Geothermal Energy Use, Country Update for Belgium

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ABSTRACT

The contribution of geothermal energy in the Belgian energy mix is still low. However, for deep geothermal development in Flanders, important initiatives were taken by the Flemish government in previous years: a new decree on deep subsurface including deep geothermal projects and the implementation of an insurance system to cover geological risks. In Wallonia the legal framework will evolve in the same direction in 2019, with a new decree for underground resources management and a similar insurance system.

Two deep geothermal projects are in production or under development: (1) 3 heating networks using existing unique deep wells in the Hainaut basin and (2) a pilot project in the Campine Basin consisting of 3 deep wells (the Balmatt project) will deliver heat to company buildings in 2019.

Recently, a clear revival can be observed for shallow geothermal systems compared to the last country updates (Petitclerc et al. 2016, Loveless et al. 2015). In Flanders this is mainly due to the tightening of the E-level and the obligation to produce renewable energy. This is also encouraged in the Brussels area. As a result, there is a boost in the use of heat pumps. Although air/water systems have the upper hand, more and more geothermal heat pumps are being installed.

Furthermore, Belgian scientists from different institutes and universities are involved in several ongoing geothermal research projects, which are briefly introduced in this paper.

1. INTRODUCTION

To achieve the renewable energy share in the total energy use in Belgium, geothermal energy can play a substantial role in the heating sector, which counts for 50% of the total use of energy. Both shallow and deep geothermal have potential to contribute.

In Belgium, the largest potential for deep geothermal development is provided by sedimentary basins located in the Mons Basin in the South and Campine Basin in the North. The use of shallow geothermal systems is more developed in the northern part of the country (Flanders) than in the South (Wallonia), because of cheaper drilling costs and favourable legislation.

2. POLICY DEVELOPMENT FOR DEEP GEOTHERMAL ENERGY

2.1 Permitting in Flanders.

The Flemish Decree of 8 May 2009 concerning the deep subsurface regulates the licensing for deep, i.e. deeper than 500 m, geothermal projects. It follows a two steps procedure with exploration and production licenses. Since the end of 2018 also an insurance system for geological risk is in place.

Applicants for an exploration licence need to submit a complete application covering the necessary data and information, including a thorough geological study. The application is opened for fair competition during 90 days. The permit grants the exclusive right for a well-defined 3D-volume at depth to explore in detail how much heat might be produced and what are the boundary conditions. During the validity period of the exploration permit (default 5 years), a production plan is set up based on detailed reservoir data. This production plan needs to be validated before a production permit can be granted. Apart from the exploration / production permit, also an environmental permit is needed.

To stimulate the investments in geothermal energy, which is characterized by high initial investment cost and high uncertainty risk, the Flemish government provides an insurance system for geological risk (VPO 2019). This covers the exploration risk, i.e. the short-term geological (uncertainty) risk. Long-term performance, technical fails and geohazards are not covered in the insurance. The maximum amount per project that can be covered is 18,7 MEUR. Only 85% of the eligible costs can be insured. A participation fee of 7% on this amount must be paid. The applicant has to validate the expected thermal power (P90 value) by a set method and perform adequate testing to prove the outcome.

2.2 Policy development in Wallonia.

In Wallonia, a regional guarantee system was adopted on 24 January 2019 by the Walloon government. The decree has two parts: 1) The regional geothermal guarantee scheme: the region covers the risk, based on the opinion of a technical committee and compensates if necessary; 2) The creation of a "geothermal guarantee" section in the Kyoto Fund, with a specific budget (to be provided during budget programming) used for compensation. To benefit from the compensation, investors contribute to the fund by paying a premium proportional to the cost of a project. The particularity of this regional guarantee is that the cost is linked to the first drilling of the doublet and covers almost all the investment before knowing if the resource reaches the expected level. The procedure to obtain a guarantee is as follows: a developer studies a project and evaluates the expected resource that could be exploited from the subsoil (thermal power). He applies for a guarantee with the Walloon government to benefit from the coverage. The technical committee (composed of the administration and scientific experts in geology and geothermal energy) validates the project as a whole based on the best scientific knowledge and recommends to the Walloon government to grant or not the guarantee (under conditions). The applicant who has obtained the guarantee pays a premium (a kind of insurance policy). Then, it carries out its first drilling and evaluates the real resource that will be exploited. If this is lower than the expected resource (in flow or temperature), he can submit a claim for compensation. The technical committee validates the actual resource and determines the actual amount of compensation to partially cover losses due to a less than expected resource.

The legal framework of the deep geothermal energy should be evolving in 2019 with the adoption of a new decree for the underground resources management. This framework will consider deep geothermal energy as a strategic resource, such as fossil fuels and metallic substances. By this way, the achievement of this new policy should stimulate industrial investment in deep geothermal energy in Wallonia.

3. POLICY DEVELOPMENT FOR SHALLOW GEOTHERMAL APPLICATIONS

3.1 Policy development in Belgium

Belgium needs all possible shallow geothermal technologies to apply this renewable energy form for new construction or renovation. Every type of geothermal system is applied, both open and closed, superficial and deeper, with water or air as energy transport medium. This is mainly caused by the very diverse geological structure with big local differences and rapid succession of different sediments. The largest differences manifest themselves between the North (Flanders) and the South (Wallonia) of the country with mostly sand/clay in Flanders and Brussels versus schist/sandstone/limestone in Wallonia.

Price-wise, a geothermal project will be more feasible in the North of the country. Partly because of this, the development of geothermal projects takes place at two speeds, with a clearly larger market and growth in Flanders and Brussels. Also, the regional governments have an impact on geothermal progress. Belgium has three administrative regions, each with its own and mutually very different licensing policy. There are also important regional differences in the stimulation of the building sector in the use of renewable energy systems.

After a hesitation in the elaboration of shallow geothermal energy systems in Belgium between 2014 and 2017, a clear revival can now be observed. In Flanders this is mainly due to the tightening of the E-level (max E40 from 2018) and the obligation to produce at least 15 kWh/m^2 renewable energy. This is also encouraged in Brussels where passive construction has been mandatory since 2015 with an obliged heat demand not exceeding 15 kWh/m^2. As a result, there is a boost in the use of heat pumps. Although air/water systems have the upper hand, more and more geothermal heat pumps are being installed.

In 2018, the price ratio of gas/electricity is unfavorable to realize large savings and short payback times, this still has an inhibitory effect. Nevertheless, geothermal systems can attract more and more individuals/companies because they are invisible and completely silent. An even more important asset is the possibility of passive cooling, not an unnecessary luxury in a very well insulated building in Belgian climate.

3.2 Policy development in Brussels

Early November 2018, the Brussels Government approved a decree regulating groundwater abstraction and geothermal systems in open circuit. This text is expected to come into effect in early 2019.

“Bruxelles Environement” decided to manage the underground water catchments:
* by assessing the degree of pressure of the catchments on the available resource;
* by controlling permanent water abstractions for domestic and industrial purposes (including artificial reinjections for geothermal duplicates and temporary catchments exceeding 96 m³/day via a permit system imposing on the operator:
* not to exceed a maximum volume captured per day (also per month or per year if applicable);
* to declare annually the volume of water taken;
* the placement of a volumetric measuring device to control the volumes captured at all times;
* if necessary, certain specific conditions allowing to limit the quantitative impacts, but also the geotechnical disorders (settlements, problem of instability of the frame) engendered by the folding of the tablecloth (ex: realization of a preliminary study of impact, limitation of the flow, placement of control piezometers, installation of containment device, prohibition of local capture of a special aquifer ...).

4. GEOTHERMAL PROJECTS

4.1 Deep geothermal Balmatt project

In January 2016, VITO completed the geothermal exploration well MOL-GT-01-S1 in Mol-Donk, northern Belgium (Bos et al. 2018). The well targeted a Lower Carboniferous fractured carbonate reservoir at a depth between 3000 and 3600 m. Reservoir temperatures encountered at the bottom of the well at 3600 m were 138 – 142°C and a well test proved the geothermal potential of the limestones. This led to the drilling of a second well to close the geothermal loop. Well MOL-GT-02 was completed and tested in summer 2016. Both wells will form a doublet that will deliver heat to an existing district heating network of VITO and surrounding companies. The geothermal plant also includes facilities for research on materials (corrosion testing and development of coatings) as well as test facilities for heat exchangers and binary systems. Next to the heat delivery, electricity production is foreseen using the Organic Rankine Cycle (ORC) technology. The initial thermal power output of the geothermal plant will only be about 8-9 MW since the return temperature is as high as 80°C, imposed by the existing high temperature heating grid already in place on the location. Connecting low temperature heating networks, that could go as low as 30°C, would double the thermal output. Regarding this addition of extra low temperature heating networks, VITO drilled a 3rd well in 2018, MOL-GT-03. MOL-GT-03 targeted the same faulted and fractured zone as MOL-GT-01-S1, although now in a SE direction at 1.6km distance to MOL-GT-01-S1 and furthermore explored the potential of lower lying Devonian strata. Comparable reservoir characteristics were expected in MOL-GT-03, however, the results of the well test were lower than expected. To have a better understanding of the reservoir, a more detailed analysis was started, using data gathered from all three wells. The evaluation involves both structural, geological, petrographical and hydrogeological aspects (Broothaers et al. 2019). It should lead to a decision on which steps need to be taken to make MOL-GT-03 a successful well.

4.2 "Porte de Nimy" deep geothermal doublet in Mons

In Wallonia, the use of deep geothermal energy is currently limited to the Mons-Borinage area, in the central part of Hainaut. Three heating networks operate using existing unique deep wells in Saint-Ghislain, Douvrain and Ghlin. These networks are managed and still developed by IDEA, the regional economic intermunicipality.

Thanks to European Regional Development Fund, a new geothermal plant will be implemented by IDEA in the city of Mons in the "Porte de Nimy" area, especially for the heating supply of the Ambroise Paré hospital. The drilling and completion of the geothermal doublet is planned in 2020, the geothermal plant building in 2021 and the heating network deployment in 2022.

The expected thermal power is estimated to 7 MW and the thermal energy distributed should reach 10.5 to 14 GWh per year.

4.3 MORE-GEO project

The MORE-GEO project is supporting the "Porte de Nimy" deep geothermal doublet project and is also granted by the European Regional Development Fund.

This project, held by the University of Mons, wants to promote in a sustainable way the development of the deep geothermal resource of the Hainaut, especially of the Carboniferous limestone reservoir (Licour 2014) already exploited by IDEA. It requires to limit the geological risk by improving the knowledge of the geothermal reservoir, but also to assess the economic risk by testing mid- and long-term realistic scenarios.

MORE-GEO is divided in three main parts: 1) the acquisition of new data from the deep geothermal reservoir; 2) the development of a hydrogeological model of the geothermal reservoir; 3) the test of exploitation scenarios within the hydrogeological model.

The new data shall provide from geophysical surveys (Martin et al. 2018) and from the drilling of the "Porte de Nimy" doublet. Beginning 2019, five deep seismic reflection lines of about 100 km-length in total will be acquired in this area, from the French border to the East of Mons (Hainaut2019 survey). These lines will spatially complete former seismic acquisitions in the area (2DMons2012 and Hainaut79) to explore the structure of the geothermal reservoir at a regional scale. Then, a gravimetric survey will follow along the Hainaut2019 seismic lines, to support and complete the seismic data. In 2020, the drilling of the "Porte de Nimy" doublet will provide new deep geological data, which will allow to precise locally the structure and the properties of the geothermal reservoir.

The development of a hydrogeological model of the geothermal reservoir requires former geological data completed by the results of the new acquisitions. Before the set-up of a regional-scale model, a first model of the "Porte de Nimy" area has been built to model heat transfers and flows at the scale of the new geothermal doublet (Gonze et al. 2018).

After the completion of the regional-scale model, several realistic exploitation scenarios will be tested to evaluate the impact of varying geothermal energy production parameters, but also to assess the effects of the establishment of new geothermal doublets in the area. At the end, the use of this model will provide an efficient management tool of the deep geothermal resources of Hainaut.

4.4 MEET project

The main objective of MEET (2018-2021) is to capitalize on the exploitation of the widest range of fluid temperature in EGS (Enhanced geothermal systems) plants and abandoned oil wells. The aim is to demonstrate the lower cost of small-scale production of electricity and heat in wider areas with various geological environments, to support a large increase of geothermal based production sites in Europe in a near future. To boost the market penetration of geothermal power in Europe, MEET project main goal is to demonstrate the viability and sustainability of EGS with electric and thermal power generation in all kinds of geological settings with four main types of rocks: granitic (igneous intrusive), volcanic, sedimentary and metamorphic with various degrees of tectonic overprint by faulting and folding. MEET brings together 16 European partners: Industrials, small and medium enterprises, research institutes and universities, but also several geothermal demonstration sites in Europe located in the various geological environments described above. The assessment of the technical, economic and environmental feasibility of EGS is an integral part of the project, as well as the mapping of the main promising European sites where EGS can or should be implemented soon. Thus, MEET will provide a roadmap of next promising sites where demonstrated EGS solutions could be replicated in a near future for electricity and heat production with an evaluation of the technology and its economic feasibility and environmental positive impacts.

For Belgium the possibility of re-opening the deepest well from Belgium, Havelange well (5648m in depth), and its conversion in a geothermal well will be studied.

4.5 DGE Rollout

The exploration of Deep Geothermal Energy (DGE) in most NWE regions requires specific expertise and technologies in the complex geological situations (strongly faulted high permeable carbonates and coarse clastic rocks) that could be found exemplary clear cross border in Germany, France, the Netherlands and Belgium. It is the objective of DGE-Rollout (2018-2022) to produce energy and reduce CO_2 emissions by replacing fossil fuels through increasing the usage of DGE in NWE for high-temperature heat supply of large-scale infrastructures to cover the energetic base load. This will be achieved by mapping and networking, by applying innovative decision and exploration strategies and testing for production optimization. In two pilots (Balmatt, BE; Bochum, DE) the production optimizing will be tested by implementing high temperature heat pumps and new cascading schemes from high (>100°C, big network) to low temperature (>50°C, single enterprise) and gain a CO_2 reduction of 25.000 tons/year. By realizing further plants in DE, FR, BE, NL this could reach up to 215.225 t/y until 2023. 10 years after project's end at least 1.000.000 t/y will be achieved, but it is expected to reach up to 5.000.000 t/y in the long run. Further activities will apply innovative decision and exploration strategies that are cheaper, risks minimizing, more reliable and see a 3D Atlas of the complex geological situation as the spatial basis usable for DGE. To set the stage for DGE tools to increase social acceptance will be checked out, (planning) legal conditions as well as business models for enterprises will be evaluated and compiled, a network "NWE-DGE" will be set up to sustain the outputs and investments in the long-term roll-out after the end of the project.

4.6 Brugeo project: shallow geothermal resource assessment (Brussels)

In Brussels, the Brugeo project (2016-2020) receives ERDF funding from the Brussels-Capital region and the European Union. The project's goal is to promote geothermics in the Brussels area, especially shallow geothermal installations with a heat pump. The geothermal energy has significant development potential in this urban area despite a lack of accurate geological and hydrogeological data in some areas. The geothermal potential of Tertiary sediments over the first 40 to 120 m are relatively well known. The exploration phase of the project focused his interest to the probable geothermal potential of the Paleozoic rocks encountered at greater depths (from about 40 m depth). An exploration drilling at Anderlecht was conducted in 2018 by the Geological Survey of Belgium (Brugeo member) and demonstrated the high potential (productive water flows, high thermal properties of the Cambrian sandstone and quartzites). This promising result has encouraged the private sector (Iftech/AGT) to realize the first open system in the Brussels Paleozoic basement. This pilot-project of 10 wells (150 m - 200 m depth) started end of summer 2018. The installation will provide 1396 kW to partly heat the 45,000 m^2 of the covered town of the Gare Maritime (Extensa project). The Brugeo consortium planned to provide the Brussels geothermal potential maps for beginning of 2020 and to strongly increase the communication towards the public to foster the use of shallow geothermal energy in the coming years.

4.7 Assessment of the geothermal potential of the old mines of Wallonia

A one-year project has been launched in February 2019 by the Directorate of the sustainable energy promotion of the Walloon administration (SPW-DGO4) to evaluate the geothermal potential of the Walloon old mines. The interest for this technique in Wallonia has been recently increasing, as shown by recent master thesis reports (Gonze 2017, Vopat 2017).

After a European benchmarking of the mine water geothermal energy use, the consortium formed by VITO, University of Mons, ABO-Group and Mijnwater B.V. will identify and assess favorable old mine sites in Wallonia and determine the feasibility of surrounding heating networks next to these sites. The project also contains the realization of a business plan for a pilot project and the submission of an action plan to promote this technique in Wallonia.

5. CONCLUSIONS

Unless the fact that effective geothermal energy production is still low in Belgium, promising activities are on their way. For deep geothermal energy production, we have the pilot plant (Balmatt) and the project in the Hainaut area. Different exploration activities are planned (geophysical prospection). Because of different government measures, the shallow geothermal sector has a revival, more and more geothermal heat pumps are being installed.

Policy (new or adapted decrees, insurances) in the different regions will support further development of both deep and shallow geothermal projects in the coming years. Belgian institutes and universities are involved in various national, European geothermal research projects, which aim to further develop geothermal energy.

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Tables A-G

Table A: Present and planned geothermal power plants, total numbers

Table B: Existing geothermal power plants, individual sites

There are no geothermal power plants in Belgium.

Table C: Present and planned deep geothermal district heating (DH) plants and other uses for heating and cooling, total numbers

	Geothermal DH plants		Geothermal heat in agriculture and industry		Geothermal heat for buildings		Geothermal heat in balneology and other	
	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)
In operation end of 2018	17	14.55	7	0.12	10	14.42	?	?
Under construction end 2018	8-9							
Total projected by 2020								
Total expected by 2025	7	11	0	0	7	11	0	0

Table D1: Existing geothermal district heating (DH) plants, individual sites

Locality	Plant Name	Year commis-sioned	CHP	Cooling	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2018 produc-tion (GW_{th}/y)	Geoth. share in total prod. (%)
Saint-Ghislain	Saint-Ghislain	1985	No	No	6	6	13.37	100
Douvrain	Douvrain	1985	No	No	4	4	1.06	100
Ghlin	Geothermia	2018	No	No	7	7	0.12	100
Mol-Donk	Balmatt	2018	No	No	8-9	/	/	/
total								

Table E: Shallow geothermal energy, ground source heat pumps (GSHP)

	Geothermal Heat Pumps (GSHP), total			New (additional) GSHP in 2018		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2018	25622 *(est.)*	338,6 *(est.)*	544,4 *(est.)*	1940 *(est.)*	24,4 *(est.)*	16 *(est.)*
Projected total by 2020	30063 *(est.)*	389,6 *(est.)*	626,5 *(est.)*			

Table F: Investment and Employment in geothermal energy

	in 2018		Expected in 2020	
	Expenditures (million €)	Personnel (number)	Expenditures (million €)	Personnel (number)
Geothermal electric power				
Geothermal direct uses				
Shallow geothermal	42,4 *(est.)*	149 *(est.)*	50,9 *(est.)*	179 *(est.)*
total				

Table G: Incentives, Information, Education

	Geothermal electricity	Deep Geothermal for heating and cooling	Shallow geothermal
Financial Incentives – R&D			Yes, if appropriate in certain regional/federal research program
Financial Incentives – Investment			Yes, but decreasing in size
Financial Incentives – Operation/Production			No
Information activities – promotion for the public			Yes, as result of certain R&D projects
Information activities – geological information			Yes, as result of certain R&D projects
Education/Training – Academic			No
Education/Training – Vocational			Yes, set-up of heat pump programs (RESCert)