Interreg North-West Europe
DGE-ROLLOUT

Socio-economic potential mapping for Deep Geothermal Energy

Focus: Netherlands

Deliverable T1.2.3

Timme van Melle (EBN)
Jessica Klop (EBN)
Gabriela de los Angeles Gonzalez de Lucio (GD NRW)

July, 2022

Disclaimer

The purpose of the following report is to give a short overview of the aspect that has been defined as a milestone in the socio/economic mapping potential inside the DGE Roll-out project in Germany. It should provide general information to local, regional, and national public authorities, project developers, politicians and enterprises with heat demand. However, this report does not replace the own independent research on this topic. Appropriate legal advice should be obtained in actual situations.

The recommendations given herein are the authors' subjective opinions based on the research which has been done for this report. It does not rely on experience during drilling or seismic exploration in the field. It mainly sums up the opinion of experienced project partners and actual goals in contributing as much as possible to stop climate change.

We cannot guarantee the accuracy, reliability, correctness or completeness of the information and materials given in this report and accept no legal responsibility. For further reading, please refer to the literature mentioned herein about the socio-economics aspect above mentioned.

Contents

Socio-economic potential mapping for Deep Geothermal Energy 1

Focus: Netherlands 1

Introduction 4

Socio-economic aspect in Geothermal Projects 5

Methodology 6

Results 9

Social 9

Population distribution 9

Heat demand 10

Social level map 11

Economic 13

Income 13

District heating 14

Environmental 15

Nature conservation areas 15

Greenhouse gas emissions 16

Socio-Economic Potential 17

Conclusion 18

References 18

Appendix A 19

Introduction

Climate change is a global concern that requires regional action. Northwest Europe aims to reduce CO2 emissions through the transition from fossil fuels to renewable energy sources. The need for an opportunities overview is growing to meet the energy demand of the population and industry. The heat demand covers almost 50 % of the total energy demand. It can be substituted with geothermal energy. In this project, we focus on deep geothermal energy (DGE).

The importance of evaluating both topics, social and reservoir factors, is described in the technical approach pyramid (Moeck, et al., 2020). It considers social and geological aspects in the exploration phase of geothermal projects and emphasizes the decisive surface and subsurface elements.

As part of the DGE-ROLLOUT project, deliverable 2.3 “Mapping of socio-economic potential for DGE” has been developed covering the decisive elements. Its aim is to inform the current socio-economic situation for new geothermal projects, considering the investor profile (van Melle, et al., 2021) and the heat demand (Fraunhofer IEG, 2021).

Inside the DGE ROLLOUT project, the economic aspects related to deep geothermal projects has been described and analysed in reports: WPT1 D3.1 Legal Framework (Van Malderen, 2020), WPT1 D3.2 Financial Risk Management (Taşdemir & Arndt, 2020) and WPT1 D3.3 Examination of the German regulatory framework and financial risk management of DGE, A recommendation approach (Taşdemir & Dombrowski, 2021) . These topics will not be covered in this report, so the reader is referred to them.

Socio-economic aspect in Geothermal Projects

The methodology for geothermal exploration is based on the existing one for hydrocarbons (Moeck & Beardsmore, 2014). The exploration phase distinguishes between geosystems, plays and prospects according size and detail of the geological model. The workflow suggested by Moeck (Moeck, et al., 2020) integrates the surfaces and subsurface parameters in groups to evaluate a geothermal project (Figure 1). The subsurface group is the geologic-technical focus pyramid with all the factors related to the reservoir. The geosystem includes the overall characterization of the reservoir rock, the play is an area of interest within the geosystem, and the prospect is the exploration target that will later be exploited. This process is called the scalability of the subsurface. The other group is the societal-technical focus pyramid, which characterizes the efficient use of these resources on the surface. Factors as demand, existing infrastructure and land access are considered. The next step is the determination of the project in the decision plane. The different possibilities of geothermal energy systems and the existing requirements, well documented, are analysed to match the best option. The socio-economic potential mapping report is a starting point, that is, a guide with the necessary information to communicate about the potential on the surface.

The difference between fossils and geothermal energy sources is at the surface, geothermal energy cannot be transported over long distances because of heat dissipation. Therefore, it becomes essential to know the surface conditions.

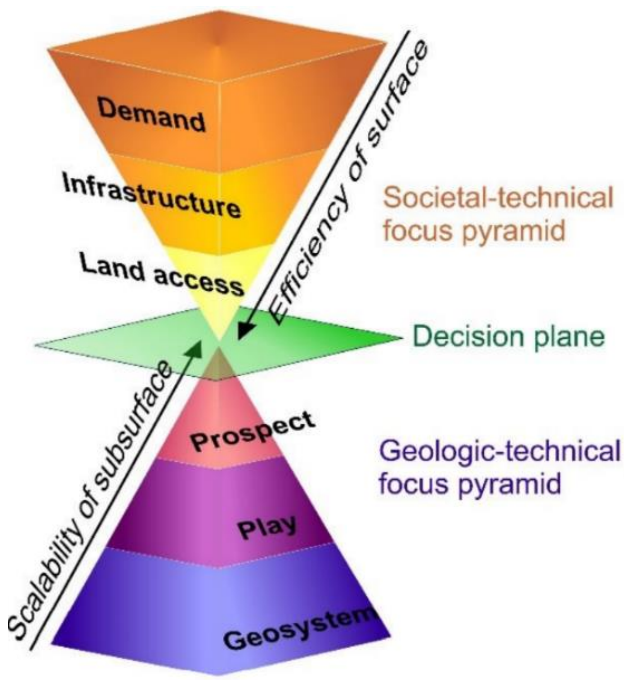

Figure 1 Decision-making factors to start a geothermal project, after (Moeck, et al., 2020).

The societal pyramid factors particularised are:

- Demand

  In the case of Northwest Europe (NEW), it can be classified in energy and heat demand, sector or end-user types, current supply and density population.

- Infrastructure

  This aspect holds the existing infrastructure to the distribution of energy or heat, for example, the district heating networks.

- Land access

  This factor includes data such as land ownership, environmental protection and culturally areas.

Additional to these considerations, the International Renewable Energy Agency (IRENA) incorporate other factors with a socio-economic focus. The Factors are related to the welfare improvements to the population and the environment such as reduction of gas emissions (International Renewable Energy Agency, 2017).

The importance is, for example, projects within regions with risk insurance or incentives could have a higher probability of investment, like the Balmatt energy plant in Mol (Belgium), which had investments from the Knowledge Institute and the Flemish government. In the case of heat demand, it is necessary to be situated in an area with heat demand because geothermal energy is not suitable to be transported over long distances. Kabel ZERO (NRW.Energy4Climate, 2022) is a German project to supply part of the heat demand of the paper factory Kabel Premium Pulp & Paper GmbH with deep geothermal energy. Proposal wells are located in the company's area associated with this project.

Methodology

The socio-economical factors to be considered in the geothermal project assessment can be established on diverse sources, based on literature, surveys and interviewing people involved in geothermal projects and policy (Chocobar, 2020). Those are methodologies widely used in social sciences to collect information and gathering the elements.

The methodology of this project was based on literature and surveys. The main categories Social, Economy and Environment are took from the literature, mainly the *societal pyramid factor* (Moeck, et al., 2020), *benefits for the society* (International Renewable Energy Agency, 2017) and *Identification of socio-technical factors within the play-based geothermal exploration process: Application and* *considerations in Central America* (Chocobar, 2020). Those categories are the typical groups for the factors involve in socio economic studies.

Socio-economic factors have been discussed with the different project partners. Their expertise in different phases of geothermal projects, from exploration to energy supply, is essential to select the correct parameters. Factors were defined by answering three questions:

- What information is needed to know about energy demand? e.g. population distribution and energy demand.
- What information is needed in general within the project proposal? e.g. infrastructure and regulation.
- What other factors could be related to the success of a DGE project? e.g. acceptance and investment.

In the social category were chosen factors that describe the community, the distribution of the population in the state, the heat demand, the percentage of employment-related to renewable energies, and the acceptance of renewable energies among the society. The economic category englobes the factors like income per capita, infrastructure (the existence of heating districts), the existence of investments in renewable energies or the existing regulations that promote or encourage the use of renewable energies. Finally, the environment category considers the current situation of factors that could be beneficial, such as greenhouse gas emissions reduction. Also, factors could limit the development of projects such as protected areas. The crucial factors defined in the DGE ROLLOUT project are summarized in Table 1.

Table 1 Categories and factors defined for the socio-economic analysis of geothermal projects.

Social	*Country information*	Population distribution
		Heat demand
		Employment / Forecast
		Social level map
	Acceptance	Political parties map / Election maps
Economic	*Infrastructure*	District heating
	Finance	Income
		Level of debt of municipalities
		Investment
Environmental	*Land access*	Land ownership
		Assigned land usage
		Environmentally sensitive areas
	Greenhouse gas emissions	

Collecting data

The data collection has been carried out through different official databases, such as those of the state statistical institutes, the official database or directly on the website of the mentioned institutions. The sources of information are divided into four groups: social, economic, environmental, and geographic data. It is the basis for the graphical representation of the information.

Socio-Economic Index

The different quantifiable factors of the socio-economic potential for deep geothermal energy were combined into a joint index. The factors population density, social progress index, acceptance of renewable energies, availability of district heating networks, gross domestic product, public debt, environmentally sensitive areas and greenhouse gas emissions were considered. For the other components, a harmonized and spatially resolved data set is not available, which is why they are not included in the calculation of the index.

Detailed discussions of aggregation of various indicators is given e.g. in Lustig (2011), Decancq and Lugo (2013) and Annoni and Bolsi (2020). Following this, a simplistic approach is adopted in this report, where the composite index I is calculated via an unweighted generalized mean:

$$I = \left(\frac{1}{n}\sum_{i=1}^{n} x_i^{\beta}\right)^{\frac{1}{\beta}}$$

Where n is the total number of components, x_i is the i-th component of the socioeconomic potential, and the constant β describes the compensability between the individual components. A β of 1 corresponds to the arithmetic mean. In accordance with Annoni and Bolsi (2020), a β of 0.5 was used, being between the arithmetic and geometric means.

Before the factors can be combined, a normalization is necessary to scale the parameters between 0 and 100 (for some parameters, like the social progress indices or the acceptance, this is already the case). For this purpose, a min-max transformation was performed:

$$x_{norm} = \frac{100 * (x - x_{min})}{(x_{max} - x_{min})}$$

Respectively for the parameter public debt (high debt corresponds to low potential):

$$x_{norm} = 100 - \frac{100 * (x - x_{min})}{(x_{max} - x_{min})}$$

The minimum and maximum values are either based on the database or were defined individually. They are summarized in Table 2.

Table 2: Min/max values of some components for the normalization.

Factor	Unit	Minimum	Maximum
Population density	Ppl/km²	149	5000
Total heat demand of municipality	MWh/ha/yr	0	3000
Gross domestic product	€/cap/yr	20000	44100
Household carbon footprint	t(CO_2e)/cap	0	22

Results

The data collected in general are direct measurements of the selected factors. Maps have been created in QGIS, an open-source software dedicated to geospatial analysis. Some data are available in various sources at the Europe Union, country or state level. Preference was given to state sources as they have the highest spatial resolution of information. The version or date of data collection is the latest available.

Social

This category encloses the population characteristics in North Rhine-Westphalia. Knowing the number of inhabitants or energy demand makes it possible to identify zones with potential for DGE projects due to the corresponding customer structures.

Population distribution

The total population of the Netherlands is about 17,5 million people. This has been growing and is projected to grow towards 20 million in 2060. The most populated area is the 'Randstad' area, in and between the four main cities: Amsterdam, Rotterdam, Utrecht and The Hague (Figure 2). About 10 million people live in this region. Outside of this region there are a number of bigger cities (>150.000). Traditionally, this area with good access to the trading ports to sea, has been the economic center of the Netherlands. It still provides most employment in industry (Rotterdam, Amsterdam harbour) and services. The quality of living in the big cities has increased in recent times, which makes them more popular to live in and to move to. The important zones are the Randstad in the West, the bigger cities in the rest of the Netherlands, and the horticultural areas that are spread throughout the country.

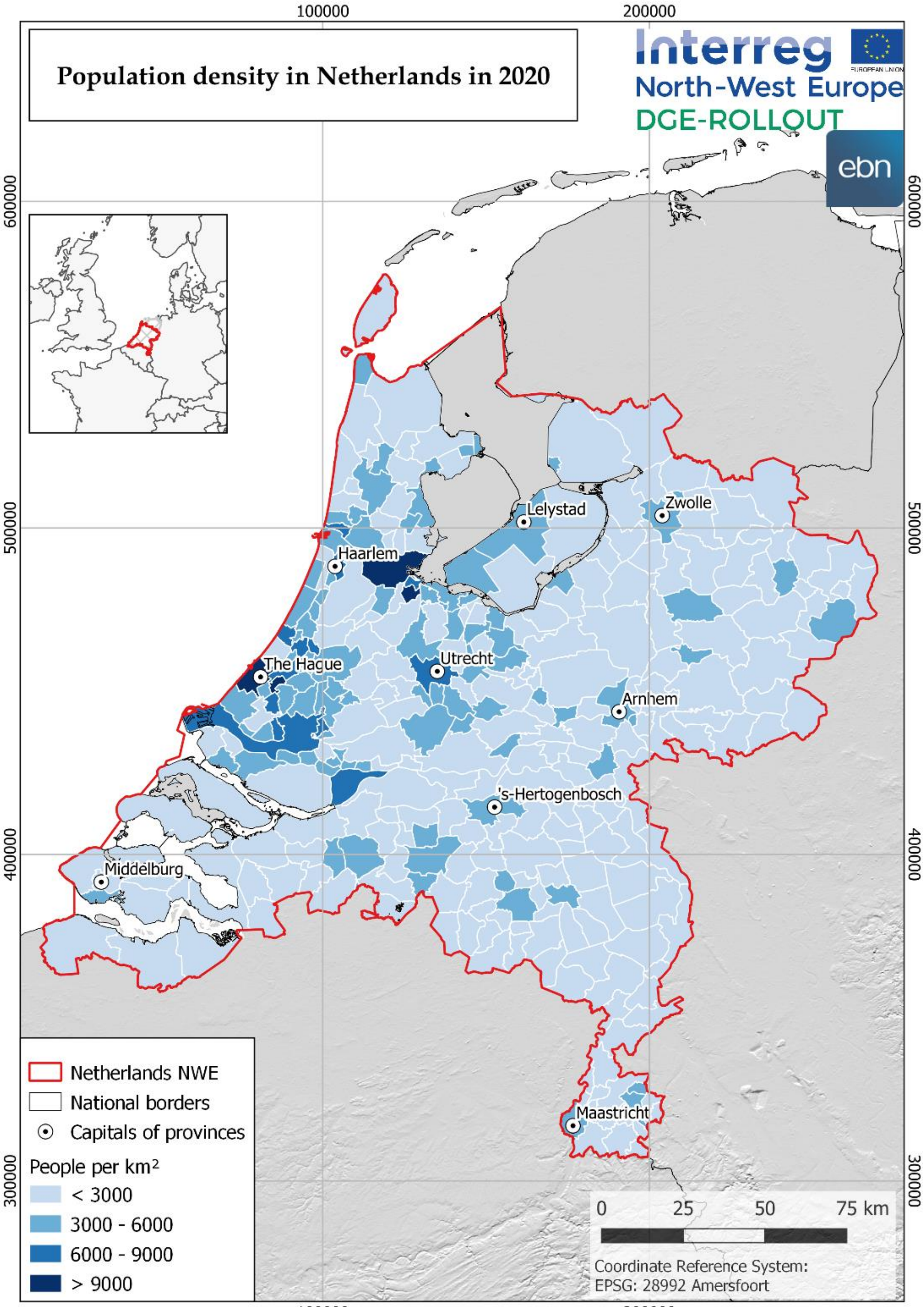

Figure 2 Population distribution in The Netherlands

Heat demand

The heat demand in Northwest Europe was described and analyzed in the DGE-ROLLOUT report "WP T1 - 2.1 Map of the spatial distribution of the heat demand at the surface" (Strozyk et al. 2021). The map was generated from heat demand (HD) data measured or calculated by each project region in North-West Europe and has a spatial resolution of 100 x 100 m². Heat demand is strongly correlated with population density (Figure 3). Exceptions are heat demand related to horticultural areas.

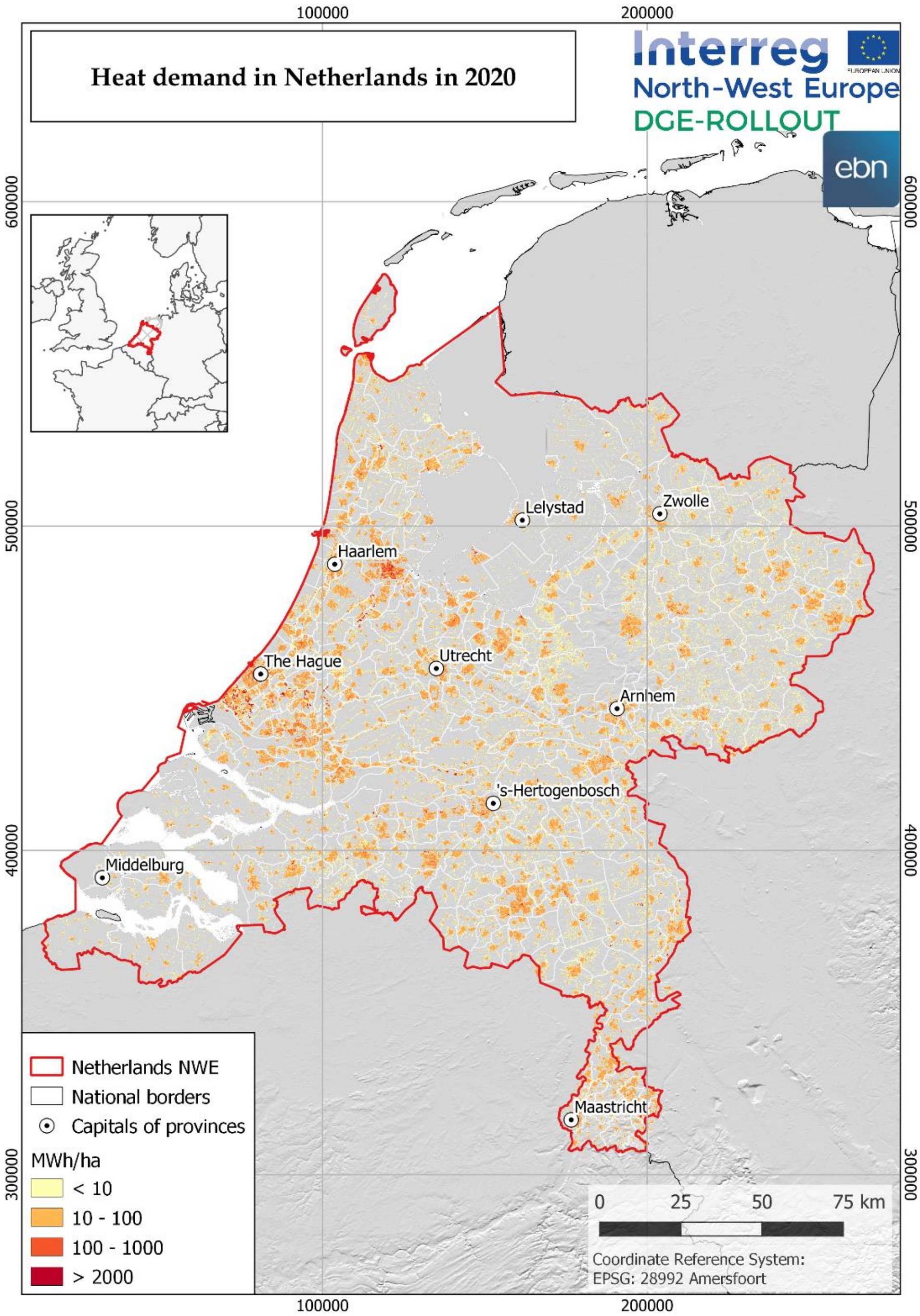

Figure 3 Map of residential and tertiary sector heat demand in The Netherlands.

Social level map

The social level has been described through different indexes, for example, the Human Development Index or the European Social Progress Index. The first encloses three dimensions, each with one indicator: life, education and income to evaluate a decent standard of living. The second has three dimensions, each with four indicators: Basic human needs, Foundations of well-being and opportunity, excluding the economic indicators. Every indicator group defines components, 55 in total.

The European Social Progress Index (EU-SPI) was selected to create the map because of the factor "environmental quality". It has eight components air, noise and general pollution, plus nature protection areas. Overall, there progress index similar across this region (Figure 4). It is slightly higher nearer the Randstad, where there are jobs that require a higher education and have higher pay.

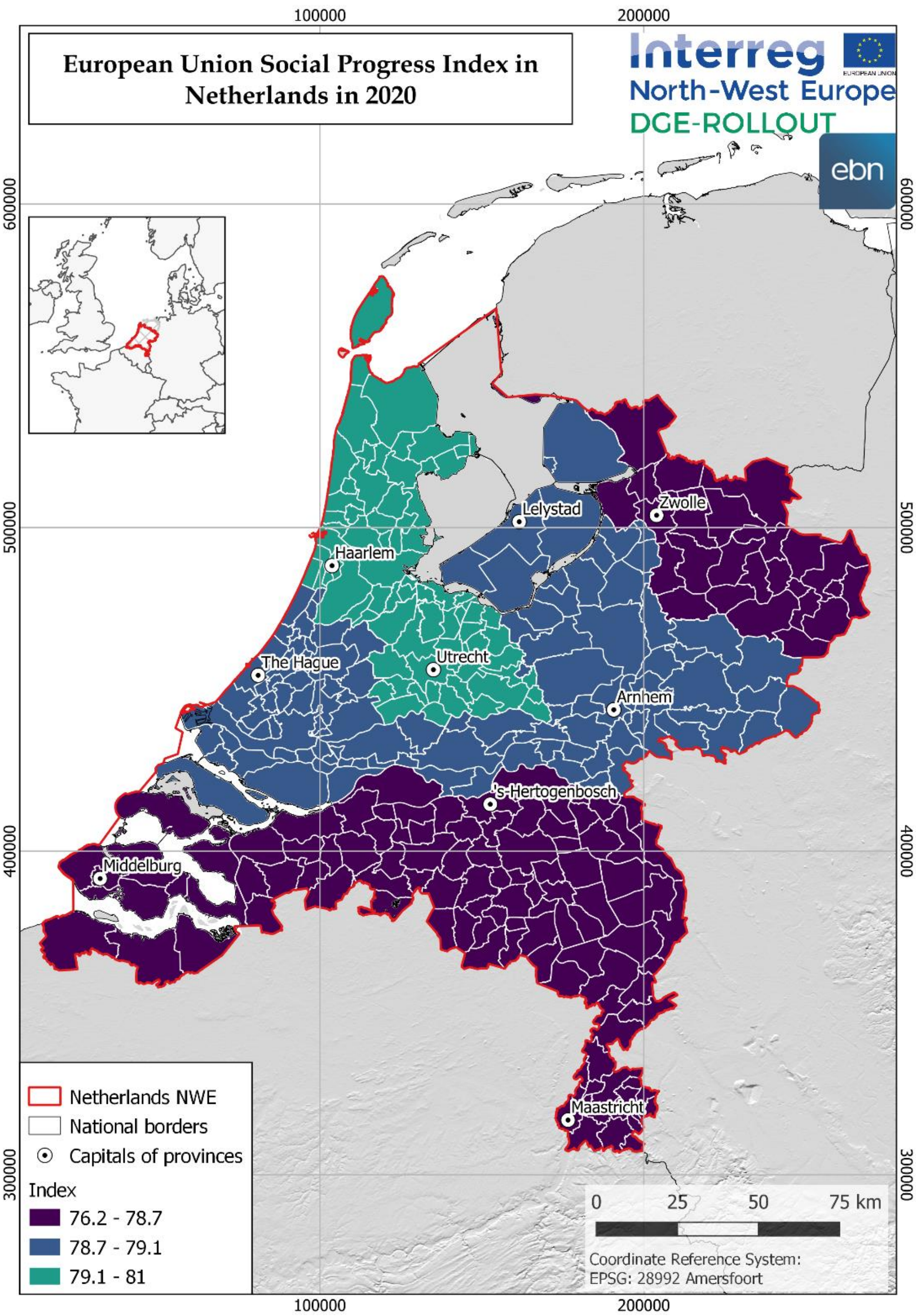

Figure 4 European Social Index in The Netherlands

Economic

Income

The Gross Domestic Product (GDP) at the market is an indicator of the national economic situation. This number is the total value of all goods and services produced in a region minus the ones consumed in their intermediate production (European Commission, 2022). The highest income areas are the affluent areas that are connected to the bigger cities (Figure 5). These are commuter communities with many large detached houses. Rural areas further away from the big cities generally have a lower average income level. There are fewer high-paying jobs here and it is not easy to commute to the main employment centres. Amsterdam, Utrecht, Rotterdam and The Hague are the largest cities with the region. Economically these areas are very important.

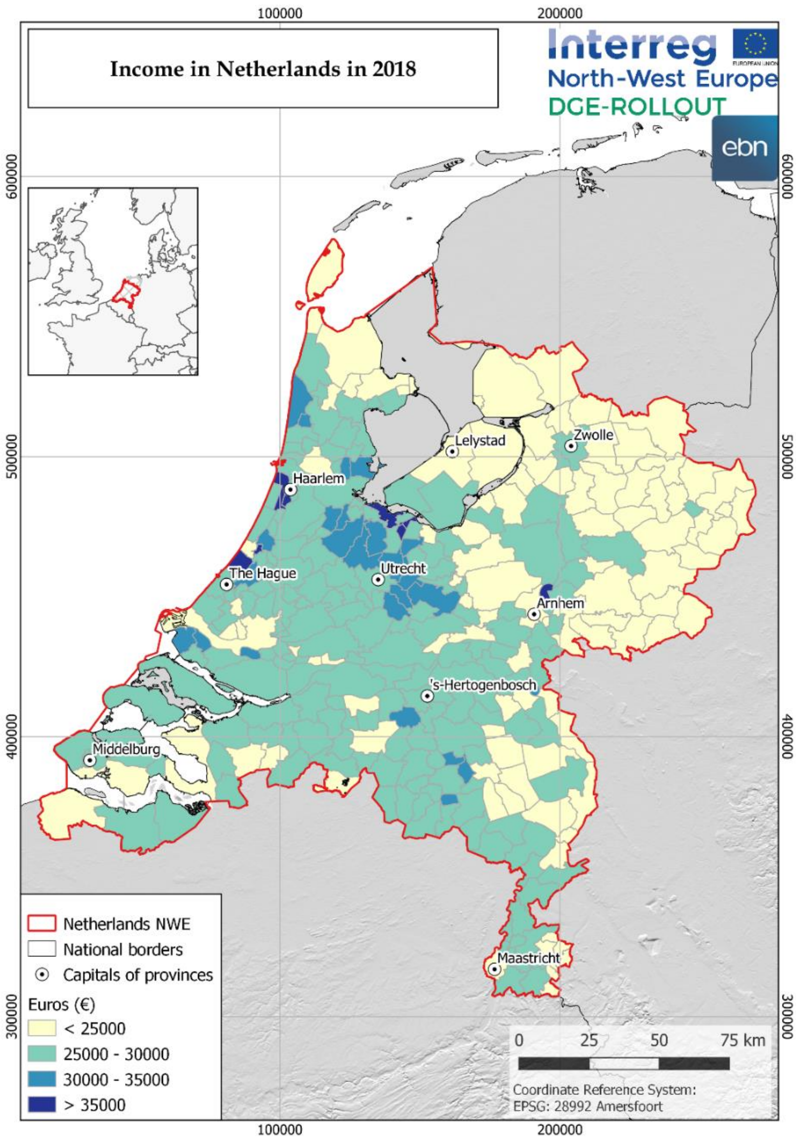

Figure 5 GDP in The Netherlands with data updated in 2018

District heating

The importance of the District Heatings (DH) lies in the potential of the heat that these can generate, the capacity of heat distribution with the existence infrastructure with different level of costumers.

There are a number of companies active in district heating: EnNatuurlijk, Vattenfall, Eneco are large players. There are also some municipal companies in for example Purmerend. The largest networks are in Amsterdam, Rotterdam, The Hague and Utrecht. There are also large district heating networks in Tilburg, Breda, Arnhem and Nijmegen. The municipalities with District heating infrastructure are showed in Figure 6.

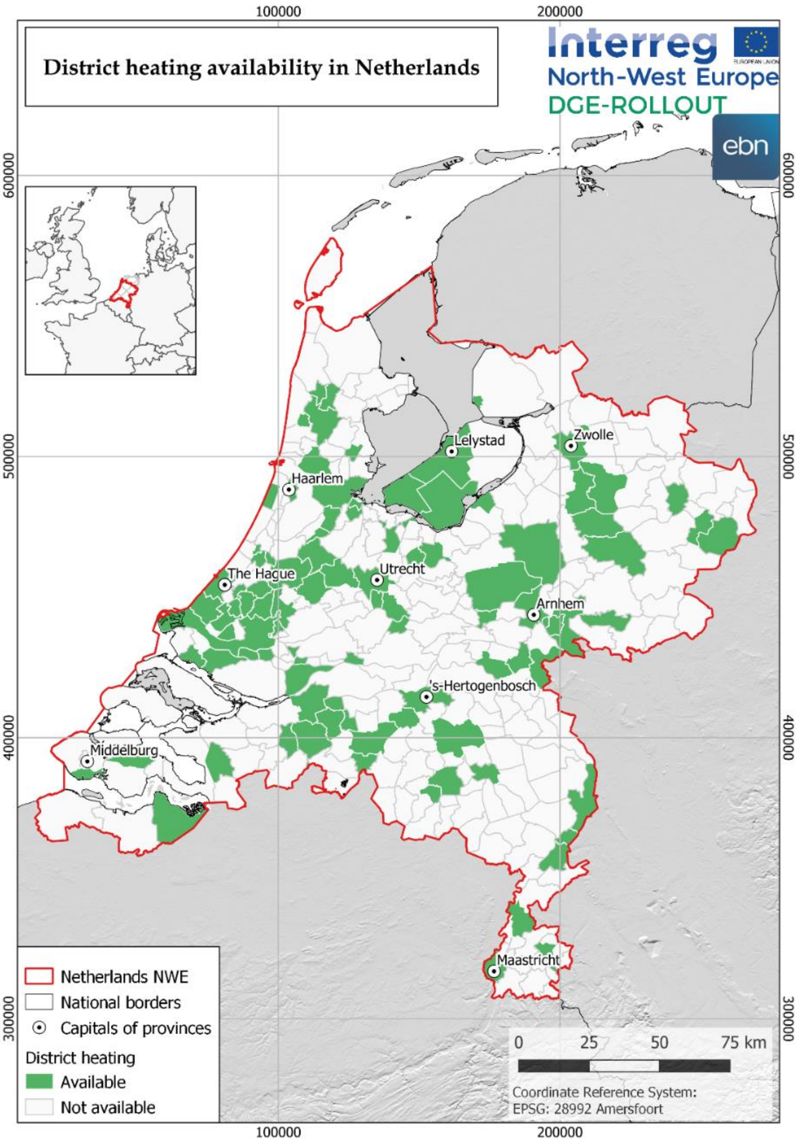

Figure 6 Cities with existence of district heating network in The Netherlands.

Environmental

Nature conservation areas

Natura 2000 is a network of conservation areas in the European Union. The site designation encloses 3 types of sites, protected areas under habitat directive, bird directive, and sites under both directives. Human activity is not excluded in these zones, but it is looking to manage it in a sustainable manner. For this reason, is contemplated a minor restriction in the geothermal projects, and special regulations must be considered a difference in areas outside the conservation areas.

In the Netherlands, the main nature areas are coastal areas, wet areas and forests (*Figure 7*). In a small country like the Netherlands these nature areas limit the potential for development – for example because of nitrogen emissions restrictions. There are always restrictions to take into account when trying to find a location for the development of geothermal energy. Often these can be worked around by adjusting the location or meeting additional requirements. It is however difficult to find locations near populated areas – which is where the heat demand is.

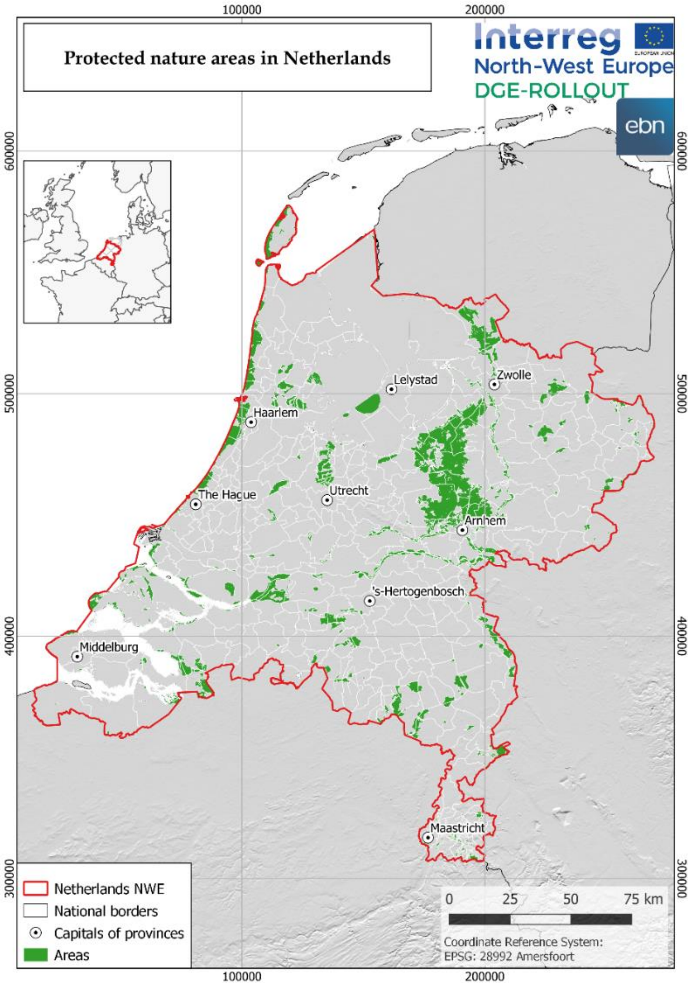

Figure 7 Nature 2000, protected nature areas in The Netherlands.

Greenhouse gas emissions

The three major Greenhouse Gases are Carbon dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O), reaching 98% of the gases related to the Greenhouse effect. The other 2 per cent correspond to Fluorinated gases. The sources of the C02 emissions are the heat and electricity production by fossil fuels combustion, among others. The production of greenhouses gases due to energy production can reach one-quarter of the human-driven emissions (Natural Resources Defense Council, 2022).

The biggest emissions per capita are the areas with industry, greenhouses and intensive farming. As these areas have relatively low population, they show up on *Figure 8*. In absolute terms the cities are also areas with high emissions. Some deep geothermal projects have been developed in the zone, particularly in the horticultural areas near The Hague and in Noord-Holland (above Haarlem).

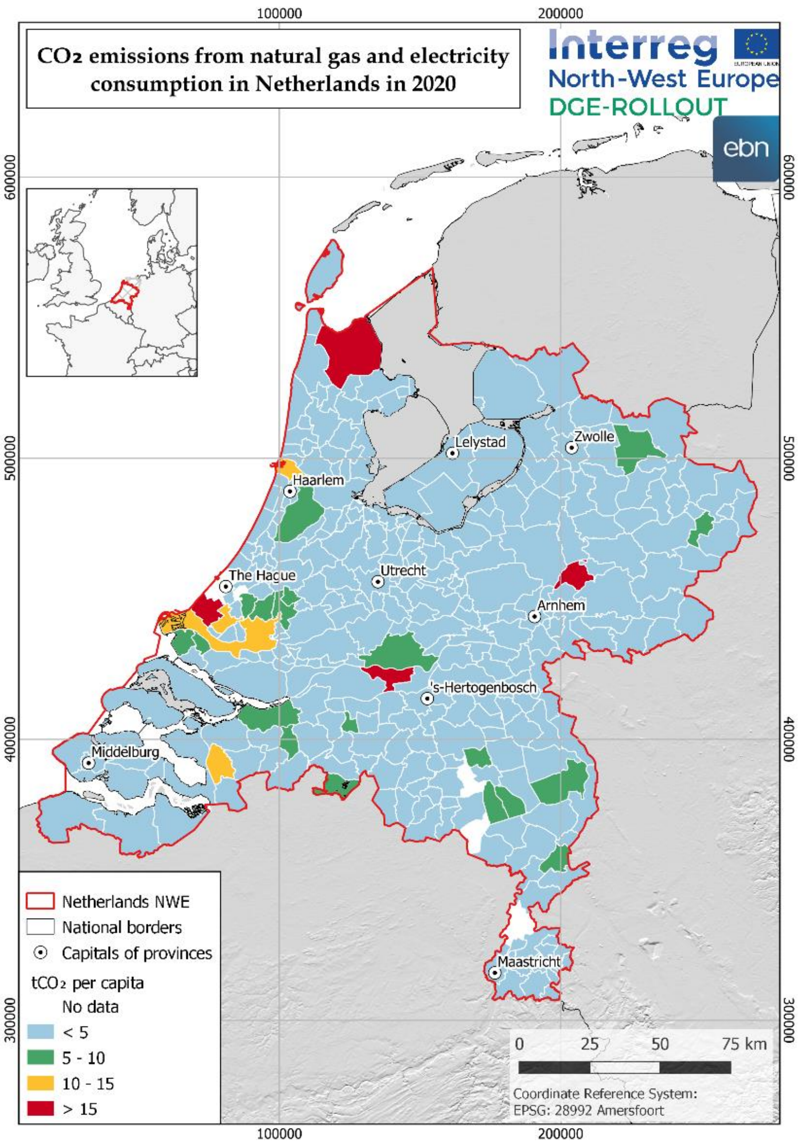

Figure 8 Greenhouse emissions in The Netherlands.

Socio-Economic Potential

Based on the data described above, a composite index for the socio-economic potential for deep geothermal energy was calculated. The absolute values are strongly dependent on the calculation approach, which is why the map is mainly suitable for a qualitative interpretation of the potential.

Around Rotterdam and The Hague there are many opportunities for providing geothermal heat. It is an area with a lot of heat demand and district heating networks.

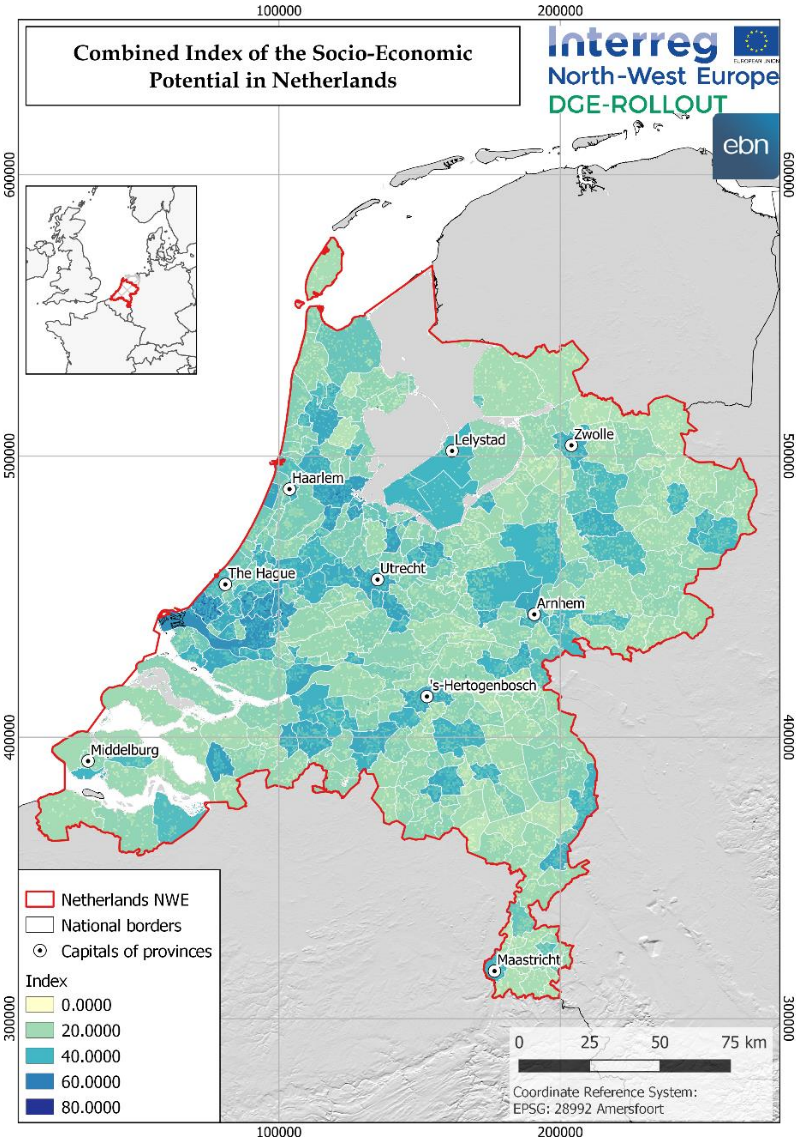

Figure 9 Composite index for the socio-economic potential for deep geothermal energy in the Netherlands.

Conclusion

In general, the socio-economic index is in correlation with the existing geothermal projects. In the area south of The Hague there are many geothermal projects and developments. The areas around Haarlem, Utrecht, Arnhem and 's-Hertogenbosch are relatively underdeveloped. This is due to a lack of subsurface data. This data is being gathered by the SCAN projects which focuses on these areas.

In the Netherlands the heat demand and existing district heating networks are the most important surface driver for geothermal projects. The socio-economic potential index in combination with subsurface mapping, it can allow a first prioritization of areas for geothermal development.

References

Chocobar, J., 2020. *Identification of socio-technical factors within the play-based geothermal exploration process: Application and considerations in Central America,* Bochum: s.n.

European Commission, 2022. *Database.* [Online]
Available at: https://ec.europa.eu/eurostat/web/main/home

Fraunhofer IEG, 2021. *Map of the spatial distribution of the heat demand at the surface. Deliverable T1.2.1,* s.l.: DGE-Rollout project.

International Renewable Energy Agency, 2017. *RENEWABLE ENERGY BENEFITS: UNDERSTANDING THE SOCIO-ECONOMICS,* Abu Dhabi: s.n.

Moeck, I. et al., 2020. Geothermal Play Typing – Current Development and Future Trends of a Modern Concept for Geothermal Resources Assesstment.

Moeck, I. S. & Beardsmore, G., 2014. A new 'geothermal play type' catalog: Streamlining exploration decision making. *Thirty-Ninth Workshop on Geothermal Reservoir Engineering*.

Natural Resources Defense Council, 2022. *Greenhouse Effect 101.* [Online]
Available at: https://www.nrdc.org/stories/greenhouse-effect-101

NRW.Energy4Climate, 2022. *Kabel-ZERO.* [Online]
Available at: https://www.energy4climate.nrw/themen/best-practice/kabel-zero

Taşdemir, B. & Arndt, M., 2020. *Report Financial Risk Management Deliverable T1.3.2,* s.l.: DGE-ROLLOUT Project.

Taşdemir, B. & Dombrowski, B., 2021. *Examination of the German regulatory framework and financial risk management of Deep Geothermal Projects Deliverable T1.3.3,* s.l.: DGE-ROLLOUT Project.

Van Malderen, E., 2020. *Report Legal Framework Deliverable T1.3.1,* s.l.: DGE-ROLLOUT Project.

van Melle, T., Strozyk, F. & Welkenhuysen, K., 2021. *Investors Profiling Deliverable T1.2.2,* s.l.: DGE-Rollour Project.

Appendix A

Factor	Database
Population distribution	https://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search;jsessionid=9C85B6D15460AB9A6650DC456DCDA198#/metadata/524b1e94-1981-4ef6-be1f-482d309b5db8
Heat demand	(Fraunhofer IEG, 2021)
Income	Statistics | Eurostat (europa.eu)
Social Progress Index	EU Social Progress Index - 2020 | Data | European Structural and Investment Funds (europa.eu)
District heating	https://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search;jsessionid=9C85B6D15460AB9A6650DC456DCDA198#/metadata/75f196bd-6fb2-4939-99a5-cd40d753183d
Legal framework	legal-framework-with-contributors_dge-rollout.pdf (nweurope.eu)
Financial risk management (funding/investment)	Financial Risk Management Report (nweurope.eu)
Environmentally sensitive areas	https://ec.europa.eu/environment/nature/natura2000/data/index_en.htm
Greenhouse gas emissions	https://klimaatmonitor.databank.nl/jive

PROJECT PARTNERS

Geologischer Dienst NRW

Fraunhofer IEG

vito

brgm Geoscience for a sustainable Earth

ebn

DMT

Geological Survey of Belgium

Technische Universität Darmstadt

TNO innovation for life

RWE

PROJECT SUP-PARTNERS

Ruhr Universität Bochum RUB

GeoThermal Engineering

MORE INFORMATION

Dr Martin Salamon (Project Manager)

Martin.Salamon@gd.nrw.de

+49 2151 897 230

www.nweurope.eu/DGE-Rollout

@DGE–ROLLOUT

SUPPORTED BY

europiZe UG

Dr Daniel Zerweck

+49 176 6251 5841

www.europize.eu

europize realising projects