Interreg North-West Europe DGE-ROLLOUT

EUROPEAN UNION

Socio-economic potential mapping for Deep Geothermal Energy

Focus: France

Deliverable T1.2.3

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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

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.

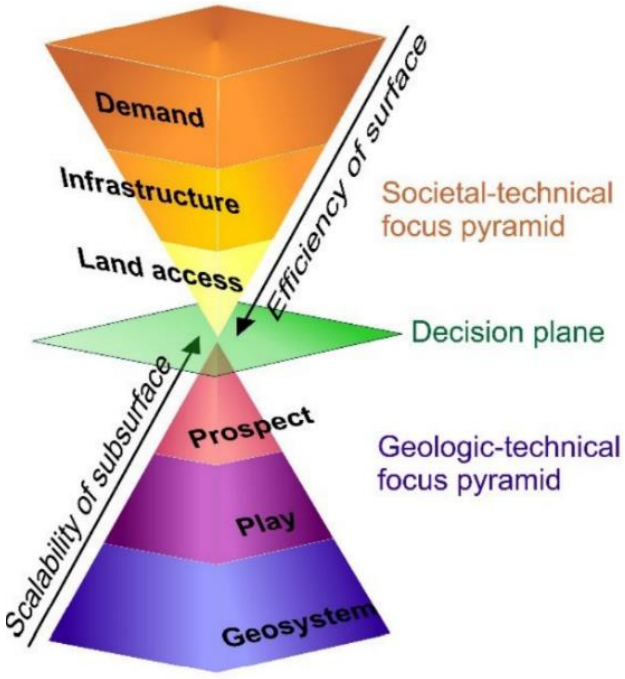

Figure 1 Decision-making factors to start a geothermal project, after (Moeck, et al., 2020).

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.

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	0	3050

Total heat demand of municipality	MWh/ha/yr	0	3000
Gross domestic product	€/cap/yr	15577	40456
Public debt per capita	€/cap	0	6500

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 Hauts-de-France. 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

Hauts-de-France has about 6 Million citizens. However, it is losing population, going from 3rd most populated region in France in 2013 to 5th in 2021. The most populated area is the Lille Metropole and the former Mining Basin (Figure 2).

Most of the population is concentrated in the Nord and Pas-de-Calais “département” (subdivision below region). The Nord is the most populated “département” of France. The growth of this area is due to the mining industry that was developed in the last century. The south of the region while not as much populated is increasing more in population benefiting from the proximity to Paris.

The map shows an area where the population is concentrated corresponding to the former mining basin. The Lille metropole is also an important area of population concentration. Next area that is more concentrated is the Amiens metropole in the center oust of the region. Finally, the south of the region shows a more distributed population but that is progressing.

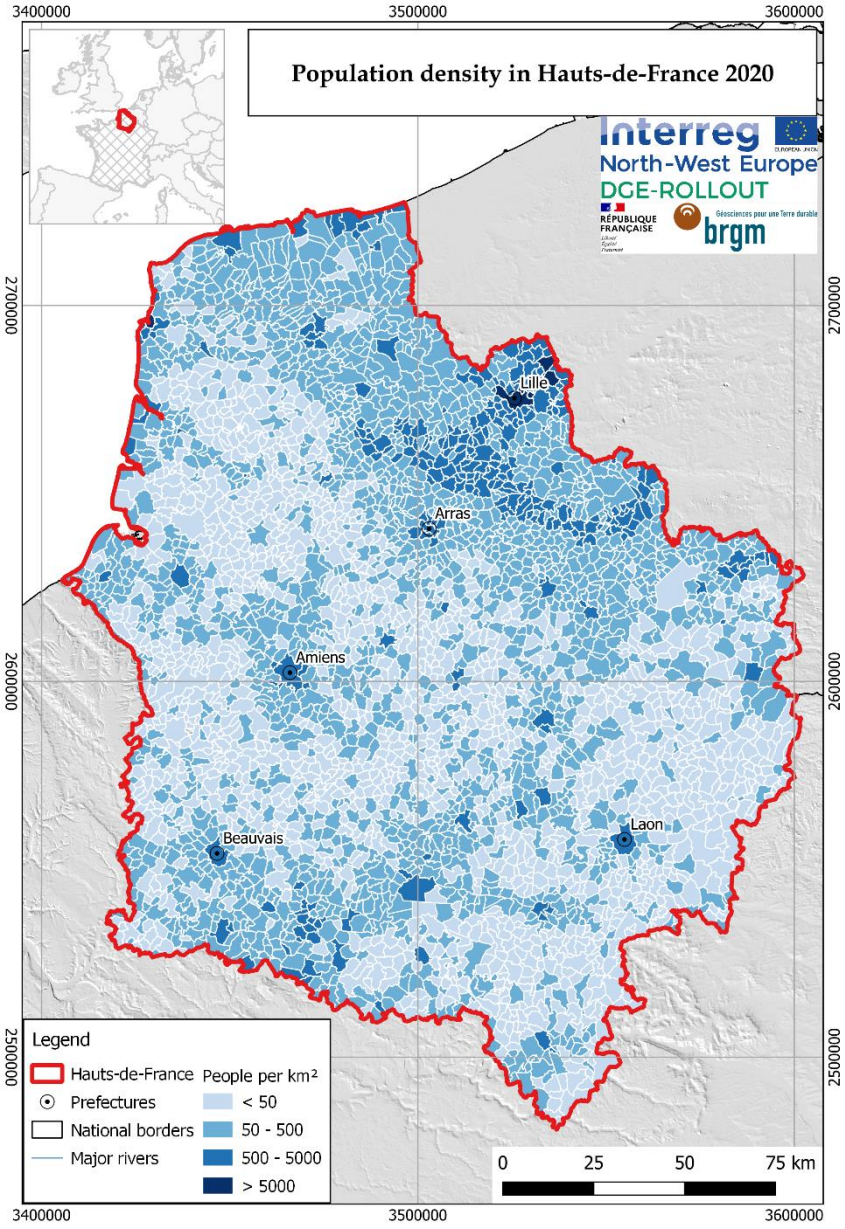

Figure 2 Population distribution in Hauts-de-France

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.

The heat demand distribution follows the population distribution and is more important in the area of Lille and the former mining basin.

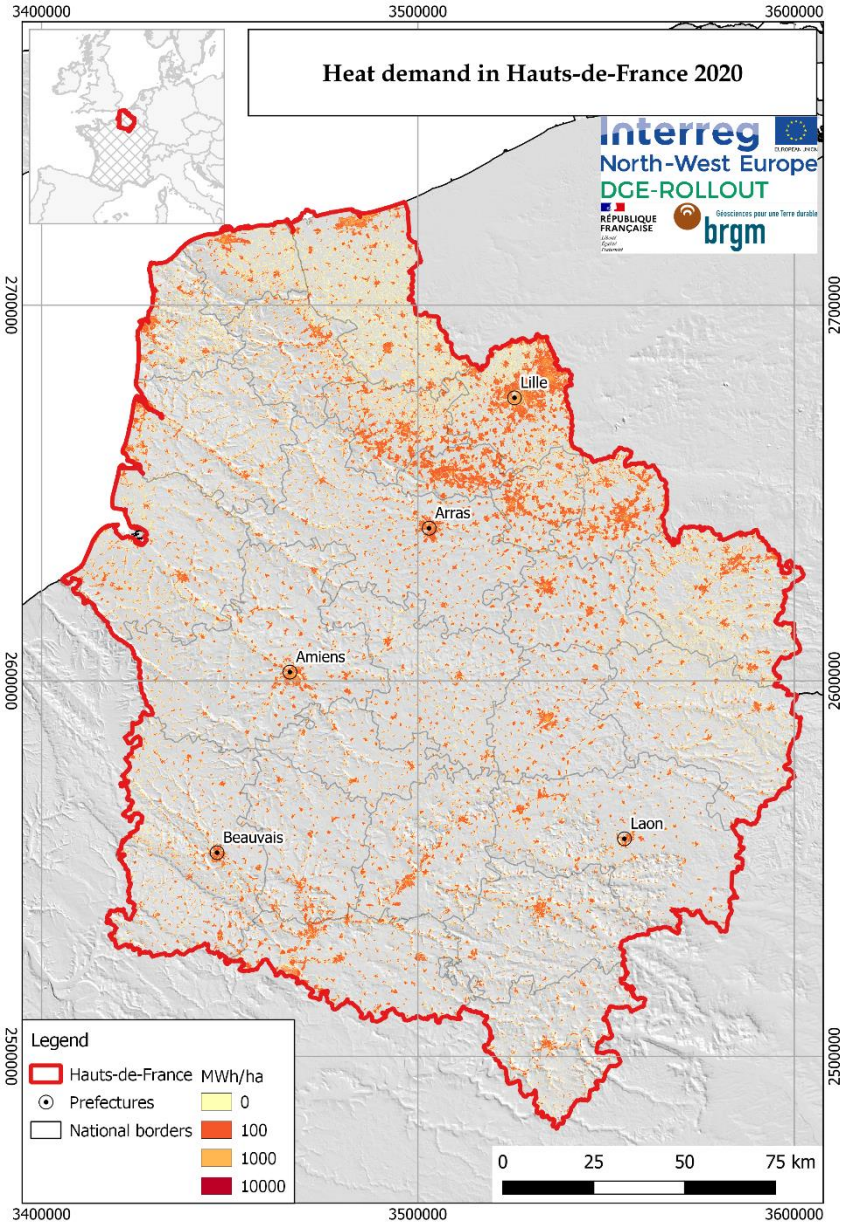

Figure 3 Map of residential and tertiary sector heat demand in Hauts-de-France.

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.

The EU-SPI is mostly constant over the region varying between 70 and 73. However, at a smaller resolution, a clear North-South distinction can be made with a higher index in the northern “départements”.

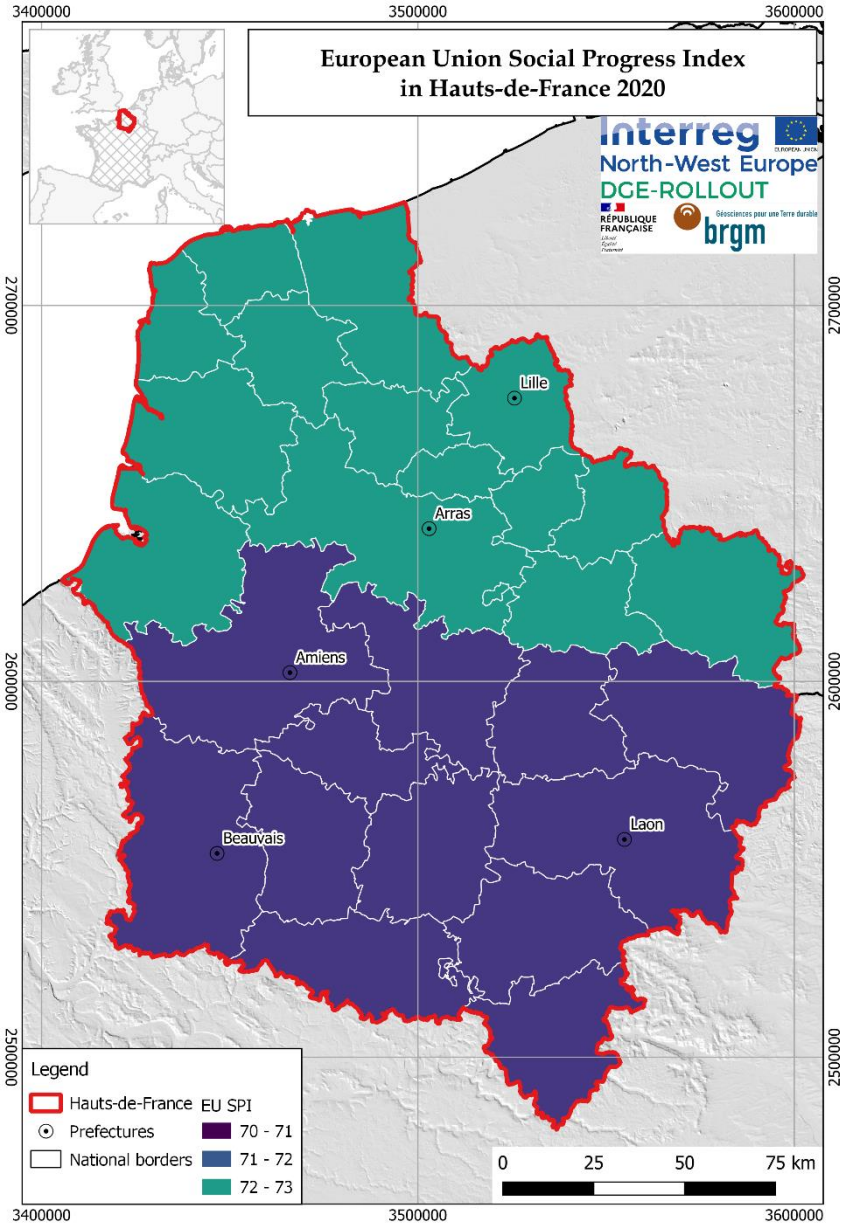

Figure 4 European Social Index in Hauts-de-France

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 GDP of the region varies between less than 20 k€/inhabitant and more than 35 k€/inhabitant. In 2018, the mean GDP in Hauts-de-France is 27 k€/inhabitant which place it second to last in the French metropolitan regions and 8% below the metropolitan national mean. The former mining basin is characterized by a lower GDP (<20 k€/inhabitant) compared to the Lille and Amiens metropole as well as the south of the region. The east of the region is also characterized by a low GDP.

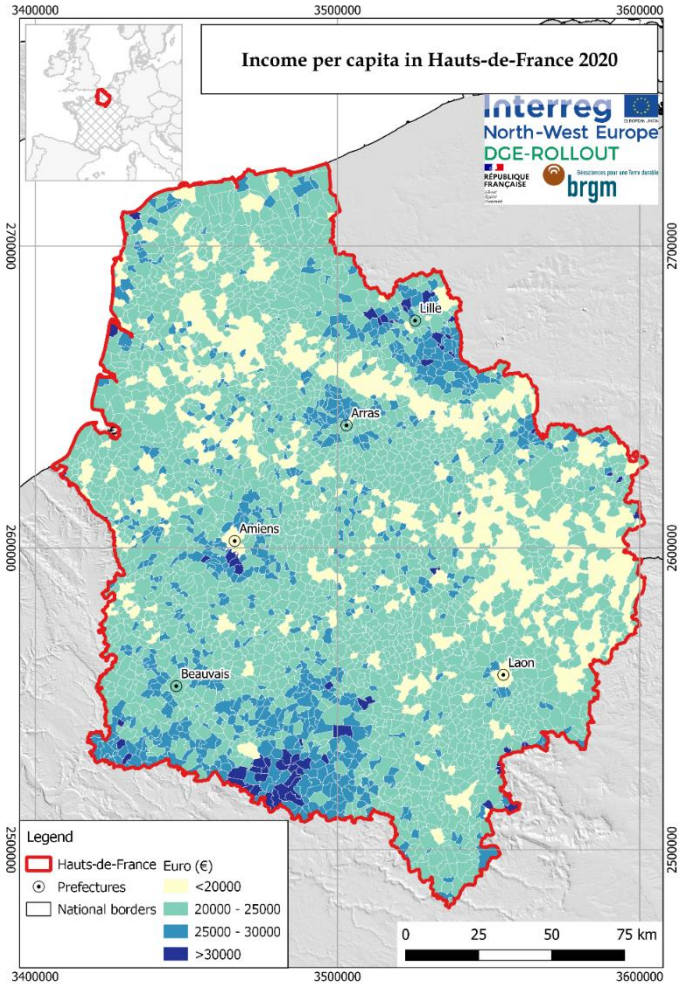

Figure 5 GDP in Hauts-de-France with data updated in 2018

District heating

The importance of the District Heating (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.

The existing DHs reach 833 until 2020 (Réseaux de chaleur et de froid, 2020) and provided the 6% of France´s heat sector for domestic heat water and heating system.

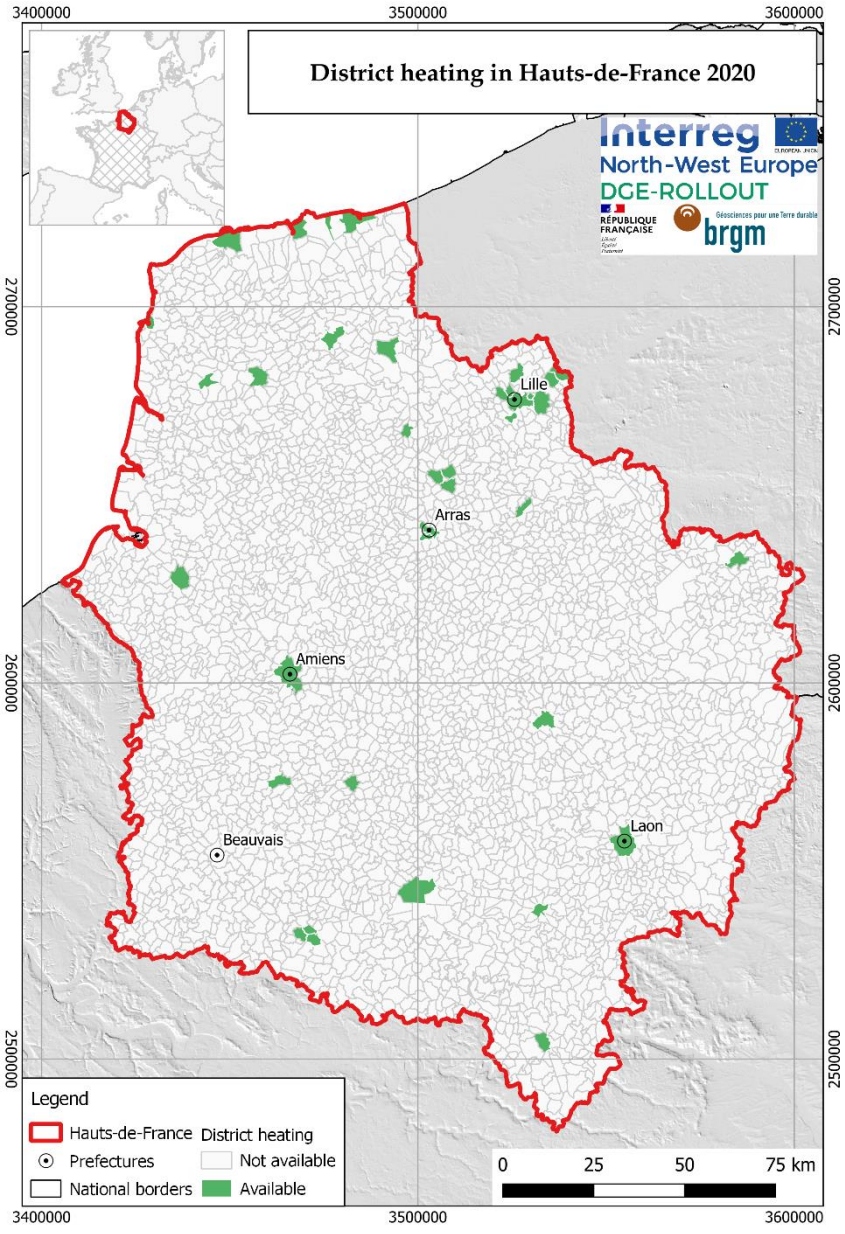

Figure 6 Cities with existence of district heating network in Hauts-de-France.

Level of debt of municipalities

The possible funding at the municipality level is highly dependent on the public debt. In Figure 7, the public debt of the municipalities of Hauts-de-France per capita is shown. No clear geographic trend can be established.

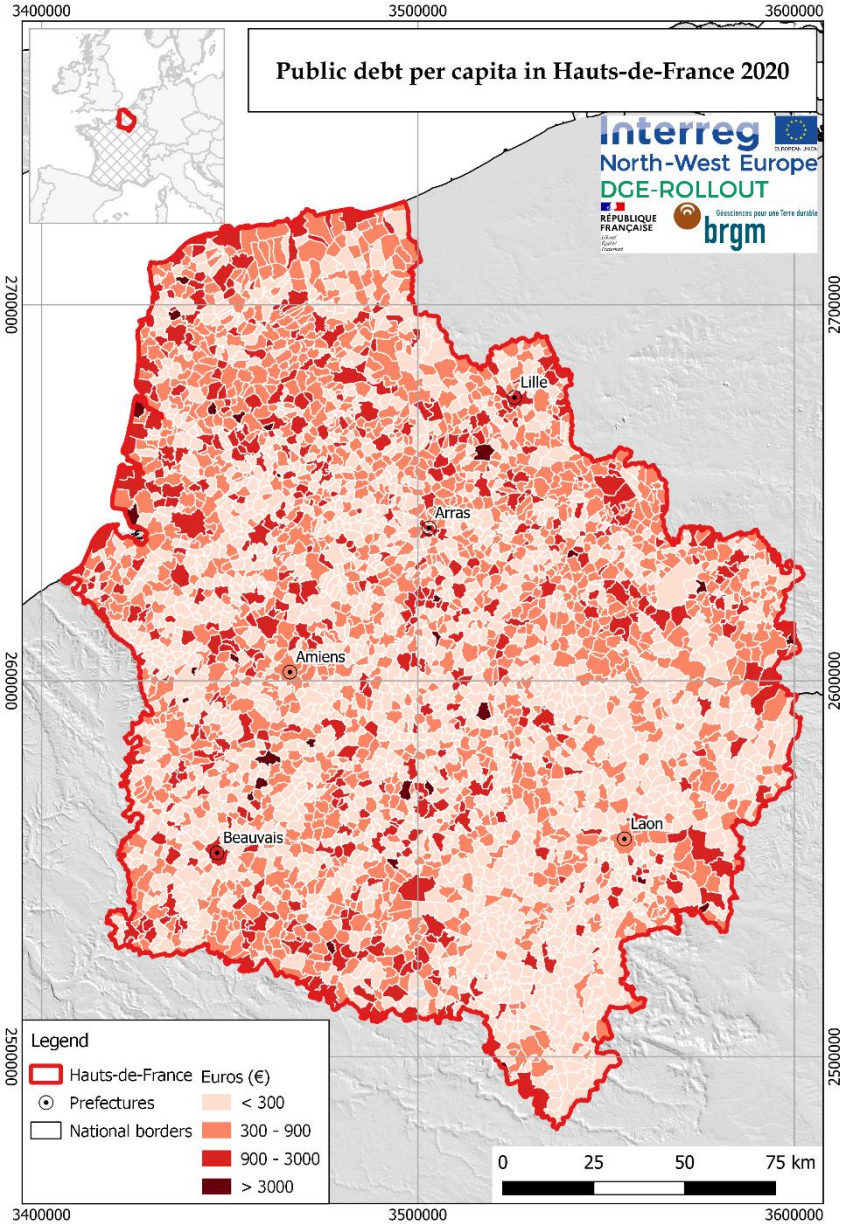

Figure 7 Public debt in Hauts-de-France

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.

Natura 2000 zones are located mainly:

- at sea, along the cost,
- on the eastern part of the former mining basin,
- along the Somme river between the sea and St-Quentin
- south of the Oise river between south of Compiegne and St Gobain.

Other restricted areas exist. They are a gas storage site close to Compiegne city and other conservation areas scattered over the region.

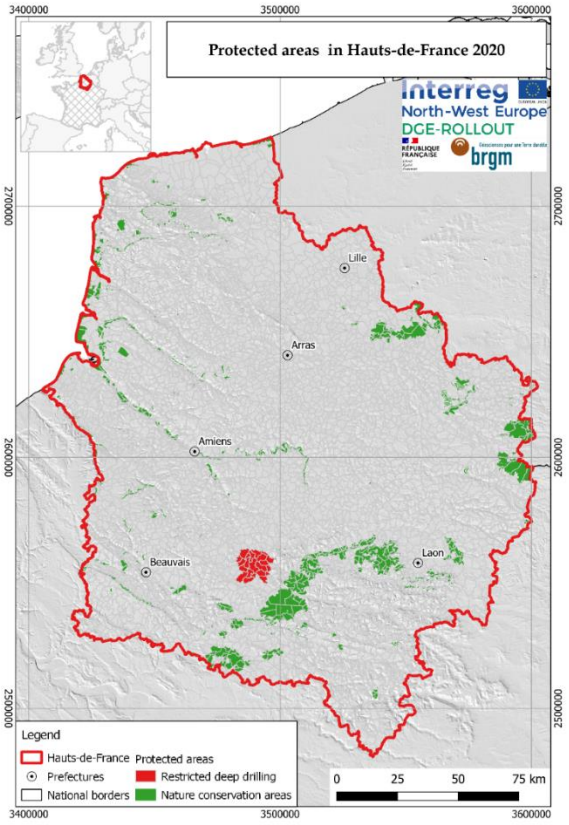

Figure 8 Nature 2000, protected nature areas in Hauts-de-France.

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.

The cities with the higher potential are the Lille metropole, Amiens metropole, Aras, Lens and Laon.

The predominant parameters in the resulting index calculation are the heat demand and existing district heating networks.

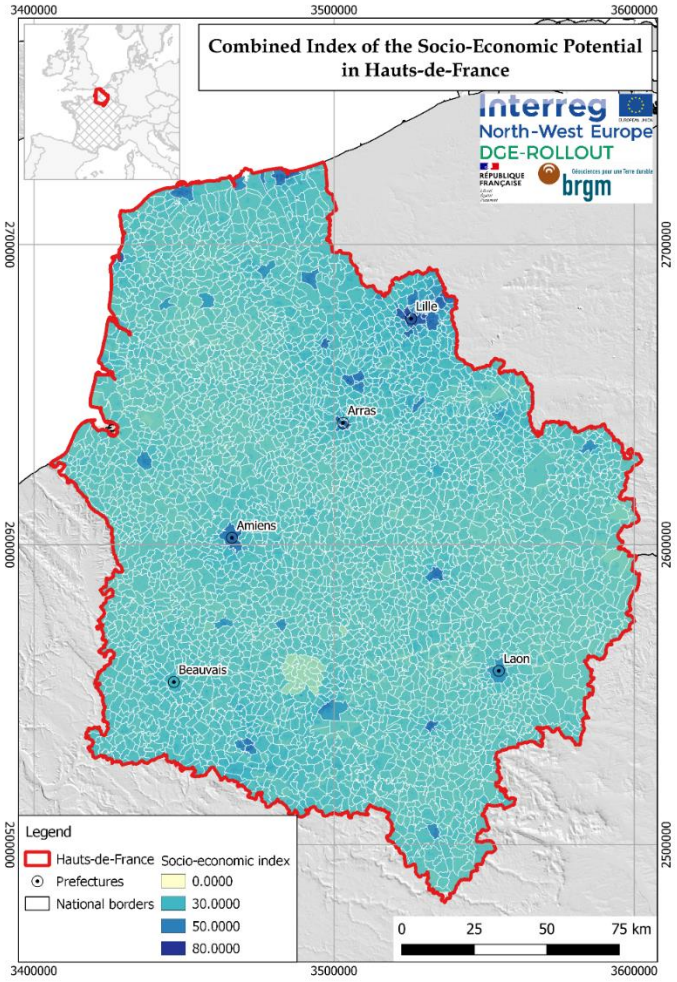

Figure 9 Composite index for the socio-economic potential for deep geothermal energy in Hauts-de-France.

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*.

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

Réseaux de chaleur et de froid, 2020. *District Heating and Cooling in France.* [Online]
Available at: https://reseaux-chaleur.cerema.fr/espace-documentaire/district-heating-and-cooling-france

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
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	District Energy in France | Euroheat & Power
Legal framework	legal-framework-with-contributors_dge-rollout.pdf (nweurope.eu)
Financial risk management (funding/investment)	Financial Risk Management Report (nweurope.eu)

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