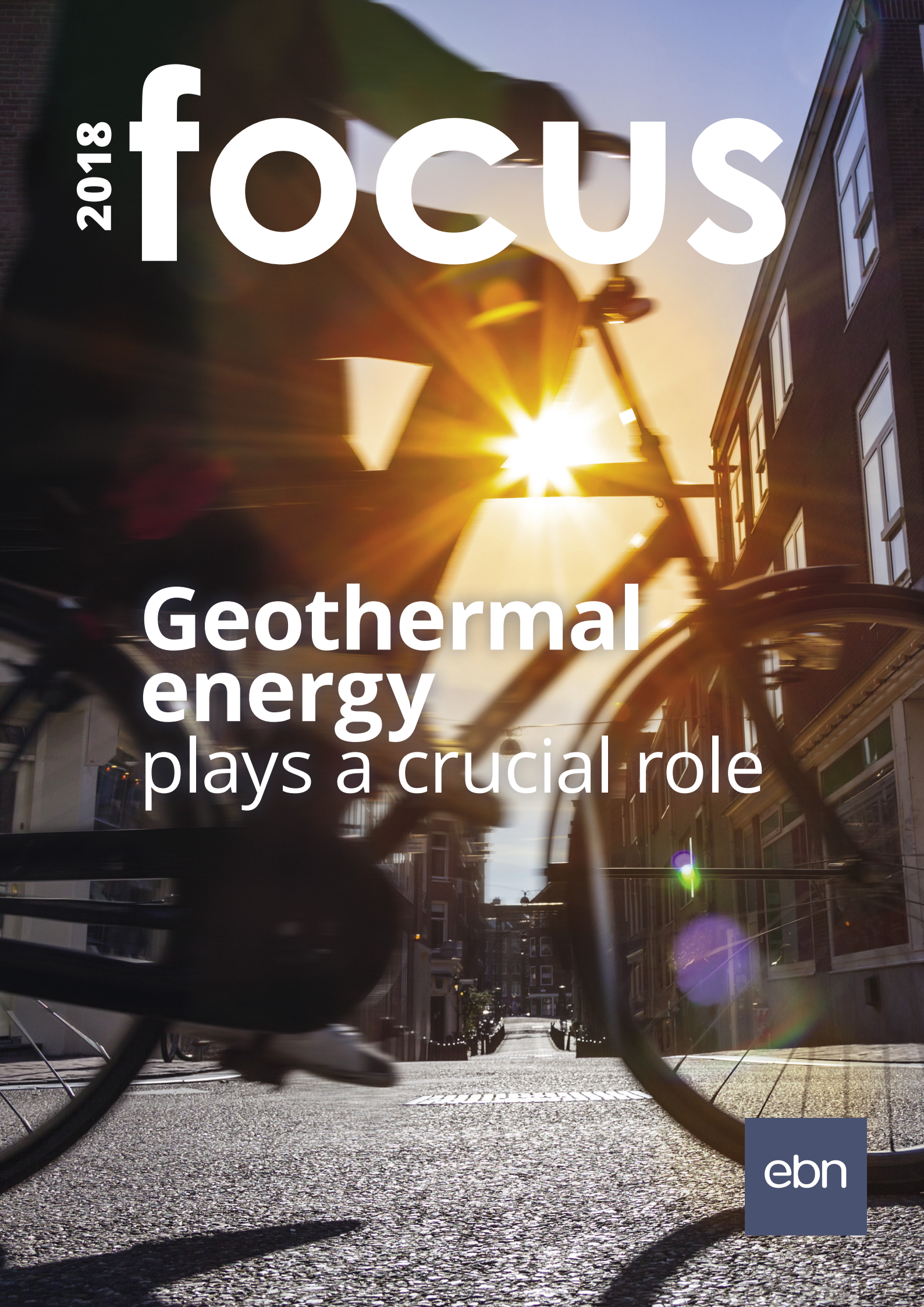
2018 focus

Geothermal energy plays a crucial role



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Clear directions and coordination are essential

Geothermal energy plays a crucial role

Nearly half of the Dutch total energy consumption is used for heat. Geothermal energy may provide up to 20 per cent of this. The geothermal potential is enormous, but developing this potential requires careful dealing with technical and social aspects.

It is in society's interest to use the Earth's subsurface, which belongs to all of us, optimally in the upcoming energy transition. 'Every man for himself' is not desirable; the whole is greater than the sum of its parts.

The entire heat market with demand, supply and infrastructure should not only develop simultaneously, but also at a fast pace. The absence of large-scale (bundled) heat demand, uncertainty about the supply and the absence of infrastructure explains the lack of large-scale initiatives. Clear directions, coordination and far-reaching cooperation are important to realise a significant share of geothermal energy in the Netherlands. A strong role for the government seems obvious here, just as the government also played a leading role in the previous energy transition from coal to natural gas.

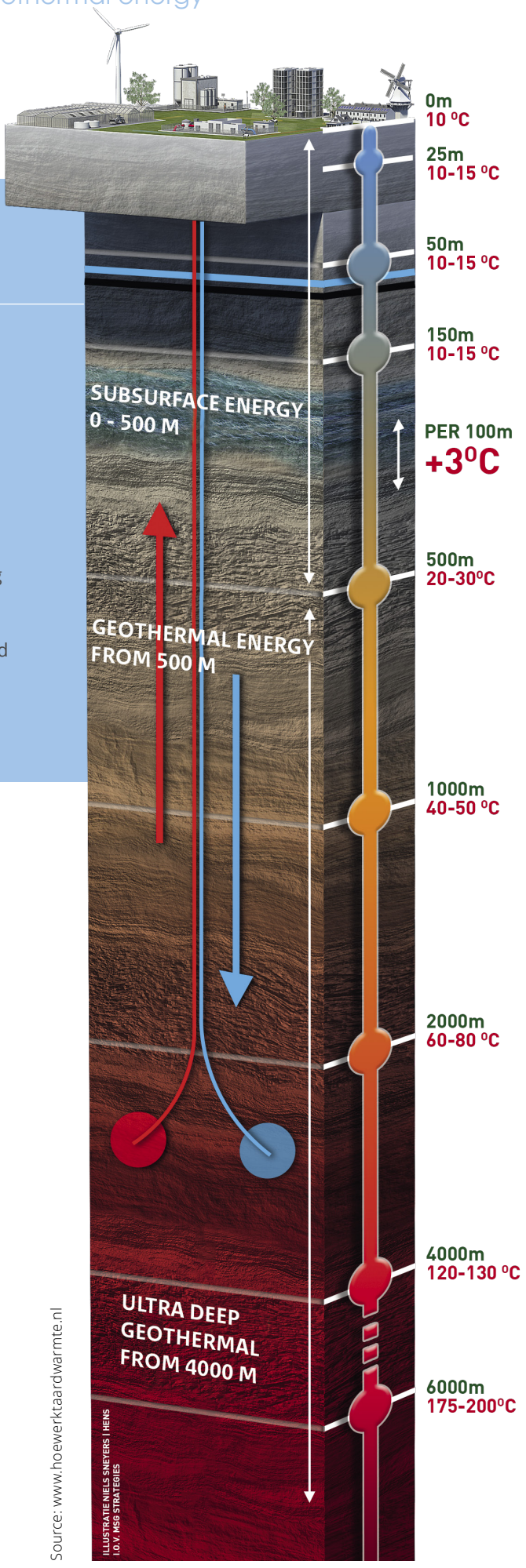
An enormous potential

To meet our future sustainable energy needs, we could use solar energy, wind power, tidal energy and gravity (hydropower). We can also use geothermal energy stored in the earth. In the Netherlands, we already have considerable experience with heat extraction from the shallow subsurface (up to 500 metres depth), called subsurface energy. In this article, we focus on heat extraction from layers deeper than 500 metres, called geothermal energy. Pioneers in greenhouse horticulture, have initiated the first geothermal projects. These horticulturists use geothermal energy from sandstone layers at 2,000 to 3,000 metres depth to heat their greenhouses. The results are as expected and promising for upscaling. Geothermal energy is one of the sustainable energy options, perhaps even a necessity, to meet our future heat requirements.

There is still a lot to do to accomplish this growth. Although we already have some experience with geothermal energy, there are still many unknowns about the feasibility of large-scale application of geothermal energy. We do not yet know exactly which opportunities exist in the Netherlands, not to mention where they are located. There are still many blank areas on our 'geothermal map'. Dealing with the conversion from a gas grid to a heat grid is a major challenge. It is a significant change for residents, and requires a major investment. It is

Geothermal doublet

Earth's temperature rises by about 30 degrees Celsius every kilometre. Hot water can be present in permeable layers, a so-called aquifer. To extract this heat from the earth, two boreholes (a doublet) are drilled to a permeable earth layer. Hot water is pumped out through the first borehole. A heat exchanger extracts the heat for use in greenhouses or for district heating. The cool water is pumped back into the same layer through the second borehole. At surface, these boreholes are only a few metres apart, but at depth the boreholes are about 1.5 to 2 kilometres apart. This is to prevents early cooling of the aquifer. The water in the aquifer gradually warms up again due to a continuous heat flux from the earth's core. The extracted heat is distributed to homes, buildings, industries and greenhouses through a network of pipes.



Source: www.hoewerktaardwarmte.nl

unclear who will dare make, or must make, this investment. The absence of a heat pricing mechanism makes it even more complex.

Seismische Campagne Aardwarmte Nederland (SCAN)

The 'geothermal map' of the Netherlands is far from complete: there are still many 'blank areas'. SCAN is a collaboration between TNO and EBN to determine the potential of geothermal energy in those areas where there is little information available about the subsurface. The project was commissioned by the Ministry of Economic Affairs and Climate Policy and covers the development and reworking of existing seismic surveys, collecting new seismic data and - at a later stage - executing exploration drilling. The SCAN project plan is being developed and the project will start mid-2018.

Legislation and regulations are mainly based on oil and gas exploration and production and not always applicable to geothermal activities. Adaptations in legislation are necessary, along with proper application of it.

We must continue to guarantee safety. The risk of subsurface tremors, for example, should not be compared one-to-one with (and are indeed less

Photo © Rodney Photography

Presentation of the Geothermal Energy Master Plan for the Netherlands to Ed Nijpels, chair of the Climate Council.

than with) gas production, but every risk must be considered. Attention to safety will be high in the coming years. The State Supervision of Mines (SSM) also refers to this in their 2017 report: State of the Geothermal Energy Sector.

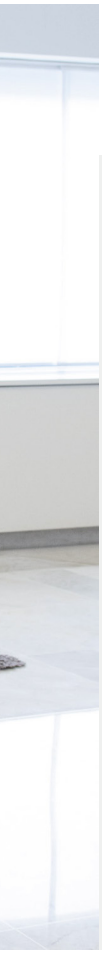
Public support plays an essential role in all these developments. The opportunities and risks of geothermal energy should be explained properly and transparently and we need to discuss it with everyone involved and affected. Geothermal energy offers opportunities to meet our energy requirements and our climate objectives, but the technology will need a social 'licence to operate'. This does not happen automatically and is not just the responsibility of the authorities. No matter how many opportunities geothermal energy offers, there are important considerations to be made. A pump station must be built at the location where the water is being pumped out and pumped back.

That will affect the built environment. And however promising the prospect of upscaling geothermal energy for the heat transition is, we must remain realistic. We need to develop geothermal energy safely and responsibly, and with both feet on the ground. Transparent communication plays an important role here.

Industry, authorities and politics must work together

Almost half of our energy consumption is for heating. About 20 per cent is used for heating greenhouses and 40 per cent for heating buildings (offices and houses). The remaining 40 per cent is used by industry, varying from light industry (paper mills, dairy companies, beer breweries) to heavy industry (petrochemical and steel industry). We disregard the heavy industry because it has a high temperature requirement (more than 200 degrees Celsius) which geothermal energy cannot deliver in the Netherlands.

Horticultural greenhouses require a water temperature ranging from 60 to 90 degrees



Geothermal Energy Master Plan for the Netherlands

The Master Plan is a roadmap for developing geothermal energy in the Netherlands. It is an integral plan to optimally unlock geothermal potential through strong growth of the exploration and production activities, expansion of the heat networks and the coordination of heat demand portfolios and robust public support.

The Master Plan was developed in the spring of 2018 with and on behalf of DAGO (Dutch Association of Geothermal Operators), SPG (Stichting Platform Geothermie) and WNW (Stichting Warmtenetwerk). The Ministry of Economic Affairs and Climate Policy (responsible for geothermal energy and the energy supply) and the Ministry of the Interior (responsible for the sustainability of the built environment) acted as observers. Many other parties such as TNO, IPO, VNG, SSM, LTO and IPO were involved through interviews and working sessions.

The project led to a joint Master Plan of the sector on how geothermal energy, heat grids and heat demand can develop optimally to achieve 50 petajoule per year in 2030 and over 200 petajoule per year by 2050. The Master Plan analyses the situation and provides a roadmap with guidelines for all parties to achieve these goals.

Almost half of our energy consumption is for heating

Celsius. Existing Dutch horticultural projects use heat from layers at 2,500 to 3,000 metres depth. The process industry could use heat from even deeper layers with a temperature exceeding 130 degrees Celsius. In some regions, this can be found at a depth beyond 4,000 metres. We call this ultra-deep geothermal energy (UDG).

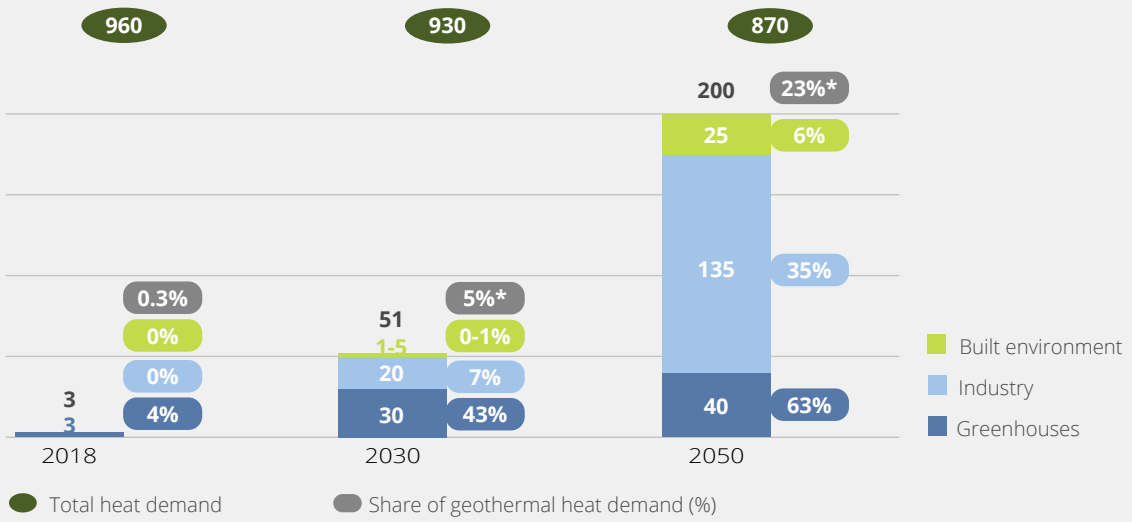
Success is possible under the right conditions

Geothermal energy can eventually provide around 20 per cent of our total heat demand. That is substantial, but it is subject to certain conditions.

In 2017, approximately 2.5 petajoule (PJ) of geothermal evergy was produced at 16 production locations. This can, and must, increase rapidly in the coming years. When all lights are green (i.e. all conditions are met), geothermal energy could contribute 50 PJ per year by 2030. This means that geothermal energy produced will need to double every three years. By 2030, there would be around 150 sites in the Netherlands each producing 0.3 PJ per year. Geothermal energy could contribute around 200 PJ per year by 2050.

One condition to steer the growth in the right direction is to further develop knowledge and actively share knowledge and experience with (and among) all parties involved. Providers or operators will grow explosively, and other parties may enter the market as well. We can compare this development with that of wind energy, for example, where the first pioneers in the 1970s and 1980s experimented with small wind turbines at a farm or industrial site. The owner produced and used wind energy. After this essential start-up phase of development and research, large companies are building increasingly larger wind farms in recent decades. Such a development could also occur with geothermal energy. Developing the heat market and the expansion of heat networks play a key role in the Netherlands.

Ambition geothermal energy vs. total heat demand (PJ)



* Geothermal can contribute 5% of the total heat demand in 2030 and 23% by 2050

Team analysis, CE Delft, IF Technology, LTO Glaskracht, McKinsey Energy Insights

Green Deal UDG – Ultra-Deep Geothermal Energy

Ultra-deep geothermal energy (UDG) can contribute to the heat supply for the light industry. In the Netherlands this heat can be found beyond a depth of four kilometres, especially in the Dinantian limestone. The Dutch subsurface below this depth however has not yet been extensively studied.

In the Green Deal UDG, authorities, companies, research institutes and six consortia work together to safely and responsibly develop one or more pilot UDG projects before 2021. The projects will ideally be spread over three geological regions and provide insight into geological and technical risk reduction for a safe, responsible and cost-effective development of UDG. The parties have committed themselves to boost knowledge about UDG through collaboration.

The six consortia are at more or less the same stage of development. More detailed exploration is now needed to better understand the subsurface, such that the first UDG exploration well can be drilled safely and responsibly. The Exploration Work Programme (EWP) describes the study activities for the Dinantian limestone required for each of the six projects. Integral project development will be applied as the various activities are strongly interrelated. Wherever possible, work is carried out jointly. This results in higher quality work, avoidance of duplication and a reduction in costs for all parties. At the end of the EWP, a substantiated business case will be drawn up based on the results and an exploration strategy for each region. A consortium can then decide on implementing a pilot project. Drilling is therefore not part of the EWP.

The EWP has an estimated duration of 2.5 to 3 years, with activities starting in the second quarter of 2018.

The growth of geothermal energy production also places demands on local authorities, because they also need to gain experience with these projects, both in terms of licences and support. This is closely related to the fact that for geothermal energy to develop responsibly in the coming decades, the public and politicians must have sufficient knowledge of the technology and any possible effects. Local authorities can play a crucial role in this. Here, too, all parties should work closely together and share and strengthen each other's knowledge and insight.

Subsurface effects

Recent seismic events in the Groningen gas field warrant extra attention will be paid to the possible effects of geothermal energy on the subsurface. Such effects may not only concern possible tremors or earthquakes, but also the possible effects on, for example, groundwater. Deep wells involve drilling through various layers. The shallow layers are reservoirs for our groundwater, shielded by layers of clay at the top and bottom. When we drill through these layers, it must not affect the groundwater. Groundwater quality is essential for nature and agriculture. And groundwater is the source of drinking water in large parts of the Netherlands. Good quality groundwater requires solid borehole design and maintenance as well as continuous monitoring to prevent leakages. Fortunately, much experience has been gained with the over 4,000 wells for gas production in the Netherlands, and the risk of leakage or pollution is very low.

Safety must be paramount for all activities in the subsurface. It cannot be excluded that we find gas under pressure. The installations must therefore have safety measures such as valves. And, because there is increased naturally occurring radioactivity at greater depths, drilling waste must be carefully removed. All these possible effects have long been known from global oil and gas production. They must also be handled with care in the world of geothermal energy.

The extraction of geothermal energy is comparable to oil or gas extraction in several ways. But some parts are different. With oil and gas extraction, relatively large quantities of oil or gas are removed from the (deep) subsurface. With geothermal energy, (virtually) nothing is removed. The amount of hot water that is pumped out is almost equal to the amount of cooled water pumped back into the same layer. Only heat is removed and transferred to a heat network, making it a closed system. We may expect fewer effects, but this must be substantiated and proven scientifically.

Whether or not earthquakes may occur and what the consequences might be depends on many factors. Deep geology is one of them. Is it a tectonically active area (such as parts of Italy or Turkey)? Are there any cracks, or fault lines, and are they critically stressed? Can large stress differences occur along cracks due to production or injection? What is the size of a project and what is the size of the affected subsurface? The situation obviously differs from place to place and from project to project. Gas production has different effects than the production of geothermal energy, which ultimately removes nothing from the subsurface.

What about the risks?

Human activities in the subsurface, such as extraction of gas and geothermal energy, may induce seismic events. Small earthquakes and tremors may be felt at surface and ultimately may cause damage. Thorough research into the risk of seismicity and possible consequences at surface is therefore key, as it may guide whether and in which way activities can be continued. Companies with subsurface activities must submit a so-called Seismic Risk Analysis to the regulator (State Supervision of Mines) before the start of each project. They must present an analysis of the possibility of earthquakes occurring and describe how risks are mitigated.

Safe geothermal energy with public support

Photo © Stadtwerke München

There are also big differences regionally; for example, earthquakes occur naturally in parts of the province of Limburg. To make predictions for a geothermal energy project, we need to properly understand those differences. We must also look closely at seismic activity (or the lack thereof) in geothermal energy projects at home and abroad. This is, therefore, subject for much research.

Surface effects

Like almost all other forms of energy generation, geothermal energy will also affect our environment. We should realise that drilling must be carried out close to where the heat is needed as heat is inevitably lost during transport. A production site will initially occupy around half a hectare (during the drilling phase). This is comparable in size to a soccer pitch. Once the plant is operational, it will occupy approximately half that area. After the drilling phase a 'pump house' remains and must be in keeping with the surroundings as much as possible. The visible effect will therefore be different and probably smaller than that of, for example, solar fields, wind turbines, power stations or masts, but there will be an effect on the landscape.

Geothermal energy in your backyard

The German city of Munich has set itself the goal of making the city's heat supply sustainable. Geothermal energy plays a key role, as the city has a favourable location due to its subsurface. Over seven geothermal energy projects have been executed so far. Further away from Munich city, more projects have been developed that provide electricity and heat to municipalities.

These municipalities have set up several projects, which were later taken over by Stadtwerke München and are now managed by them. Stadtwerke München has a strong base in the community and is owned by the municipality, which generates confidence and strong support among its residents.

The first project was implemented over 10 years ago. In 2014, a decision was taken to investigate how the greater area could be optimally developed. This included the collection of new 3D seismic data (170 km^2) across the city of Munich. The activities were carried out over a period of four months. Almost 7,000 signals were sent into the ground during this period. The reflections from the subsurface layers were received by a large network of so-called geophones at surface. Based on this information, a 3D image of the subsurface was created which is used to optimally plan the geothermal wells. The projects will provide heat for over 80,000 households and will be completed in 2019 and 2020. All in all, the city's vision is slowly becoming reality.

Photo © Kenneth Stamp

Working together on shared interests

The Netherlands has a major interest in the growth of geothermal energy to fill in part of the future sustainable energy consumption. Geothermal energy can also strengthen our economy. Several companies have gained experience with geothermal energy from deeper layers. Research institutes are also working on geothermal energy. Unfortunately, all this research and expertise is still fragmented. Local authorities require frameworks for drawing up regulations and assessment frameworks for issuing licences. Entrepreneurs need insight into long-term possibilities and certainties but must also be able to seize these opportunities. Potential users need a realistic overview of the sustainable opportunities including pro's and con's. The financial aspects must be presented realistically. Geothermal energy still requires subsidy, but it is one of the cheaper sustainable heat sources. If we want geothermal energy to take off, geothermal energy will also have to be developed without subsidies. Finally, the society needs a well-founded and realistic understanding of all aspects of geothermal energy. ◄