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## Deliverable D7.4

# Market and Business Innovation 2<sup>nd</sup> version

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## Abbreviations

GEO4CIVHIC	Most Easy, Efficient and Low-Cost Geothermal Systems for Retrofitting Civil and Historical Buildings
BHE	Borehole Heat Exchanger
BTES	Borehole Thermal Energy Storage
COGS	Cost of Goods Sold
DHW	Domestic Hot Water
FDCF	Future Discounted Cash Flows
GHE	Ground Heat Exchanger (general term, includes BHE)
GHP	Geothermal Heat Pump
GSHP	Ground Source Heat Pump
IP	Intellectual Property
KERs	Key Exploitable Results
NZEB	Near-Zero-Emission Building
ODEX	Overburden Drilling EXcentric - Is a downhole air hammer system that is designed to advance casing during drilling.
PBT	Pay-back Time
RES	Renewable Energy Sources
SFH	Single Family House
SGE	Shallow Geothermal Energy
TRL	Technology Readiness Level
UTES	Underground Thermal Energy Storage
ZEB	Zero-Emission Building

## Executive Summary

This Deliverable D7.4 reports the activities related to the Task 7.3 – Marketing Intelligent Activity and Business Innovation Models for each solution and building type – aiming to carry out an assessment of the European market and the business models for the integrated GEO4CIVHIC solutions.

The aim of this document is to provide the final version of the GEO4CIVHIC Business Innovation Plan as the continuation of the preliminary version which was reported in D7.3.

This report provides a comprehensive review of the most recent developments regarding the application and market integration of the cutting-edge technological solutions emerging from the GEO4CIVHIC project, with a primary emphasis on the project's key exploitable outcomes. Within this report, you'll find an in-depth business plan that delineates the strategies and tactics employed by the GEO4CIVHIC project to achieve its goals. This document serves as a detailed roadmap from marketing, financial, and operational standpoints. The present deliverable is focused on:

- The introduction of the D7.4 Market and Business Innovation task to be followed during GEO4CIVHIC project, including objectives, explanation for contribution of partners, baseline, and relation to other activities.
- The executive summary of the GEO4CIVHIC Business plan, main results/achievements related to geothermal energy systems market.
- The (Company) Consortium description of the GEO4CIVHIC project.
- Description of seven main KERs as stand-alone products/technologies/methodology and integrated solution namely:
  - KER 1: Plug and play heat pump with variable or fixed speed drivers,
  - KER 2: Heat pump for high temperatures and dual source applications,
  - KER 3: High temperature heat pumps for renovated civil and historical buildings,
  - KER 4: Versatile and compact drilling rig unit JOY 3P GEO4CIVHIC,
  - KER 5: Semi-automatic feeder for drilling rods and co-axial tubes mounting,
  - KER 6: Compact vibration-rotation drilling head and drill bit (VD80 and VD105),
  - KER 7: Efficient coaxial heat exchangers for piling with vibration-rotation drilling head (HYDRA-RED Method),
  - KER 8: GEO4CIVHIC Integrated solution,with more detail information on the background to its development, benefits and features, unique selling points, advantages to customers, disadvantages or weak points, future developments (if foreseen).
- The description of “Business Model of the Integrated GEO4CIVHIC Solution” including business model canvas of the new solution with detailed explanation of business model canvas methodology.
- Brief summary of four real demo sites that the innovative improved geothermal solutions developed in the project has been implemented and tested in real operational conditions
- Market research and competitor analysis to understand market viability of GEO4CIVHIC project, and create overall marketing strategy for the products and services and GEO4CIVHIC project.
- The Operating Plan of the GEO4CIVHIC project to explain key responsibilities of the actors in the GEO4CIVHIC project. In the section, the roles of each partner in the GEO4CIVHIC consortium and the relations among partners is explained with service system map.

- The Financial projections are based on analysing the Technology Readiness Level (TRL) alongside Future Discounted Cash Flow (FDCF) analysis. This provides valuable insights for decision-making, risk mitigation, resource allocation, market entry strategies, and investor communication. It ensures that financial projections are realistic, aligned with technology maturity, and support the overall success and profitability of technology development projects.
- The last section briefly outlines the conclusions.

## Objectives of the report

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The main objectives of the Task 7.3 are described as follows:

- The prompt identification of emerging market trends and threats imposed by political, economic and social conditions that could jeopardize the commercial potential of the GEO4CIVHIC results.
- Continuous monitoring of the competition and technological advancements, so as to promptly identify new competitors to the GEO4CIVHIC products and solutions (launched prior to the finalization of the project), with identical or similar features and value. This will give feedback to all previous technical WPs and will trigger mechanisms for properly updating the GEO4CIVHIC specifications towards ensuring its clear differentiation and competitive advantages against other technologies.
- Providing valuable market and industry data which will enable the definition of viable business models on the basis of: funds and ventures that could ensure smooth operations and successful business development.

### Contribution of Partners

Solintel is the task leader and responsible to deliver the present document. All partners, based on their expertise and knowledge, contributed to carrying out the activities needed for the completion of D7.4.

### Baseline

For the preparation of this deliverable, a review of the state-of-the-art for the technologies developed within GEO4CIVHIC has been performed, analysing the current markets and the available systems.

The assessment of the market has been focused on: drilling technologies, ground source heat pumps and the integration of geothermal systems in buildings.

### Relation to other activities

Inputs: some information has been taken from task 5.5, task 6.1 and task 7.5, concerning the mapping activity used for the market potential study, specific regulations and the key exploitable results to develop such technologies, plus contributions provided by all Consortium partners in terms of the description of the product and some related competitors.

### Structure of the Document

This document contains the following content:

- **Chapter 1:** a brief explanation on how the task 7.3 has been developed and finished merging its outcomes into D7.3 (previously submitted) and D7.4.
- **Chapter 2:** Short overview of the experience and expertise of the GEO4CIVHIC consortium that is considered as main value of the project focused on geothermal heating and cooling systems.
- **Chapter 3:** A summary and a brief update to the market potential for geothermal heat production and use in the building sector in several countries along Europe. This part is based on what has been done in the previous deliverable D7.3.

- **Chapter 4:** Description of main KERs as stand-alone products/technologies with more detail information about their background to its development, benefits and features, unique selling points, advantages to customers, disadvantages or weak points, future developments (if foreseen). Presentation of an integrated GEO4CIVHIC business model including the value proposition, customers segments, relationship and channels, key activities and resources finally the key partners, cost structure and the revenue stream. In addition, the chapter presents the deployment of the integrated solution into the four real demo sites.
- **Chapter 5:** The operating plan which includes the key responsibilities of the consortium is detailed presenting 4 main groups (Central monitoring, technical providers, Consultancy & engineering companies and Universities, Research Centres and Associations).
- **Chapter 6:** The financial projections is presented in terms of TRL increases in conjunction with the FDCF analysis for each technology and related technical developers (providers).
- **Chapter 7:** Finally, the conclusion of the report is presented.

# 1 Introduction and Methodology

The GEO4CIVHIC project is trying to accelerate the deployment of shallow geothermal systems for heating and cooling in retrofitting existing types of buildings, including historical buildings. It will be based on innovative technological solutions, improvements and enrichment of results obtained from previous EU projects, notably the Cheap-GSHP and Geotech projects. GEO4CIVHIC consortium is working on a compact drilling machine of reduced dimensions and ground heat exchanger technologies, as well as a new generation of heat pump technologies for both low and high temperature suitable for all buildings, climate and underground conditions.

Assessment of the market opportunities and the definition of the strategies needed for a future successful commercial exploitation is established in WP7. In particular, Task 7.3 assures that the innovation developed in the project is not hindered by new upcoming market evolution and competition.

The methodology deployed for the completion of task 7.3 and the two deliverables associated to the latter, is dependent on the main objectives mentioned before. The figure below illustrates the 2-phase process that is to be followed. The explanations that follow provide details for the objectives of each deliverable including amendments that will be performed following feedback and review processes during the course of the project.

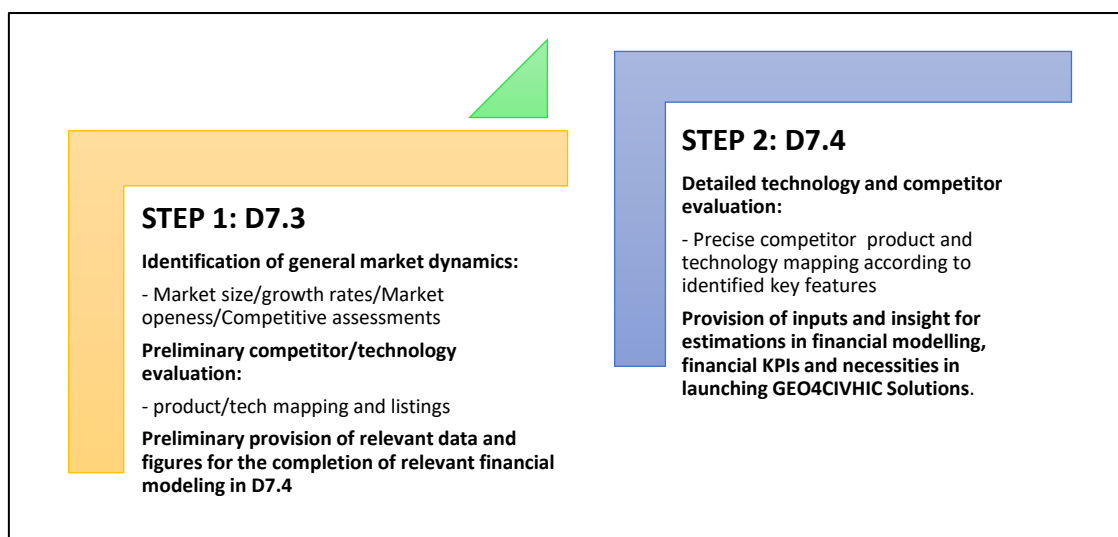


Figure 1.1 Methodology employed for T7.3 completion

## Step 1

Step 1 corresponds to the first market deliverable and comes at a preliminary stage in the project where innovations and technologies were still in development. The objective in this step was to provide preliminary market information on general trends and competitor assessments. D7.3 set the basis for further and more detailed activities as the project moves forward. In addition to this, the information and data contained within that document can be used in order to obtain insights on the economic potential of the project results.

## Step 2

This step provides an update on all the initial market observations provided in D7.3, identifying potential new competitors, unexpected dips in the market, or new regulations. Moreover, one of the key outputs of this stage is to provide a more detailed competitor assessment. Since the project results and innovations are at a more mature development stage, the consortium has

provided a detailed analysis of competitors and the technical features of their products in order to assess the potential strengths and weaknesses of GEO4CIVHIC KERs with respect to these products. This provides key insights on the positioning of GEO4CIVHIC within its respective markets in order to establish effective business strategies and relevant operational structures for the GEO4CIVHIC business plan for the commercialization of the project results. This roadmap towards commercialization is supported by deterministic capital budgeting models with a discounted cash flow analysis which reflects the market growth rates and trends identified through the market analysis as well as chosen competitive pricing policies for GEO4CIVHIC products established through the prior comparative analysis with competitor products.

## 2 Short Consortium description

The GEO4CIVHIC Consortium has a broad base of experience and expertise can be considered as main value of the project focused on geothermal heating and cooling systems, besides being well-balanced comprising 20 partners from 9 countries – Italy, Spain, Belgium, Ireland, Germany, Romania, Greece, Malta and Switzerland– and bringing together research organizations, specialised organisations, large industrial companies, Universities and specialized SMEs. GEO4CIVHIC Consortium will cooperate to provide the market with innovative, cost-effective shallow geothermal technologies, in order to realize a greater utilization of renewable heating and cooling within European scenario. In briefly, the consortium can be introduced to show their values that will contribute our business.



Figure 2.1 GEO4CIVHIC consortium partners

### 3 Market Analysis

This section provides a market research and competitor analysis to understand market viability of the GEO4CIVHIC project solutions and creates an overall marketing strategy for the products and services developed during the project. Additionally, this section shows the total potential value of the market for these technologies in all targeted markets. In the section, general geothermal energy market and renewable heating and cooling market has been analysed to understand total size and value of such market.

#### 3.1 Key market target

GEO4CIVHIC project focuses on four key aspects as already mentioned:

1. Innovating borehole drilling technology;
2. Innovating heat pumps;
3. New drilling methodologies and
4. Replicable geothermal heating and cooling system solutions for wide scale market deployment.

Therefore, the objective should extend beyond simply marketing an innovative drilling system to specialized companies and installers. It should encompass addressing the requirements of various stakeholders. It is imperative to engage key players in the construction and design industry to ensure they understand the benefits of GEO4CIVHIC solutions. Additionally, public entities associated with the energy and building markets should also be involved in this outreach effort.

The professionals or entities that can be considered within the GEO4CIVHIC project as key target customers are depicted in the following Figure 3.1.

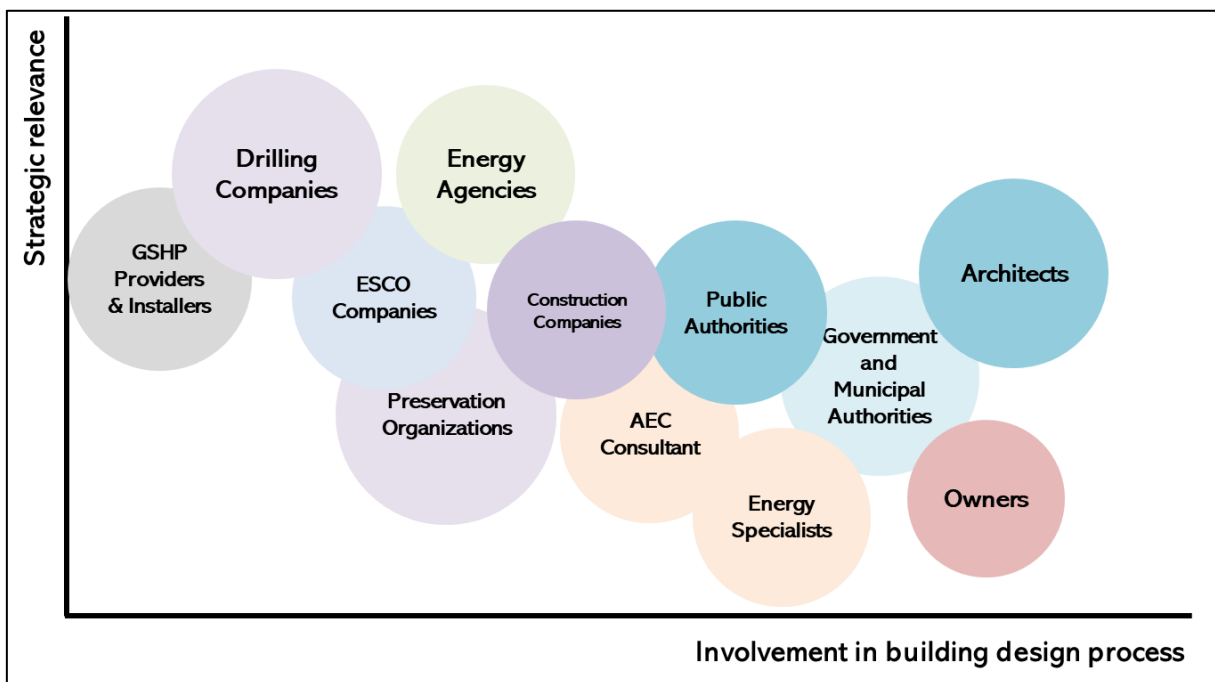


Figure 3.1 GEO4CIVHIC project solutions key target customers

### 3.1.1 Segmentation

The main target is to develop and demonstrate easier-to-install and more efficient GSHEs, using drilling machine innovations tailored for the built environment and developing or adapting HPs and other hybrid solutions for retrofits through a holistic engineering, construction and controls approach. This will be possible through the reduction of cost in the initial investment by:

- reducing the energy required from each borehole heat exchanger by using a second generation of dual source heat pump, hence reducing the borehole length
- decreasing the drilling cost by using optimised and specialized drilling machines able to reach the designated depth of new borehole heat exchangers
- decreasing the administrative costs and the times for procedures, by decreasing the risk of possible interaction with shallow aquifers
- decreasing the needed area of borehole heat exchanger fields, by combining GSHP with air-to-water heat pumps, in a unique solution dual source mode
- decreasing the energy losses of GSHP working mode, by improving the building energy management, which means indirectly the need for less borehole length

The geothermal market is fragmented and differs in each country with different building typologies, undergrounds, climates and energy market shares. For a serious study on market potential of GEO4CIVHIC innovations this report adopts a country-by-country approach.

Deliverable D7.3 [1] performed a complete assessment of the potential for the GEO4CIVHIC technologies in Europe by analysing the surface geology of different countries, which influence the performance notably in the drilling technologies and methodologies developed in this project. As well as the different climatic conditions since these affects the modes of performance of the developed heat pumps.

The GEO4CIVHIC project has developed versatile and compact technologies suitable for buildings with many technical constraints like confined space for drilling as well as historical buildings with their own specific limitations. Historical buildings are integral symbols of European cities, towns, and villages, representing the continent's cultural heritage. Currently, approximately 35% of the EU's buildings are over 50 years old, with almost 75% of the building stock being energy inefficient. There is a common preconception that historical buildings, especially those with special protection, should be exempt from implementing new energy-efficient technologies. While cautious renovation plans are necessary for historical buildings, the argument that renewable energy installations cannot be integrated to preserve their nature and appearance is not always valid in the context of sustainability. Furthermore, renovating existing buildings has the potential to yield significant energy savings, reducing the EU's total energy consumption by 5-6% and cutting CO<sub>2</sub> emissions by about 5%<sup>i</sup>. Building codes now demand more efficient new constructions, with current buildings consuming only half as much energy as those built in the 1980s.

Enhancing the energy performance of historical buildings also improves internal comfort conditions, reduces energy demand, and mitigates the risk of fuel poverty. Ensuring user comfort is essential to ensure the continued use, conservation, and endurance of historical buildings over time. Retrofitting historical buildings requires meticulous planning to consider case-specific variables thoroughly. An effective approach focuses on improving envelope thermal

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<sup>i</sup> [https://commission.europa.eu/news/focus-energy-efficiency-buildings-2020-02-17\\_en](https://commission.europa.eu/news/focus-energy-efficiency-buildings-2020-02-17_en)

transmittance without compromising the façades historic integrity, such as implementing thermal insulation.

To promote innovation in the cultural heritage sector, the European Framework for Action on Cultural Heritage provides a common approach for heritage-related activities within EU policies and programs. It encourages a holistic, integrated, evidence-based, and multi-stakeholder approach to cultural heritage policies and programs. Several EU-funded projects have emphasized energy efficiency in heritage buildings. These projects demonstrated that energy efficiency measures can be effectively implemented in historical buildings while preserving their cultural heritage and architectural significance. Through interdisciplinary collaboration and knowledge sharing, historical buildings can embrace sustainability without compromising their unique identities.

Energy consumption is an essential consideration when adopting a renewable geothermal system for several reasons:

- Sustainability and Environmental Impact
- Energy Security and Independence
- Cost Savings and Stability
- Long-Term Energy Solution
- Diversification of Energy Portfolio
- Reduced Water Consumption
- Grid Stability and Decentralization

Considering energy consumption when adopting a renewable geothermal system is essential for promoting sustainability, mitigating climate change, ensuring energy security, and fostering economic development. Geothermal energy offers a reliable, cost-effective, and environmentally friendly alternative to conventional energy sources, making it a crucial component of the global transition to a cleaner and more sustainable energy future.

Table 3.1 shows a summary of the energy consumption in residential buildings in different EU markets where the GEO4CIVHIC project (Ireland, Belgium, Italy and Malta) real demo sites are located and 4 additional European countries (Greece, Romania, Spain and Germany). The table also shows the renewable energy use as percentage for heating and cooling.

For comprehensive details on how energy consumption is calculated, please refer to the EUROSTAT metadata. This invaluable resource provides in-depth insights into the methodologies and processes employed for energy consumption estimation and analysis.<sup>ii</sup>

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<sup>ii</sup> [https://ec.europa.eu/eurostat/cache/metadata/en/nrg\\_bal\\_esms.htm](https://ec.europa.eu/eurostat/cache/metadata/en/nrg_bal_esms.htm)

Table 3.1 – Summary of the energy consumption for different EU countries [2]

COUNTRY	ENERGY CONSUMPTION <sup>iii</sup>			
	By Sector	By Mode (Residential)	By Fuel (Residential)	Renewable (Heating and Cooling) <sup>iv</sup>
Italy	<p>Industrial; 23% Residential; 29% Commercial and Public services; 16% Transport; 32%</p>	<p>Heating; 78% Water heating; 13% Cooking; 8% Cooling; 1%</p>	<p>Natural gas; 72% Electricity; 24% Diesel; 3% Solar; 1%</p>	<p>Year</p>
Spain	<p>Industrial; 27% Residential; 20% Commercial and Public services; 13% Transport; 40%</p>	<p>Heating; 58% Water heating; 29% Cooking; 12% Cooling; 1%</p>	<p>Electricity; 54% Natural gas; 31% Diesel; 13% Solar; 2%</p>	<p>Year</p>

<sup>iii</sup> <https://ec.europa.eu/eurostat/databrowser/view/>

<sup>iv</sup> Detailed methodology description for this indicator is available in the SHARES tool manual in the SHARES section of Eurostat's website

COUNTRY	ENERGY CONSUMPTION <sup>iii</sup>			
	By Sector	By Mode (Residential)	By Fuel (Residential)	Renewable (Heating and Cooling) <sup>iv</sup>
Belgium	<p>Industrial; 33% Residential; 27% Commercial and Public services; 14% Transport; 26%</p>	<p>Heating; 86% Water heating; 12% Cooking; 2% Cooling; 0%</p>	<p>Natural gas; 48% Electricity; 22% Diesel; 30% Solar; 0%</p>	<p>Year</p>
Ireland	<p>Industrial; 20% Residential; 28% Commercial and Public services; 17% Transport; 35%</p>	<p>Heating; 73% Water heating; 24% Cooking; 3% Cooling; 0%</p>	<p>Electricity; 44% Natural gas; 35% Diesel; 20% Solar; 1%</p>	<p>Year</p>
Germany	<p>Industrial; 28% Residential; 30% Commercial and Public services; 15% Transport; 27%</p>	<p>Heating; 74% Water heating; 19% Cooking; 7% Cooling; 0%</p>	<p>Natural gas; 56% Electricity; 27% Diesel; 16% Solar; 1%</p>	<p>Year</p>

COUNTRY	ENERGY CONSUMPTION <sup>iii</sup>			
	By Sector	By Mode (Residential)	By Fuel (Residential)	Renewable (Heating and Cooling) <sup>iv</sup>
Romania	<p>Industrial; 28% Transport; 28% Residential; 36% Commercial and Public services; 8%</p>	<p>Heating; 72% Cooking; 11% Water heating; 16% Cooling; 1%</p>	<p>Natural gas; 73% Electricity; 27% Solar; 0% Diesel; 0%</p>	<p>Year</p>
Greece	<p>Industrial; 18% Transport; 38% Residential; 30% Commercial and Public services; 14%</p>	<p>Heating; 66% Cooking; 11% Water heating; 18% Cooling; 5%</p>	<p>Electricity; 45% Diesel; 31% Solar; 9% Natural gas; 15%</p>	<p>Year</p>
Malta	<p>Industrial; 11% Transport; 42% Residential; 23% Commercial and Public services; 24%</p>	<p>Heating; 31% Cooking; 15% Water heating; 31% Cooling; 23%</p>	<p>Electricity; 94% Diesel; 0% Solar; 6% Natural gas; 0%</p>	<p>Year</p>

The energy consumption in the residential sector in different countries shown in the table above demonstrates that the residential sector is a significant consumer of energy, and in some countries like Germany and Romania, it is the largest consumer. The main energy uses within the residential sector are for heating and domestic hot water.

The table also presents the most common fuels used for heating purposes for 2021. Natural gas is the predominant fuel in Italy, Belgium, Germany, and Romania, while electricity is the primary fuel in Spain, Ireland, Greece, and Malta <sup>v</sup>.

Finally, the table notes that there has been a slight increase in the use of renewable energy for heating and cooling between the years 2019 and 2021, especially in countries like Italy, Spain, Belgium, Germany, Greece, and Malta. This indicates a positive trend towards adopting renewable energy sources for residential heating and cooling needs.

### 3.2 Total market valuation

In the EU, energy consumption for heating and cooling constitutes nearly 50% of the total gross final energy consumption. Over time, the consumption of renewable energy for heating and cooling has gradually increased, primarily driven by the contributions of biomass and heat pumps. However, in 2021, the overall consumption of all fuels rose due to economic recovery after the lifting of COVID-19 restrictions, resulting in a slight decline in the share of renewable energy in gross final consumption for heating and cooling. The share decreased by 0.1 percentage points, going from 23.0% in 2020 to 22.9% in 2021, which is still nearly double the value recorded in 2004 at 11.7%. The growth of renewable energy in heating and cooling can be attributed to developments in the industrial sector, services, and households, including the adoption of heat pumps for electrification of heating. Among the EU Member States, Sweden stood out with an impressive 68.6% of energy used for heating and cooling coming from renewable sources, mainly biomass and heat pumps. Following Sweden, Estonia, Latvia, and Finland also demonstrated significant contributions, with 61.3%, 57.4%, and 52.6% respectively, all relying on a substantial share of biomass. (See Figure 3.2)

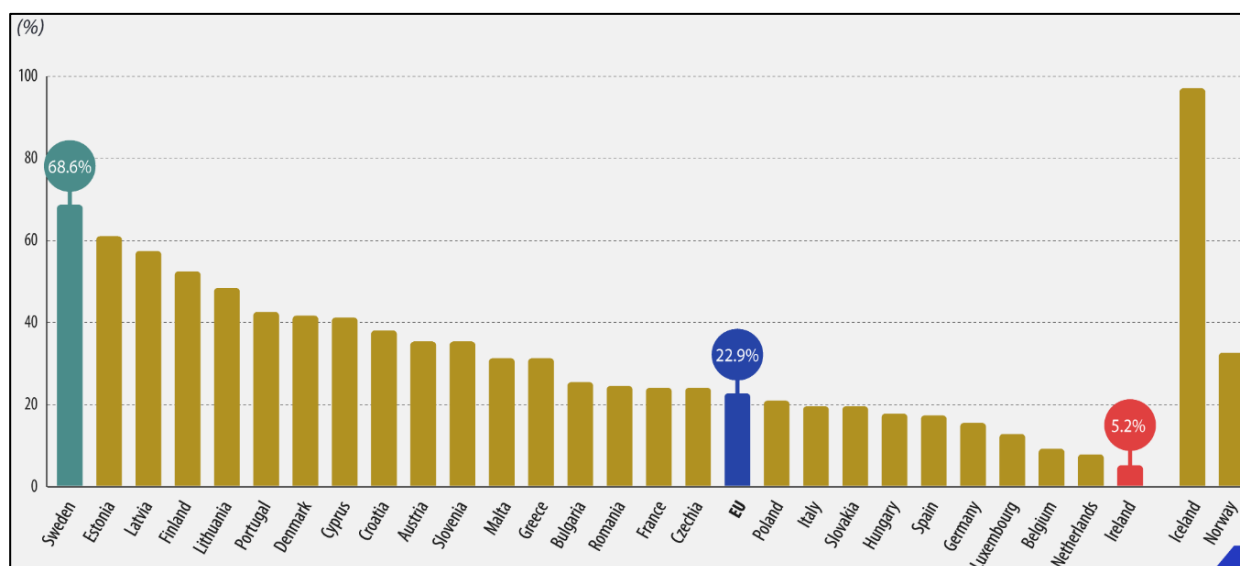


Figure 3.2 Share of energy from renewable sources for heating and cooling, 2021 <sup>vi</sup>

<sup>v</sup> [https://ec.europa.eu/eurostat/databrowser/view/TEN00125\\_custom\\_6886528/default/table](https://ec.europa.eu/eurostat/databrowser/view/TEN00125_custom_6886528/default/table)

<sup>vi</sup> <http://ec.europa.eu/eurostat/web/energy/database>

On the other end of the spectrum, the lowest proportions of renewable sources for heating and cooling were observed in Ireland (5.2%), the Netherlands (7.7%), and Belgium (9.2%).

From 2004 to 2021, all EU Member States registered an increase in the share of renewable energy for heating and cooling. The most substantial increments were reported in Cyprus (+32.1 percentage points; pp), Malta (+30.3 pp), Estonia (+28.0 pp), and Sweden (+22.7 pp). Comparatively smaller increases were recorded in Ireland (+2.3 pp), Belgium (+6.3 pp), and the Netherlands (+5.5 pp).

### **Geothermal market**

According to the IEA, buildings in Europe are the largest consumer of geothermal energy for heating because it provides a reliable and constant heat source, making it ideal for meeting heating demands in colder climates. European countries prioritize renewable energy sources to reduce greenhouse gas emissions and combat climate change. Many European governments offer incentives, subsidies, and supportive policies to encourage the installation and use of geothermal heating systems, further promoting its adoption. Due to these factors, European buildings have increasingly embraced geothermal energy as an efficient, sustainable, and environmentally friendly way to meet their heating needs. (See Figure 3.3).

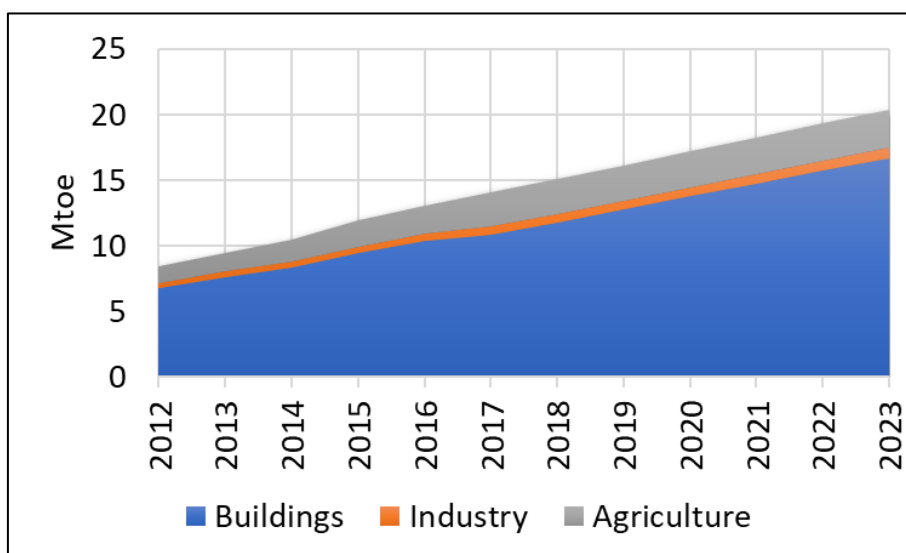


Figure 3.3 Geothermal energy consumption for heat by end-user sector, 2012-2023. <sup>vii</sup>

### **Geothermal heat pumps**

The ground-source heat pumps dominate the global geothermal usage, representing 71.6% of the installed capacity and 59.2% of the annual energy use. The total installed capacity is 77,547 MWt, and the annual energy use is 599,981 TJ/yr. The number of countries with installations has steadily increased, growing from 26 in 2000 to 54 in 2020.

Approximately 6.46 million equivalent 12 kW units (typical for USA and Western European homes) are currently installed, showing a significant 54% increase compared to 2015 and over

<sup>vii</sup> IEA, Geothermal energy consumption for heat by end use sector, 2012-2023, IEZ, Paris.

twice the number from 2010. Individual unit sizes range from 5.5 kW for residential use to over 150 kW for commercial and institutional applications. In the United States, most units are sized for peak cooling loads and are oversized for heating, while in Europe, units are generally sized for heating loads and may operate up to 3,000 equivalent full-load heating hours per year, especially in Nordic countries like Finland. The energy output reported for heat pumps was deduced from the installed capacity using an average coefficient of performance (COP) of 3.5. This COP accounts for one unit of energy input (typically electricity) producing 2.5 units of energy output for a geothermal component of 71% of the rated capacity.

The leading countries in terms of installed units are China, United States, Sweden, Germany, and Finland, accounting for 77.4% of all units. Similarly, these countries are also the top producers of geothermal energy, accounting for 83.5% of the total output [Errore. Il segnalibro non è definito].

### 3.3 Segmented direct use of geothermal energy (with GSHP) per country

#### Italy

Italy has a total of 37 direct-use geothermal sites, serving various purposes. These sites are categorized as follows: 5 for district heating, 5 for individual space heating, 1 for industrial processes, 6 for fish farming, 4 for greenhouse heating, and 16 for swimming and bathing. Among these, the space heating sector holds the largest share, accounting for 42% of the total energy and 52% of the overall installed capacity. Thermal balneology and fish farming follow closely, representing 32% for both energy and capacity, and 18% and 9%, respectively.

Ground-source heat pumps contribute significantly, making up 38% of the total installed capacity and around 30% in terms of energy. District heating systems constitute approximately 8% of the overall geothermal heat utilization in Italy. The primary district heating systems are located in Tuscany, where the fluid used to feed the networks comes from the same deep wells that supply the geothermal power plants. Another major geothermal district heating application is in Ferrara, with a 14 MWt-capacity system utilizing pressurized hot water at almost 100°C. [3]

The picture below summarises the Italy's geothermal direct-use capacity and annual energy uses.

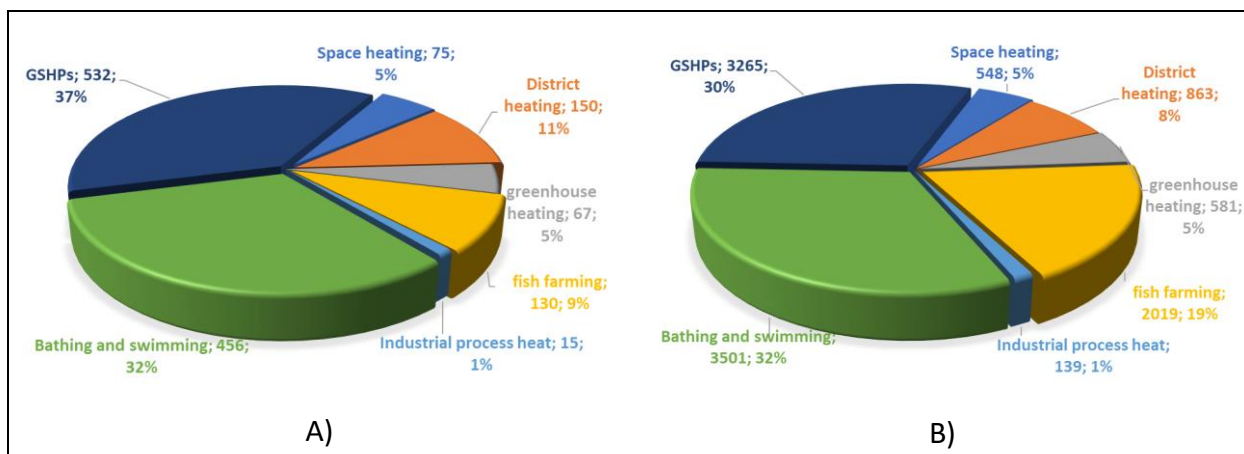


Figure 3.4 Summary of direct-use of geothermal for Italy A) installed capacity (MWt) and B) annual energy use (TJ/yr.).

## Spain

Spain does not have high enthalpy geothermal facilities. However, shallow geothermal energy is gradually progressing in the country. Open systems with geothermal heat pumps (GHPs) have been widely adopted for many years, and closed systems started gaining traction in the year 2000, both in buildings and industries. Despite the financial crisis in the construction sector, the installation of GHP systems continued to grow, albeit at a slower pace than desired considering the existing capacity and energy demands. These systems have been increasingly installed in various types of buildings, including new constructions and renovations. Public administrations are also adopting GHP systems in public buildings, aligning with the concept of 'Nearly Zero-Energy Buildings (NZEBs)' promoted by the European Union, further promoting geothermal implementation in Spain.

The future Spanish Climate Change and Energy Transition Law is expected to emphasize the role of geothermal energy for heating and cooling in buildings, contributing to Spain's energy and climate change commitments. [4]

The picture below summarises the Spain's geothermal direct-use capacity and annual energy uses.

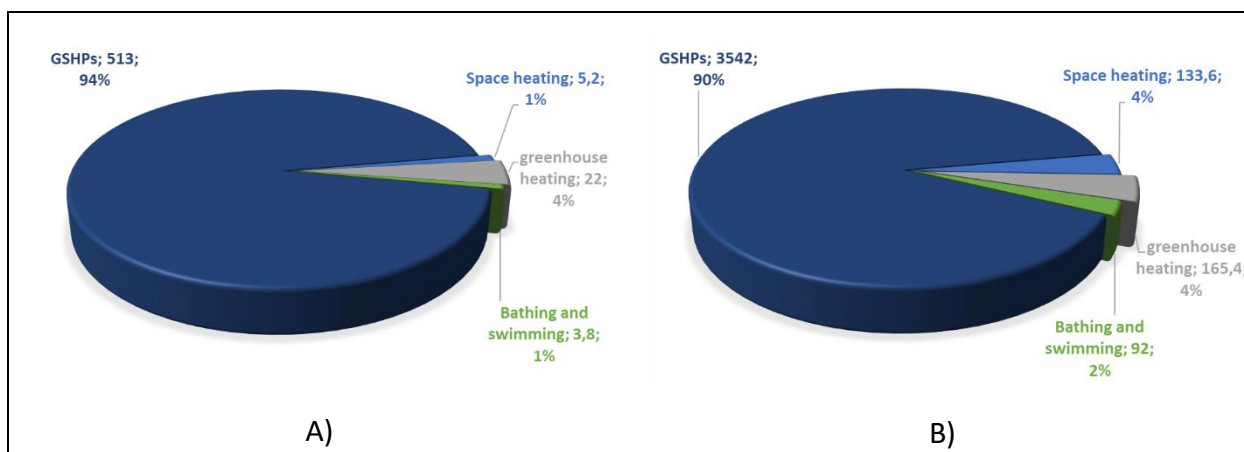


Figure 3.5 Summary of direct-use of geothermal for Spain A) installed capacity (MWt) and B) annual energy use (TJ/yr.).

## Belgium

Geothermal energy has experienced gradual growth in Belgium over the past decade, primarily driven by the adoption of geothermal heat pumps (GHP). The Saint-Ghislain and Douvrain wells have been producing geothermal water for heating networks since 1985, supplying public buildings like hospitals, schools, and swimming pools, as well as a few hundred housing units. The residual heat from the Saint-Ghislain network is cleverly utilized to stimulate the fermentation process at the Wasmuël water treatment plant.

Following a brief period of uncertainty in the development of shallow geothermal energy systems between 2014 and 2017, a clear revival is now evident. This resurgence is particularly notable in Flanders, where it is driven by stricter E-level requirements (energy performance of buildings) and the obligation to generate a minimum of 15 kWh/m<sup>2</sup> of renewable energy. A similar trend is observed in Brussels, where passive construction has been mandatory since 2015, with a

maximum heat demand of 15 kWh/m<sup>2</sup>. As a result, there is a notable increase in the installation of heat pumps, with air/water systems prevailing but geothermal heat pumps steadily gaining traction. [5]

The picture below summarises the Belgium's geothermal direct-use capacity and annual energy uses.

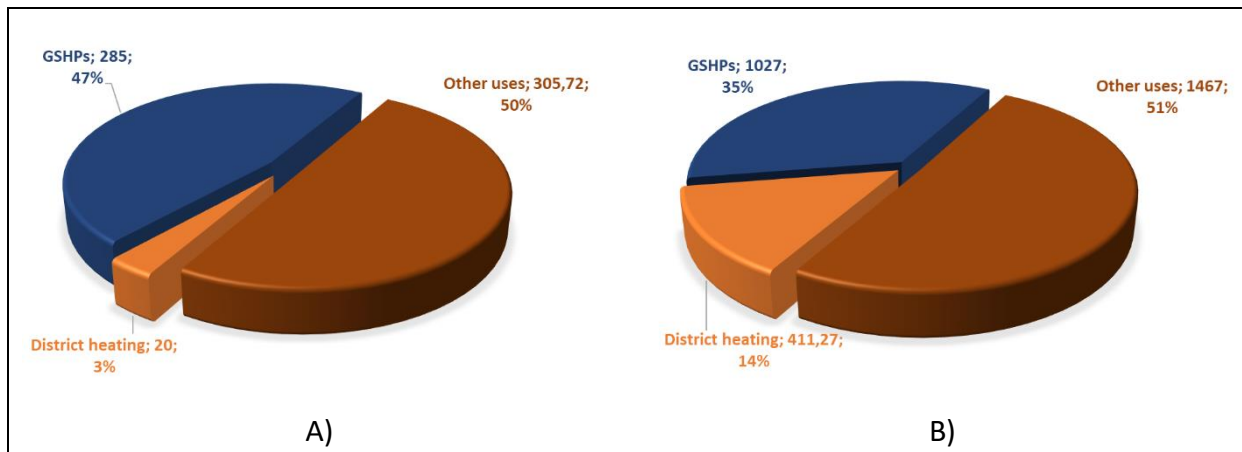


Figure 3.6 Summary of direct-use of geothermal for Belgium A) installed capacity (MWt) and B) annual energy use (TJ/yr.).

## Ireland

Extensive research conducted since the early 1980s in Ireland has recorded temperatures ranging from 13°C to 24.7°C in warm springs. Geothermal resources in Ireland are classified as low enthalpy due to its intraplate geological setting, with varying geothermal gradients across the country.

Geothermal heating and cooling contribute to around 3.3% of renewable energy in gross final energy consumption in 2017, and 1.2% of total energy in renewable energy contributions to thermal energy combined with air source heat pumps. Information on large-scale commercial geothermal systems is available through the Geothermal Association of Ireland records, but many new installations remain poorly documented or not recorded at all.

Ground source heat pump installations saw a decline in 2018, with approximately 150 units installed, representing a 1.2% decrease from the previous report in 2015. However, it is expected that the growth rate will increase following the introduction of financial support schemes in 2018. The total number of heat pumps installed in Ireland in 2018 is estimated to be around 181,000 units, with just under 10% being ground source units.

The residential sector dominates the shallow geothermal energy market in Ireland, accounting for about 85% of installations, with lower usage in the commercial and industrial sectors (14% and 4%, respectively). The most common systems have intermediate installed capacities ranging from 10 kW to 24 kW, but their growth is declining. Large-scale ground source systems typically use open loop collectors, with an increasing number adopting closed loop collectors. The majority of installed systems range between 60 kW to 250 kW for heating and cooling applications [6].

According to a recent report [7], the shallow geothermal energy market in Ireland continues to be predominantly driven by residential installations, comprising approximately 85% of the market share. Conversely, there has been relatively lower adoption in the commercial and

industrial sectors, accounting for 14% and 4%, respectively. Among these systems, those with intermediate capacity ranging between 10 kW and 24 kW appear to be the most widely utilized. This suggests a notable concentration of shallow geothermal energy systems within residential settings compared to commercial and industrial applications in Ireland.

The picture below summarises the Ireland's geothermal direct-use capacity and annual energy uses.

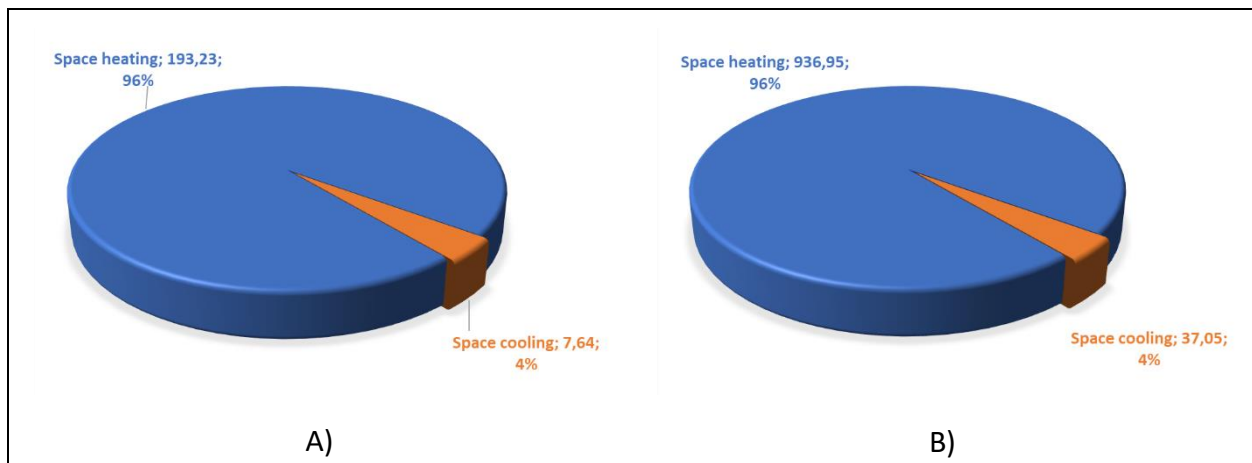


Figure 3.7 Summary of direct-use of geothermal for Ireland A) installed capacity (MWt) and B) annual energy use (TJ/yr.).

## Germany

Geothermal district heating and power plants in Germany are strategically situated in regions with favourable geological conditions, such as the Molasse Basin in Southern Germany, the North German Basin, and the Upper Rhine Graben. In addition to "deep" geothermal energy installations, there is widespread use of small- and medium-sized decentralized geothermal heat pump units for heating and cooling individual houses and offices. By the end of 2018, Germany had 382,000 operational geothermal heat pumps, primarily supplying renewable heat to residential buildings.

Thermal spas are the most common form of deep geothermal heat use, but larger district heating plants are continuously growing, now accounting for approximately 68% of the deep geothermal heat production. Alongside deep geothermal applications, numerous geothermal heat pumps for heating and cooling in office buildings and private houses contribute significantly to Germany's geothermal heat utilization.

In total, Germany currently has about 190 geothermal installations for direct use, including district heating plants, combined heat and power plants (CHP), thermal spas, and space heating. Additionally, there are five deep borehole heat exchangers operating in different locations, each serving specific purposes.

The sales figures for all heat pumps in Germany remained relatively constant between 2008 and 2015 (around 50,000 to 60,000 units per year), but in 2018, sales surged to 84,000 units. During the same period, the market share of geothermal heat pumps decreased from over 50% to less than 30% in 2018, with approximately 23,500 geothermal heat pumps sold.

In conclusion, there are 382,000 geothermal heat pump units installed in Germany, with an average size of 11.5 kW, meeting 1.62% of the residential heat demand. Geothermal heat pumps are the primary users of geothermal energy in the country, followed by district heating in 26 cities, and usage in bathing and swimming facilities [8].

The various applications of geothermal energy in Germany are included in the figure below,

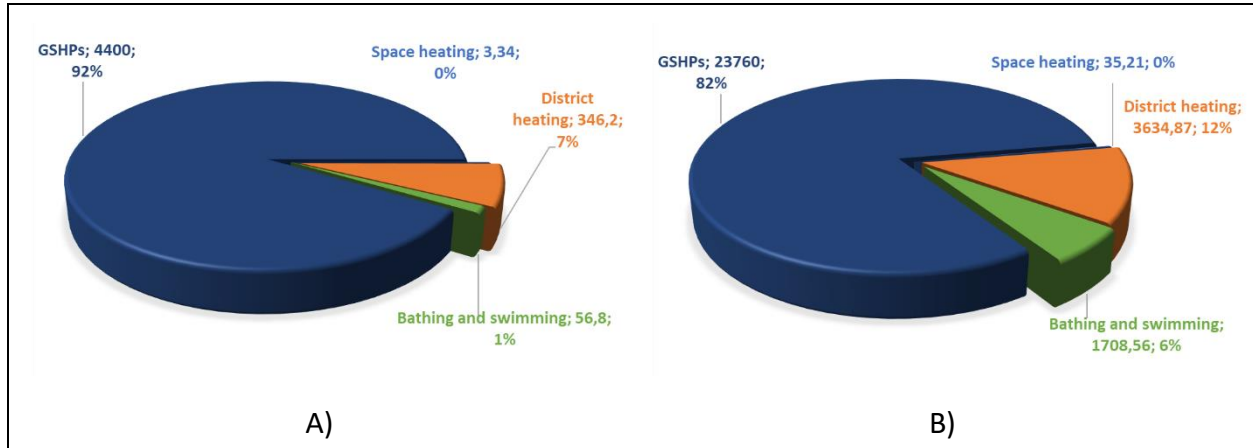


Figure 3.8 Summary of direct-use of geothermal for Germany A) installed capacity (MWt) and B) annual energy use (TJ/yr.).

**Romania**

The utilization of deep geothermal resources in Romania includes several noteworthy projects. For instance, the Agrippa Ionescu Hospital in Balotesti implemented a geothermal space and tap water heating system, supplying 270,000 m3 of geothermal water annually for heating and hot tap water. The Therme Bucharest Spa Center, the largest private geothermal investment in Romania, utilizes geothermal water for indoor and outdoor pools and heating facilities throughout the year. Additionally, the Oradea geothermal district heating system was extended to include a high school and nearby buildings, replacing natural gas with geothermal energy.

In Romania, there are 40 direct-use geothermal projects, with the majority being used for bathing and swimming, individual space heating, and greenhouse heating. The total geothermal energy utilization for these projects amounts to 245.13 MWt and 1,905.32 TJ/yr [9].

The picture below summarises the Ireland's geothermal direct-use capacity and annual energy uses.

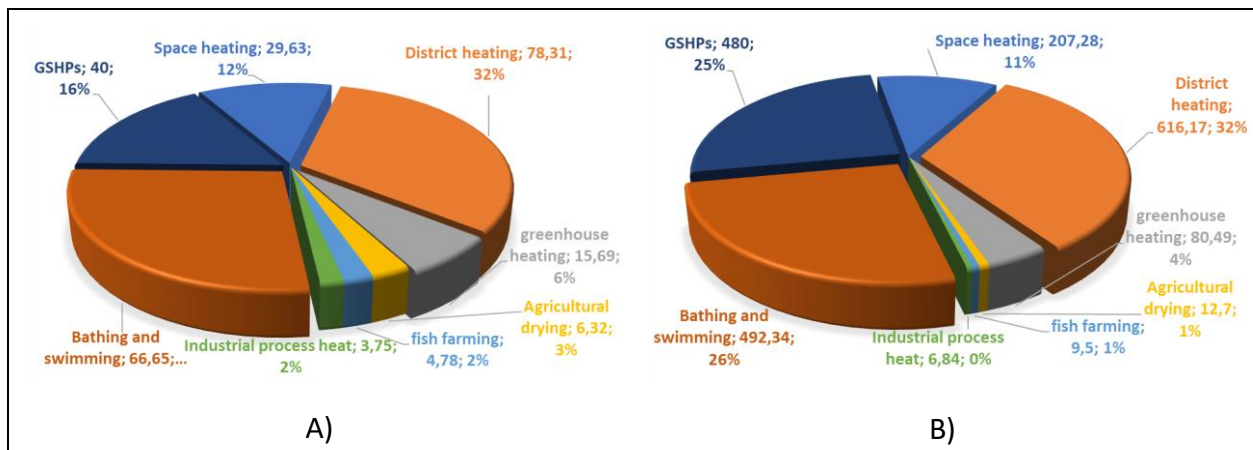


Figure 3.9 Summary of direct-use of geothermal for Romania A) installed capacity (MWt) and B) annual energy use (TJ/yr.).

**Greece**

Geothermal energy in Greece is primarily used for balneotherapy and greenhouse heating, while its applications in soil heating, aquaculture, and space heating remain limited. The country has more than 750 thermal and mineral springs, with about 70 spas and bathing centers, and over 25 outdoor swimming pools utilizing geothermal water. Geothermal greenhouses, mostly located in the north, have seen growth, with the largest investment being an 18.5 ha hydroponic greenhouse complex. Geothermal heat pumps (GSHPs) are the dominant segment in the geothermal sector, installed in large buildings and facilities like hotels, hospitals, and schools. Over 3500 GSHP systems have been estimated to be in operation in Greece.

In summary, there are 25 locations in Greece directly using geothermal energy for heating, with the main applications being greenhouse heating and individual space heating. Balneotherapy and swimming centers also contribute to geothermal usage [10].

The specific uses are included in the picture below

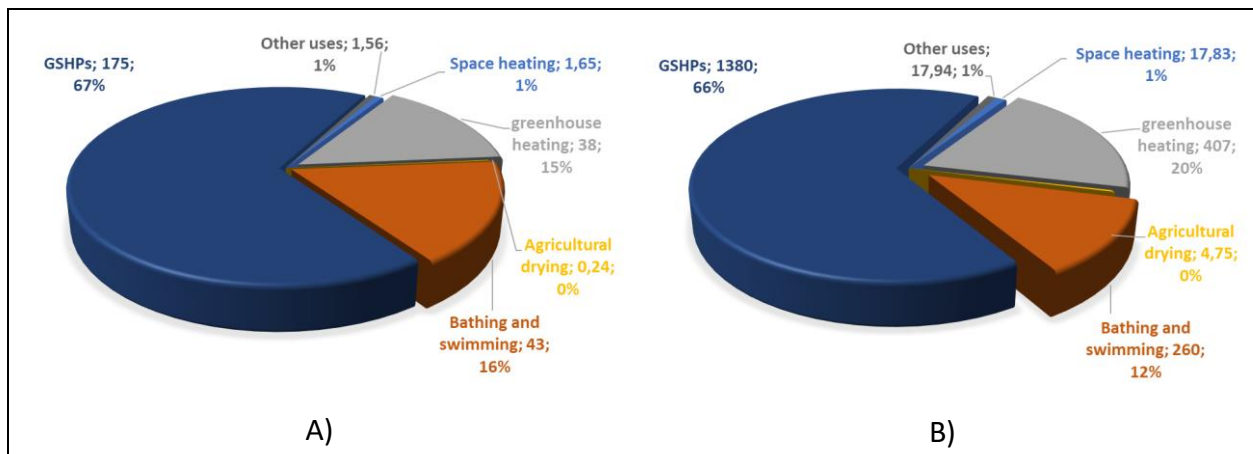


Figure 3.10 Summary of direct-use of geothermal for Greece A) installed capacity (MWt) and B) annual energy use (TJ/yr.).

### 3.4 Market trends

The global use of geothermal energy is predominantly focused on heating, but this segment is less internationalized. Geothermal projects for heating and cooling are often carried out by national companies, developed and planned at the local level, and driven by local authorities. Consequently, geothermal companies seeking international expansion may find it easier to access data on upcoming project developments for geothermal power plants, as they are larger in scale and often driven by national programs or international organizations.

The geothermal heating and cooling sector reflects broader trends in the energy system, where integrated strategies are lacking in most countries. However, there is a recent global trend towards proactive planning for decarbonizing heating and cooling within the geothermal market. An integrated approach to energy transition in the heating and cooling sector in more global geothermal markets is a crucial step towards unlocking new opportunities for export and internationalization for companies in the geothermal industry. This shift presents potential benefits for SMEs seeking to expand their services in the international arena [11].

### 3.5 Profile of relevant competitors

#### 3.5.1 Dual source heat pump

Based on the complete analysis of the direct competitors presented in Section 6.3 deliverable D7.3, the profile of the specific dual source heat pump models is summarised. These technologies are closely related to the dual source heat pumps developed within the GEO4CIVHIC project.

The Figure 3.11 below shows the pricing of the direct competitors of dual source heat pump,

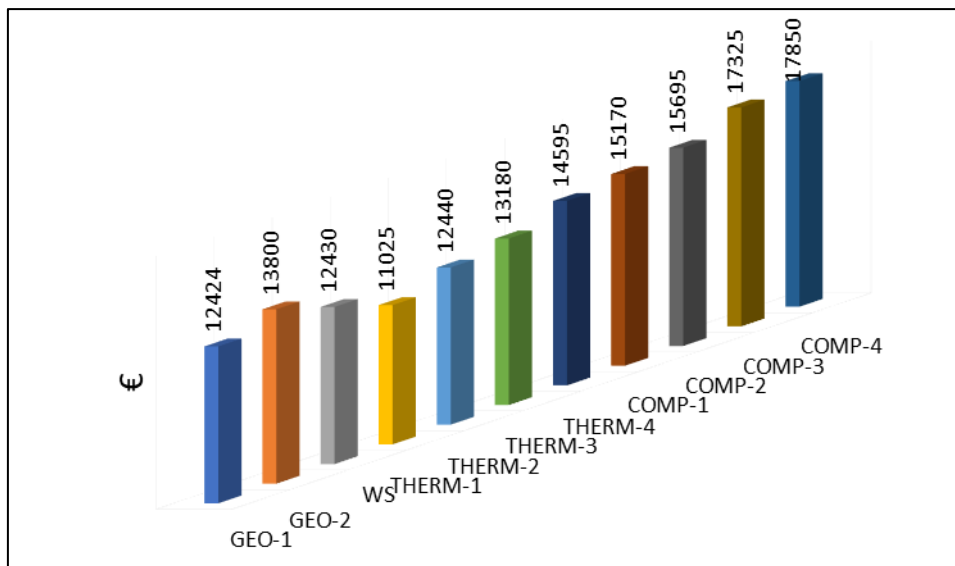


Figure 3.11 pricing of the dual source heat pump direct competitors

The prices presented above are related to the following main characteristics (see Table 3.2) of the different similar dual source products available in the market,

Table 3.2 – Profile of relevant dual source heat pump competitors

Product	Source	Size & weight	Efficiency COP/EER		Power		Refrigerant	price
			Heating	Cooling	Heating	Cooling		
<b>Altherna 3 GEO-1</b> EGSAX06D9W	Ground-water	1,89x0,59x0,67 222 kg	4,74	-		8kW	R32	12.424 €
<b>Altherna 3 GEO-2</b> EGSAX10D9W	Ground-water	1,89x0,59x0,67 222 kg	4,89	-		8kW	R32	13.800 €
<b>Altherna 3 WS</b> EWSAX069W	Ground-Air	1,89x0,60x0,67 222 kg	5,3	-	6,13 kW	5,8 kW	R32	12.430 €
<b>FlexoTHERM-1</b> 0020231528	Ground	145 Kg	4,2	4,9	5,4 kW	6,0 kW	R410A	11.025€
<b>FlexoTHERM-2</b> 0020231529	Ground	160 Kg	4,1	5,0	8,2 kW	9,4 kW	R410A	12.440€
<b>FlexoTHERM-3</b> 0020231542	Ground /Water	145 Kg	4,5	4,2	5,7 kW	5,8 kW	R410A	13.180€
<b>FlexoTHERM-4</b> 0020231543	Ground /Water	160 Kg	4,8	4,2	9,8 kW	8,7 kW	R410A	14.595€
<b>FlexoCOMPACT-1</b> 0020231531	Ground	212 kg	4,2	4,9	5,4 kW	6,0 kW	R410A	15.170€
<b>FlexoCOMPACT-2</b> 0020231532	Ground	227 kg	4,1	5,0	8,2 kW	9,4 kW	R410A	15.695€
<b>FlexoCOMPACT-3</b> 0020231545	Ground /Water	212 kg	4,5	4,2	5,7 kW	5,8 kW	R410A	17.325€
<b>FlexoCOMPACT-4</b> 0020231546	Ground /Water	227 kg	4,8	4,2	9,8 kW	8,7 kW	R410A	17.850€

### 3.5.1 Innovative drilling technology

Based on the analysis performed in Section 6.3 of D7.3, this section presents the profile of the specific drilling technologies which takes into account the drilling rig, semi-automatic feeder and the drilling head and bit. These competing technologies are closely related to the innovative drilling equipment developed within the GEO4CIVHIC project.

The Figure 3.12 below shows the pricing of the direct competitors of the drilling rig

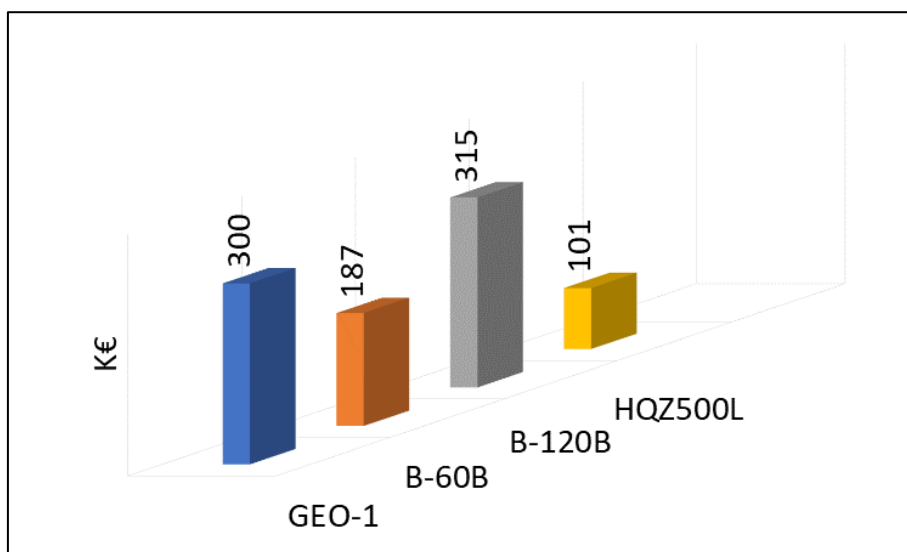


Figure 3.12 pricing of the drilling rig direct competitors

Table 3.3 – Profile of relevant drilling rig competitors

Product	Size & weight	Power	Remote control	Modular	Mast (Stroke)	Crowd Force	Drilling Torque	Price
Conrad BOXER 60B	1320x3598 mm 3200 Kg	55 kW at 2600 rpm	Yes	No	3400 mm	2000 Kg (Thrust) 4000 Kg (Tractive)	xx Kg. m at 55 rpm	187k€
Conrad BOXER 120B	1635x4906 mm 7000 Kg	55 kW at 2600 rpm	Yes	No	4200 mm	1500 Kg (Thrust) 3000 Kg (Tractive)	xx Kg. m at 55 rpm	315k€
GEOTeCH drill rig	2000x7939 mm 12000 Kg	125 kW at 2200 rpm	Yes	No	4200 mm	3000 Kg (Thrust) 6000 Kg (Tractive)	2800 Kg. m at 55 rpm	270-330k€
HQZ500L	2700x2100 mm 10000 Kg	115 kW at 2200 rpm	No	No	5350 mm	-	1000 Kg. m at 50 rpm	101k€

The next Section 0 aims to perform an assessment of why potential customers will choose to buy GEO4CIVHIC products and technologies and describe the key success factors. The assessment has been done taking into account the main advantages and key success factors of GEO4CIVHIC products and technologies that include:

- Unique features
- New technologies or systems
- Better value to customers in terms of efficiency or ROI or cost/benefit ratios
- Greater compatibility with existing systems

## 4 Products & services and Business Models

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As previously described in the initial deliverable, D7.3 [1], we presented preliminary exploitable outcomes developed within the GEO4CIVHIC project. However, as the project progressed, we identified and selected six exploitable products, an innovative methodology, and an integrated solution. These include:

1. Plug and play heat pump with variable or fixed-speed drivers.
2. Heat pump for high-temperature and dual-source applications.
3. High-temperature heat pumps for renovated civil and historical buildings.
4. Versatile and compact drilling rig unit JOY 3P GEO4CIVHIC
5. Semi-automatic feeder for drilling rods and co-axial tubes mounting.
6. Compact integrated vibration-rotation drilling head and drill bit (VD105 and VD80).
7. Efficient co-axial heat exchangers for piling with a vibrational drilling head (Hydra-red method).

The consortium partners reached a consensus to explore various business models for these six exploitable outcomes. Ultimately, our goal is to propose a comprehensive integrated solution that encompasses the seven key exploitation results within a single and integrated business model. The selection criteria for the first six Key Exploitable Results (KERs) were based on their development having achieved high Technology Readiness Levels (TRLs), positioning these results as products and/or services that are very close to entering the market, and nearly ready for commercialization.

In the following section, we will delve into the stand-alone products corresponding to the six selected exploitable results. Additionally, this business plan will provide a summary of the business models associated with these stand-alone products, created with the contributions of consortium partners, as outlined in deliverable D.7.3. This information aims to elucidate how these stand-alone products can be effectively commercialized in the market in the future, even as the overarching concept of the business plan takes shape based on the chosen business model.

### 4.1 Specific KERs to be evaluated

The specific KERs or project results for which business model is to be developed and evaluated are the ones that pertain to tangible outcomes that can be commercialized. As some of the project results correspond to guidelines or manuals which tend to support the commercialization or exploitation of more important or more tangible technical project results, it is important to identify the latter and focus on them in defining business models. Moreover, it is important that these results are aligned with the ones recognized and evaluated in the exploitation deliverables so far.

Within the exploitation deliverables, it has been determined that the main tangible or technical results that represent true commercial potential are mainly described in work packages 2 to 4 that outline the development of the GEO4CIVHIC Systems as demonstrated below. The following figure provides an overview of the project and the GEO4CIVHIC system and work structure.

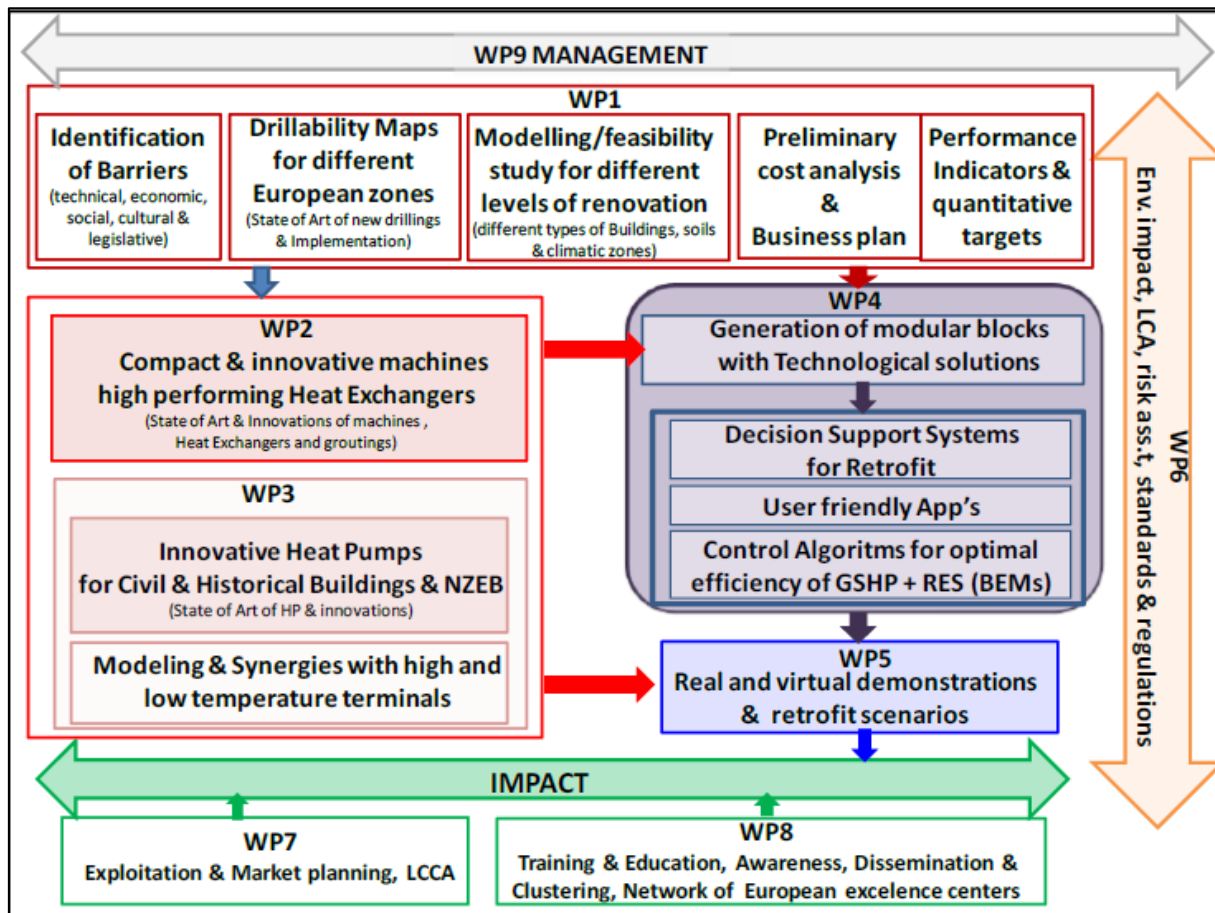


Figure 4.1 GEO4CIVHIC workplan structure

The reason why these three Work Packages are the focus is due to the fact that they correspond to the development of tangible technical solutions while most other WPs are support packages. The specific tangible results representing the highest exploitation potential from the point of view of the novelty of the solution or service, its exploitability level, time to market and uptake by the project partners can be separated into eight main KERs. The following figure provides an overview of this breakdown with KER# representing the results that will be considered in this deliverable. Certain macro categories which appear as the coloured headers here are taken as one KER such as the Collaboration platform, while others are composed of multiple KERs such as the compact rotational drill rig.

Nº	Title	KER	Exploitation Potential	Type	IP owner	IP contributor
<b>HEAT PUMP Technology</b>						
1	Plug and play heat pump with variable or fixed speed drivers	KER	Commercial	Product	Galletti-Hiref	UNIPD-DII, CNR-ITC, CRES
2	Heat pump for high temperature application and dual source application	KER	Commercial	Product	Galletti-Hiref	UNIPD-DII, CNR-ITC, CRES
3	High temperature Heat Pumps for renovated Civil and Historical Buildings	KER	Commercial	Product	Galletti-Hiref	UNIPD-DII, CNR-ITC
<b>DRILLING Technology</b>						
4	Versatil and compact drilling rig unit Joy 3P GEO4CIVHIC	KER	Commercial	Product	Hydra	Hydra
5	Semi-automatic feeder for drilling rods and co-axial tubes mounting	KER	Commercial	Product	Hydra	Hydra
6	<b>Compact Vibration-rotation drilling components</b>					
6.a	Compact Vibration-rotation drilling head and drill bit. (VD 80)	KER	Commercial	Product	TKI	Hydra
6.b	Compact Vibration-rotation drilling head and drill bit. (VD 150)	KER	Commercial	Product	TKI	Hydra
6.ab.1	Vibratory hammer drill with regard to its excitation cell	KER	Commercial	product	TKI	TKI
6.ab.2	Unbalance shafts with regard to changes in frequency and eccentric moment with constant centrifugal force and constant hydraulic input parameters	KER	Commercial	product	TKI	TKI
<b>METHODOLOGY</b>						
7	Efficient co-axial heat exchangers for piling with vibration-rotation drilling head (HYDRA-RED METHOD)	KER	Commercial	Process and Methodology	RED-HYDRA	CRES
<b>INTEGRATED System</b>						
8	GEO4CIVHIC integrated solution	KER	Commercial	Service/Product/Methodology	Individual KER owners	Individual KER contributors

Figure 4.2 GEO4CIVHIC KER breakdown

## 4.2 GEO4CIVHIC consolidated Stand-alone products and methodology

As explained in the above, the GEO4CIVHIC business plan will be based upon 6 main KERs as stand-alone products which are divided by main categories namely Heat Pump technology which includes an innovative heat pump package comprising of

1. plug and play heat pump with variable or fixed speed drivers;
2. heat pump for high temperatures and dual source applications and
3. high temperature heat pumps for renovated civil and historical buildings.

The Drilling Technology category includes,

4. Versatile and compact drilling rig unit, namely JOY 3P GEO4CIVHIC;
5. Semi-automatic feeder for drilling rods and co-axial tubes mounting and
6. Compact vibration-rotation drilling components,
  - a. 6.a) VD80 and
  - b. 6.b) VD105

including their spare components 6.1b.1) Vibratory hammer drill with regard to its excitation cell and 6.ab.2) Unbalanced shaft with regard to changes in frequency and eccentric moment with constant centrifugal force and constant hydraulic input parameters.

In the Methodology category we have the

7. Efficient co-axial heat exchangers for piling with vibration-rotation drilling head (HYDRA-RED method)

This section aims to present business model Canvas as well as an assessment of why potential customers will choose to buy GEO4CIVHIC products and technologies and describe the key success factors. The assessment has been done taking into account the main advantages and key success factors of GEO4CIVHIC products and technologies that include:

- General information about the product- Background to its development during the GEO4CIVHIC project.
- Benefits and Features
- Unique selling points
- Advantages to customers
- Disadvantages or weak points
- Future developments (if foreseen)

#### 4.2.1 Innovative Heat Pump package business model

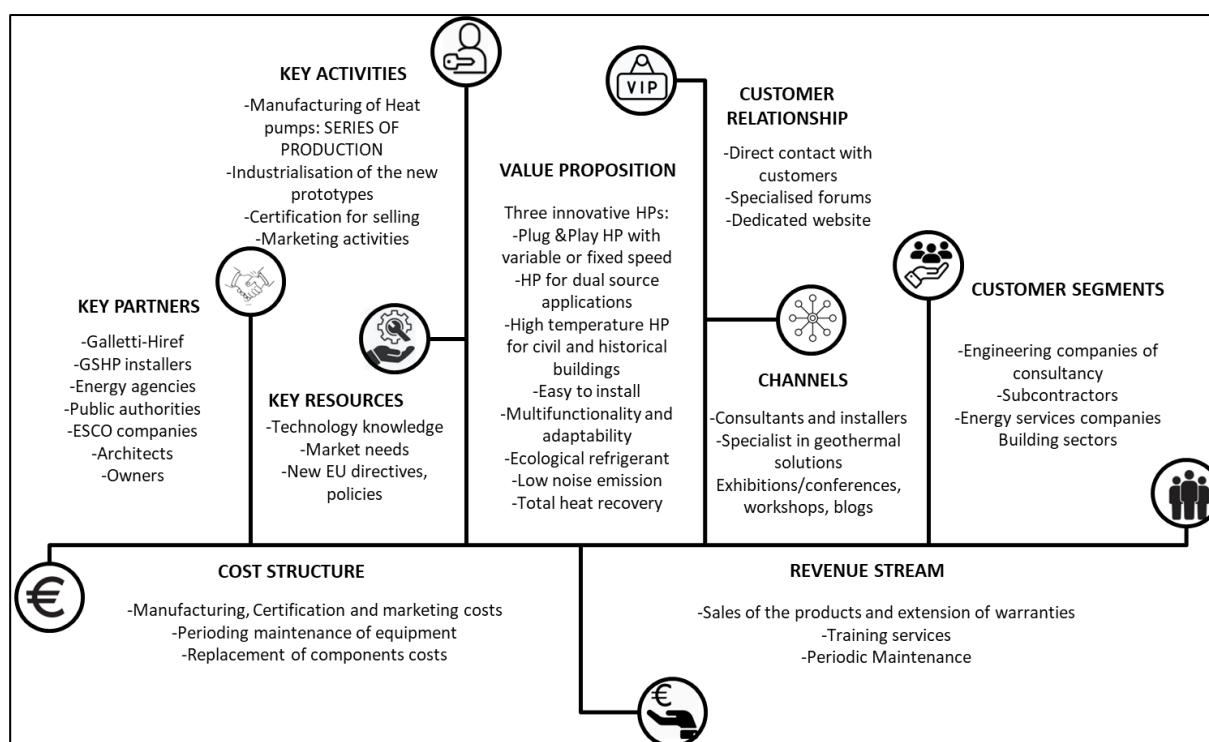


Figure 4.3 Business model Canvas – Innovative heat pump package

#### Plug and Play heat pump with variable or fixed speed drivers

##### General information about the product

Traditional water-to-water heat pumps are typically equipped with components such as user-side and source-side hydraulic pumps. The prototype is additionally equipped with 3-way valves for domestic hot water production, the expansion vessel and the safety valves for saving the system, the buffer tank and the instantaneous preparator of domestic hot water. The advantage of this layout is that the heat pump can be directly connected to the HVAC system, reducing the size of the technical room as well as the cost of installation.

Two prototypes equipped with refrigerant R454B have been manufactured: one with fixed-speed compressor (on-off) and one with variable-speed compressor (i.e., compressor equipped with inverter).



Figure 4.4 Plug and Play fixed-speed compressor (on-off, Prototype #1) and variable-speed compressor (inverter, Prototype #2) heat pump.

### **Innovation Content- Benefits and Features**

- Water to Water heat pump
- Low/ Medium temperature Heating
- Cooling
- One source
- New refrigerant: R454B alternative of R410A with low environmental impact
- Plug & Play includes:
  - Ground source circulation
  - User circulation
  - DHW instantaneous producer
  - Hydraulic accessories

### **Advantages for Customers**

These prototypes are a double source heat pump working at low temperature, suitable for low and mid temperature terminal units. The double source can be used both for reducing the GHEs field and hence to reduce the CAPEX (allowing improved performance of the machine) and when the available space in an urban area is not sufficient to host all the GHE field necessary to cover the energy demand using only a GSHP.

## Heat pump for high temperature and dual source applications

### General information about the product

Second generation of reliable and efficient heat pump based on the outcomes from GEOT€CH and Cheap-GSHPs H2020 projects, combining two different thermal sources: Water / air-water; Ground / air-ground.

### Innovation Content- Benefits and Features

- Environmentally friendly refrigerant R32-fluid, advanced heat exchanger, hybrid mode for the use of air/water heat sources (dual source), water-water (one source)
- High Coefficient of Performance (COP) and seasonal performance factor (SPF).
- Daily monitoring;
- Multifunctionality and adaptability (Low temperature in heating and cooling);
- Easy Installation (plug and play);
- Applicable for small space field because it is suitable to use less number BHE in the field.

Environmentally friendly refrigerant R454B-fluid, advanced heat exchanger, hybrid mode for the use of water/air-water or ground/ air-ground heat sources (dual source), DHW included (polyvalent execution). High Coefficient of Performance (COP) and Seasonal Performance Factor (SPF).



Figure 4.5 Dual Source heat pump for high temperatures (prototype #3)

D3.1 presents a preliminary map of suitability of installation of the different types of geothermal based Heat Pumps for low and high temperature terminals. The deliverable presents a market analysis of the most suitable Heat Pump configurations for the retrofit of buildings. Common applications (heating, cooling, Domestic Hot Water, etc.) are considered with their corresponding refrigerant cycles and operating conditions. Possible control strategies are defined. Selection rules to facilitate technology recommendation are drafted, and costs of the different Heat Pump configurations are estimated.

### **Advantages for Customers**

This third prototype is a heat pump working at two levels of temperature, suitable for retrofits where there is a zone in the building which maintains the original high temperature radiators and one zone where low temperature emission systems are installed.

### **Unique selling points**

- Dual source heat pump (air - water; air - ground)
- Low GWP refrigerant
- Modulating compressor
- Total heat recovery (heating and cooling at the same time)
- Modulating high efficiency pumps
- Easy to install
- Low noise emissions

### **High temperature hybrid heat pumps for renovated civil and historical buildings**

### **General information about the product**

This prototype developed in this project, uses the technology of the double source: it uses both the external air and the ground as heat sources/sink. Moreover, differently from common heat pumps available in the market, it produces high-temperature water for heating and cold water for cooling. Another important feature of the machine is the use of CO<sub>2</sub> as refrigerant, which allows reducing the environmental impact.

### **Innovation Content-Benefits and Features**

This heat pump concept is a winning choice for the coupling of heat-pumps with ground heat-exchangers and the design of the prototype can also be improved with the introduction of a natural refrigerants as R744. The design of this unit innovates the concept of the use of the dual source overcoming the choice of the combination of the 2 sources in parallel/alternate or in series/simultaneous and that become possible and convenient due to the use of the CO<sub>2</sub>.

In the summer mode the unit uses the two sources in series and this permits to reduce the drift of the ground temperature and increases the efficiency of heat pump, in particular in comparison to the traditional cooling units operating with CO<sub>2</sub>. This concept allows to operate with high efficiency in all climate, also in warm condition typical of central and south part of Europe.

In the winter mode the unit operates with the sources in parallel used as alternative, so on the basis of the external air temperature and on the predictable performance compared to the water source, the unit switches in order to operate with the most convenient source: this strategy allows to increase the seasonal performance by the choice of the best source and has the big indirect advantage to avoid the losses of energy due to the defrost cycle in comparison to the air source heat-pumps.

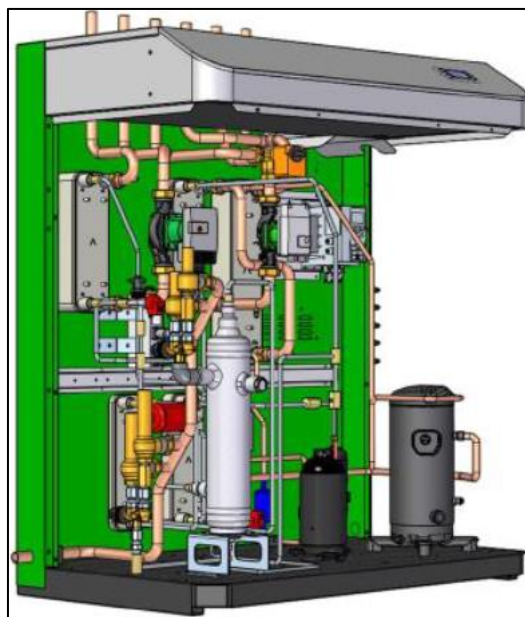


Figure 4.6 High temperature hybrid heat pumps for renovated civil and historical buildings

### **Advantages for Customers**

This prototype is a heat pump working at high temperature with the ground as source. This machine is suitable for historical listed buildings where it is not possible to retrofit neither the envelope or the emission systems. The heat pump is based on a double stage cascade refrigerant circuit.

### **Unique selling points**

- One source (ground) and dual cycle – 2 compressors and working fluids
- Low GWP refrigerant
- Cooling/Heating
- Modulating high efficiency pumps
- Easy to install
- Low noise emissions

### 4.2.1 Innovative Drilling technology

#### Drilling rig unit Joy 3P GEO4CIVHIC

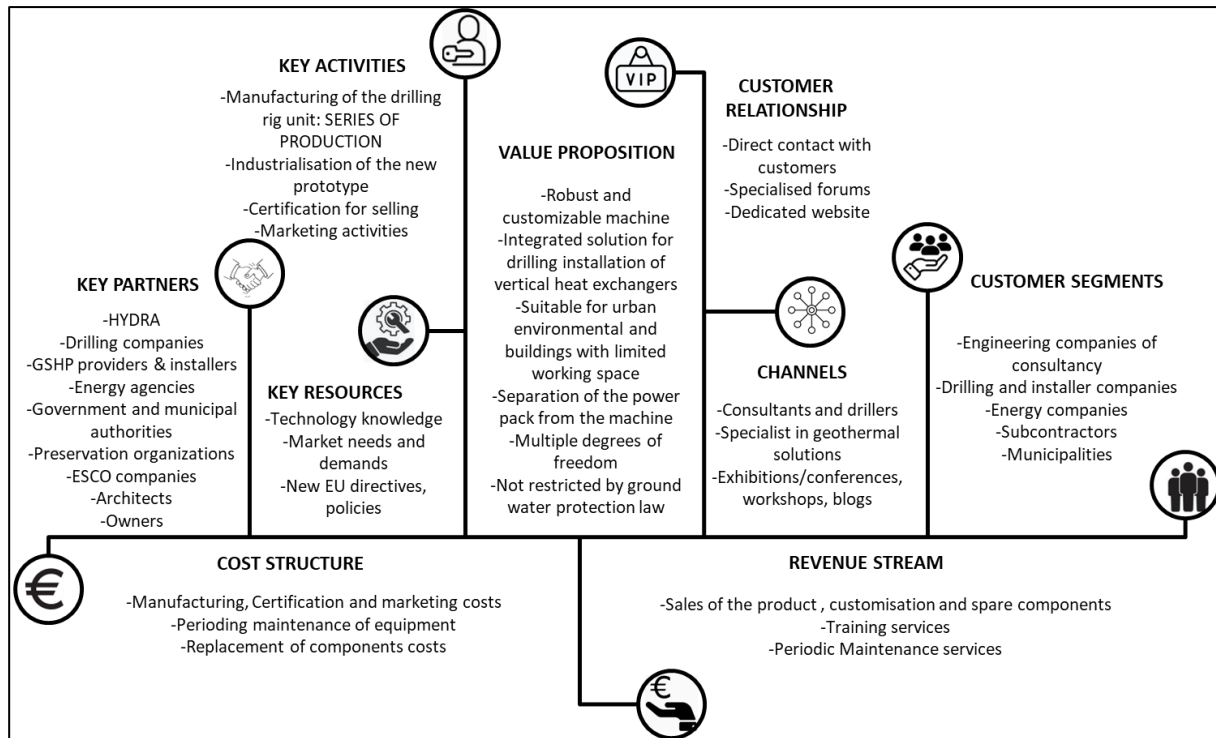


Figure 4.7 Business model Canvas – Drilling rig unit JOY 3P GEO4CIVHIC

#### General information about the product

The main feature of the newly developed drill rig is that it is a robust and compact machine that is suitable for urban environmental including buildings with many technical constraints as well as for historical ones. Due to its separation of the power pack from the machine capability is able to adapt to each different constraint in terms of limited working space.

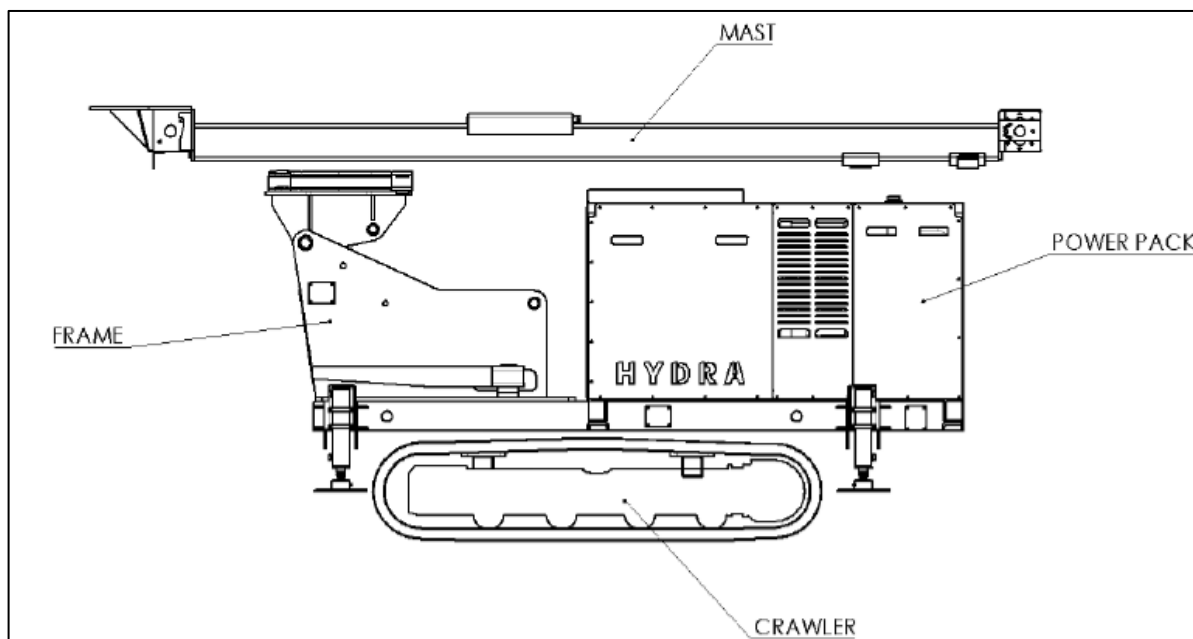
The equipment can be mobilized very quickly and is therefore capable of doing multiple perforations in one day. Last but not least the drill rig and equipment can be manufactured at a lower cost because of the reduced complexity when compared to conventional drilling equipment.

Enhanced drilling solutions, which were improved with regards to health, safety, and environmental impact. Such drilling solutions have lower costs for drilling companies.

#### Innovation Content-Benefits and Features

The drilling unit Joy 3P GEO4CIVHIC manufactured by HYDRA is a stand-alone machine composed by four main elements that are shown in figure below. These elements are:

- Frame
- Power pack
- Crawler
- Mast



A)



B)

Figure 4.8 Joy 3P GEO4CIVHIC, A) Scheme and B) manufactured drilling machine

The crawler allows the machine to move above every kind of ground. The mast hosts and moves the drilling head up and down, whereas two hydraulic clamps allow easy screwing and unscrewing of the drilling shafts. The mast is equipped with a system that allows for its rotation, enabling vertical, horizontal and even sloped perforations.

The drilling machine can be set up with ancillaries such as air compressor, water pump, bentonite pump and a winch.

A 125-kW engine provides power to a triplex pump. The triplex pump supplies hydraulic oil with different levels of both pressure and flow rate, through separate hydraulic circuits, in order to satisfy the power demand of the various functionalities of the machine, such as: rotation (drilling head); vibration (drilling head); water injection; hydraulic clamps and machine movements.

Machine	
Overall encoumber	6890 mm x 2000 mm
Weight	approx. 12,000 kg
Engine	
Model	FPT N45 ENT HW20
Rated power	125 kW (@2200 rpm)
Peak torque	712 Nm (@1500 rpm)
Mast	
Stroke	3600 mm
Crowd force (adjustable)	0-10,000 kg
Extraction force	10,000 kg
Double clamp with unscrewed	MD 305 (diameter = 305 mm)
Water pump	
Pressure	60/25 bar
Water flow rate	200/600 l min <sup>-1</sup>

Figure 4.9 Main technical characteristics of Joy 3P GEO4CIVHIC

### **Advantages for Customers**

Very good performance as it has been observed in Deliverables D5.4 – D5.7 [12, 13] in terms of rate of penetration (1.5m/min in soft to medium limestone in Malta using water flush and up to 0.8m/min in hard rick in Ireland) using compressed air) and fuel consumption. Vibro-rotation drilling technique demonstrates to be a reliable alternative to down-the-hole hammer technique in case of soft, medium hard rock.

### Semi-automatic feeder for drilling rods and co-axial tubes mounting

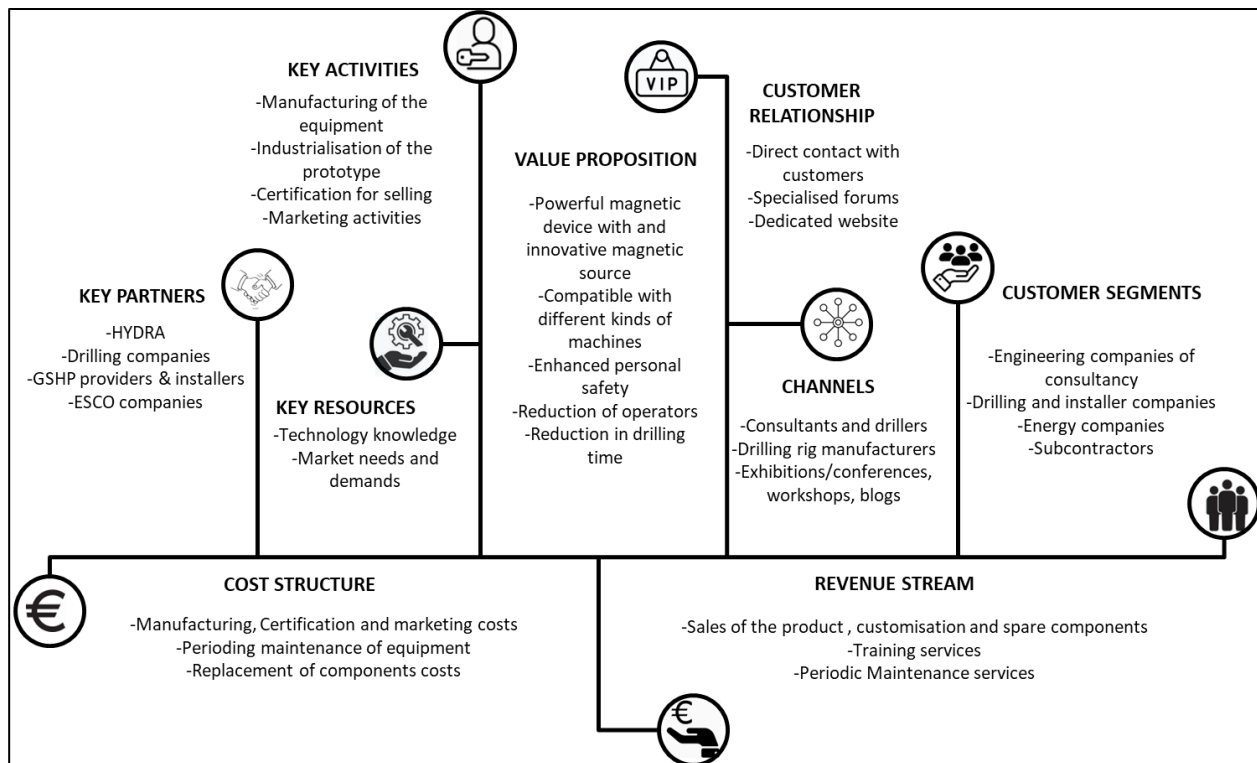


Figure 4.10 Business model Canvas – Semi-automatic feeder for drilling rods and coaxial tubes mounting

#### General information about the product

The project has developed a semi-automatic drilling rod handling system in order to speed up the non-productive times (i.e., mounting/dismounting of casings, shafts and installation of heat exchangers). The feeder machine consists of an excavator equipped with pneumatically controlled permanent magnets able to handle the metallic rods (Figure 4.11).

#### Innovation Content-Benefits and Features

Such a design results in a reduction of the dead times due to rods handling, reduces the number of the operators involved in the drilling operations and allows the operator to work in improved safety conditions compared to other drilling systems on the market. In fact, the development of these improved safety features, the operator can operate both the drilling rig remotely by means of the remote-control system of the drilling rig and the rod handling system from the cabin of the excavator. This allows full management of the drilling operations removing the need of personnel to be located in high risk areas when the drilling operations are ongoing.



A)

Parameter	Value
Mass	7200 kg
Engine power	55.4 kg
Speed	Up to 10 km/h
Sound level	99 db



B)

Parameter	Values
Size	120 x 103 x 140 mm
Weight	11
Material	Neodymium
Lifting capacity	170 kg
Air pressure	5-8 bar

Figure 4.11 Semi-automatic feeder, A) machine and B) Magnetic devices for drilling rods handling

### **Advantages for Customers**

- Safety conditions
- Remote control system
- Reduction of the operation time and operators

### Vibration-rotation drilling components (VD105 and VD80)

This is a macro category composed by two main KERs (4.2.6.a and 4.2.6.b) and the other two products (4.2.6.ab.1 and 4.2.6.ab.2) consider as a spare component for the main KERs.

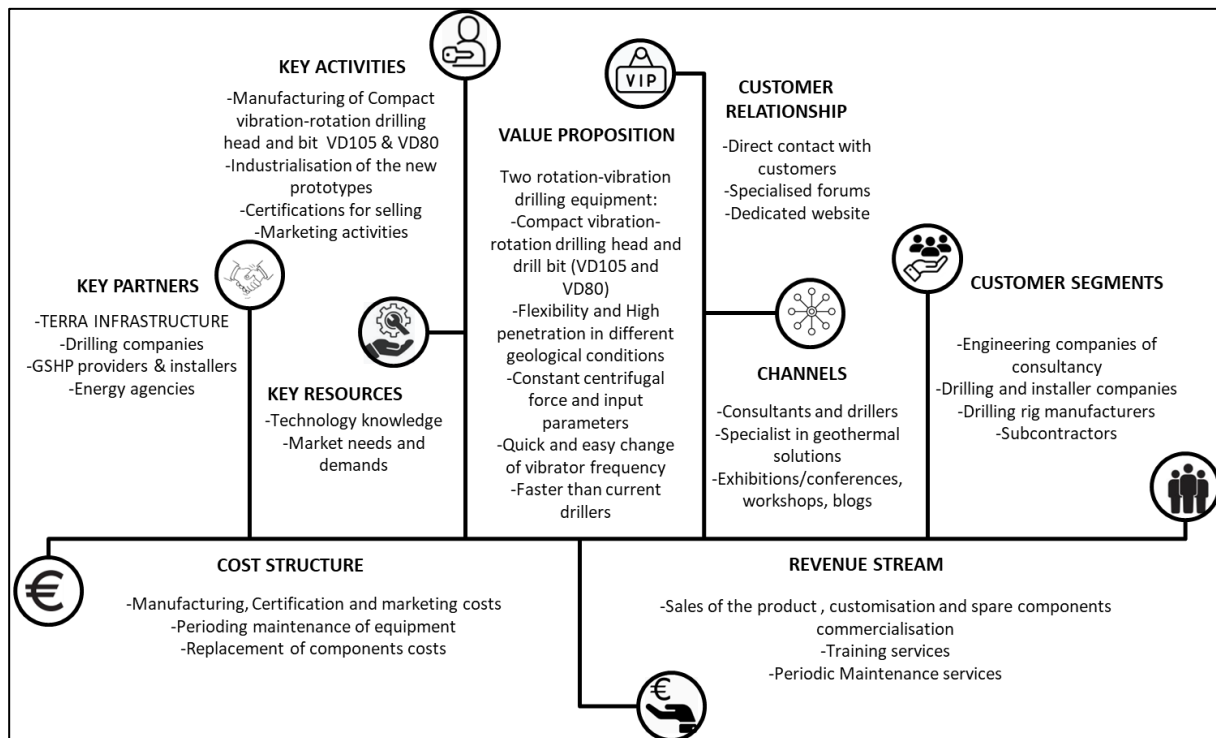


Figure 4.12 Business model Canvas – Compact vibration-rotation drilling head and bits (VD105 and VD80)

### Compact vibrational - rotation drilling head and drill bit VD 105

#### General information about the product

VibroDrill heads generate the vibration energy and passes this energy via the drill string into the drill bit. The drill bit and drill string are piled into the soil. Depending on the situation, the selected frequency enables optimum drilling speed.

In general, vibration-drilling with a drill rig has four main drilling impact characteristics:

1. up- and-down vibrations (amplitude and frequency / Hz)
2. rotation of the drill string (rotational speed / rpm)
3. push down force by drill mast chain motor or cylinder (push down force / kN)
4. retraction force by drill mast chain motor or cylinder (pull up force / kN)

These four features allow a fast and efficient drilling in nearly all geological formations, from clay to sand and gravel up to mid-hard rock.

#### Innovation Content-Benefits and Features

There are only a few restrictions where it cannot be used, mostly in hard rock, with a hardness above 150 MPa. The Main applications are:

- Geothermal drilling up to 150 m depth

- Anchor drilling (micropiles and strand-anchors) up to 50 m depth
- Self-drilling hollow bar anchors up to 60 m length
- Auger drilling (CFA = continuous flight auger drilling) up to 350 mm diameter
- Core drilling (soil sampling drilling) to get undestroyed (not compressed) core samples

The VibroDrill head VD105 is a multi-functional vibration-rotation head; where the unbalance in the vibrator cell can be changed to get a bigger eccentric moment of 0,32 kgm instead of 0,18 kgm. A second motor can be added to the rotary drive, to reach a higher torque of max. 12800 Nm instead of 6200 Nm with one motor. Both modifications can be made at the geothermal drilling site. This is very helpful if the soil conditions change or the drilling performance cannot be achieved as planned. With the smaller eccentric moment of 0,18 kgm a maximum frequency of 105 Hz can be achieved while with the larger eccentric moment a maximum frequency of 80 Hz can be achieved.

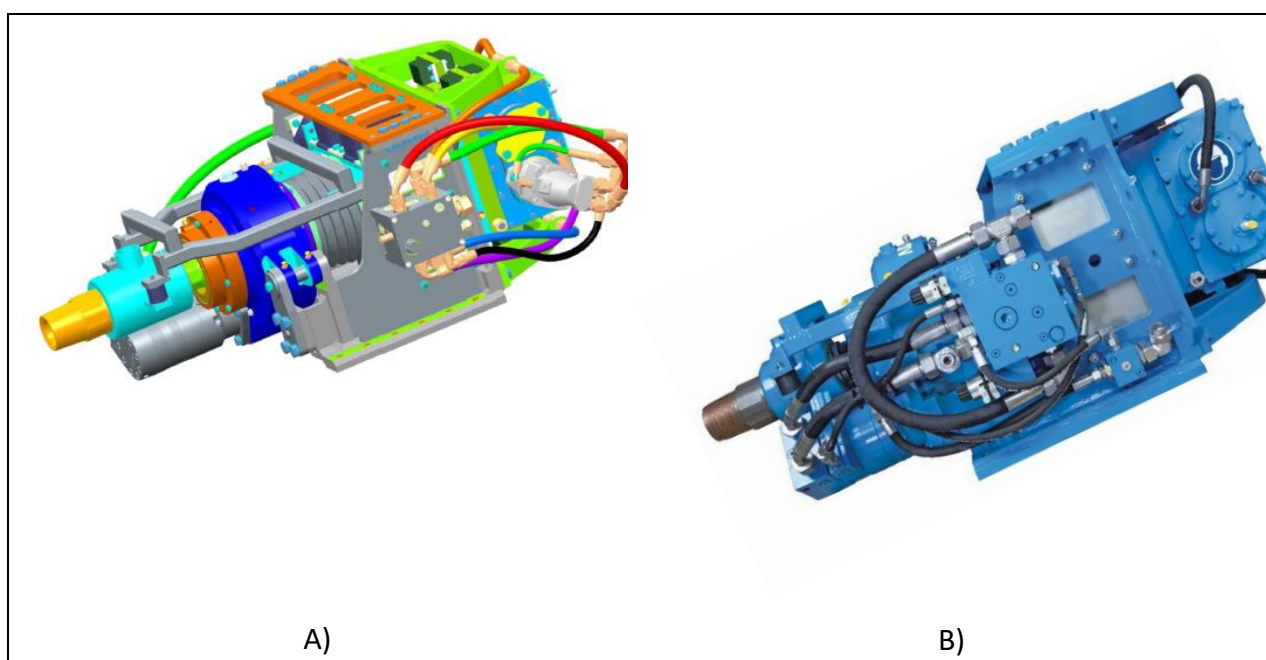


Figure 4.13 Vibro drill, A) sketch and B) manufactured equipment

The following picture shows the main technical parameters of the new developed VibroDrill VD105.

Frequency	105 Hz
Centrifugal force	80 kN
Eccentric moment	0.18 kg m
Weight	830 kg (without flushing head) 890 kg (with flushing head)
Oil flow rate (vibration mode)	90 l min <sup>-1</sup>
Oil pressure (vibration mode)	240 bar
Rotary drive torque	6200 N m (one motor) 12800 N m (two motors)
Rotary drive rotational speed	84 rpm
Oil flow rate (rotation mode)	100 l min <sup>-1</sup>
Oil pressure (rotation mode)	240 bar
Maximum drill string weight	1800 kg (105 Hz) 2800 kg (80 Hz)

Figure 4.14 Main technical parameters of the VibroDrill VD105 head

### Compact vibrational - rotation drilling head and drill bit VD 80

#### General information about the product

Both frequencies are reached at a centrifugal force of 80 kN, whereby the amplitude at 80 Hz is greater than at 105 Hz.

#### Innovation Content-Benefits and Features

The project has built a second VibroDrill, a VD80, which was designed as a stand-by unit, but can be used in clay-rich and sandy soils mainly due to its larger amplitude and the second installed motor to have a higher torque if requested in clay-rich and clay-sandy soils.

The differences between the VD 105 and VD 80 are presented below:

PARAMETER	VD105	VD80
Frequency	107 Hz	79 Hz
Eccentric moment	0,18 kgm	0,33 kgm
Rod weight	1800 Kg	2800 Kg
Drilling depth	60-90 m	60-100 m

Table 4.1 – Differences of VD 80 and VD105

### **Advantages for Customers**

For drilling geothermal bore holes between 50 m and 100 m depth in different soil conditions, in different countries, 3 different types of drill bits are designed and available: a) a full-face drill bit and b) an open ring drill bit and c) a full-face one-time drill bit (full face lost drill bit).

The advantage of the open ring drill bit is that the co-axial heat exchanger remains in the ground through the open ring drill bit. Furthermore, only little soil gets into the drill string when drilling with the open ring drill bit, because most of the drill cuttings are pressed into the soil laterally during vibration drilling or are flushed up. Good drill operators can drill down just as quickly with an open ring drill bit as with a full-face drill bit, because the vibrations in the drill string prevent any material from settling on the inside of the drill string and all material is quickly vibrated out of the drill string.

### **Unique selling point**

The main advantages of vibration drilling are:

- Significant increase of the rate of penetration up to 1 m per minute
- More precise drilling accuracy with only 1-2 % deviation from the vertical possible
- Cost reduction during drilling through better efficiency
- Lower fuel consumption of the drill rig, due to less required hydraulic oil flow
- Less noise compared to top hammer drilling
- Environmentally friendly by reducing drilling fluids and drilling mud removal
- Easy retrieval of drill rods and casings using vibrations
- Long life of VibroDrill heads and drill rigs by avoiding strong vibrations
- Low maintenance cost and easy to maintain
- Can be used in most locations and most soil conditions
- Easy to operate and easy to install on almost all drill rigs

### **Vibratory hammer drill with regard to its excitation cell**

The vibratory hammer is used to drive piles into the ground. Unlike traditional pile drivers which use a large weight to strike piles into the ground, vibratory hammers use vibrations to drive piles much more quickly, as well as to extract old piles out of the ground.

### **Unbalanced shaft with regard to changes in frequency and eccentric moment with constant centrifugal force and constant hydraulic input parameters**

Design of the unbalance shafts with regard to changes in frequency and eccentric moment with constant centrifugal force and constant hydraulic input parameters - The unbalanced shafts are designed so that the frequency and the eccentric moment can be changed in just a few steps. Balance weights are screwed to the shafts to adjust the eccentric moment. The frequency is brought about by a hydraulic motor exchange. The hydraulic input parameters on the motors remain the same. A new setting of the carrier device is not necessary. The balance weight is designed in such a way that the centrifugal force remains constant at a higher engine speed.

This two equipment above developed within this project are intended to be used as a spare component for Vibro Drill VD105 and VD80.

### 4.2.2 Efficient co-axial heat exchangers for pilling with vibration-rotation drilling head (Hydra-Red method)

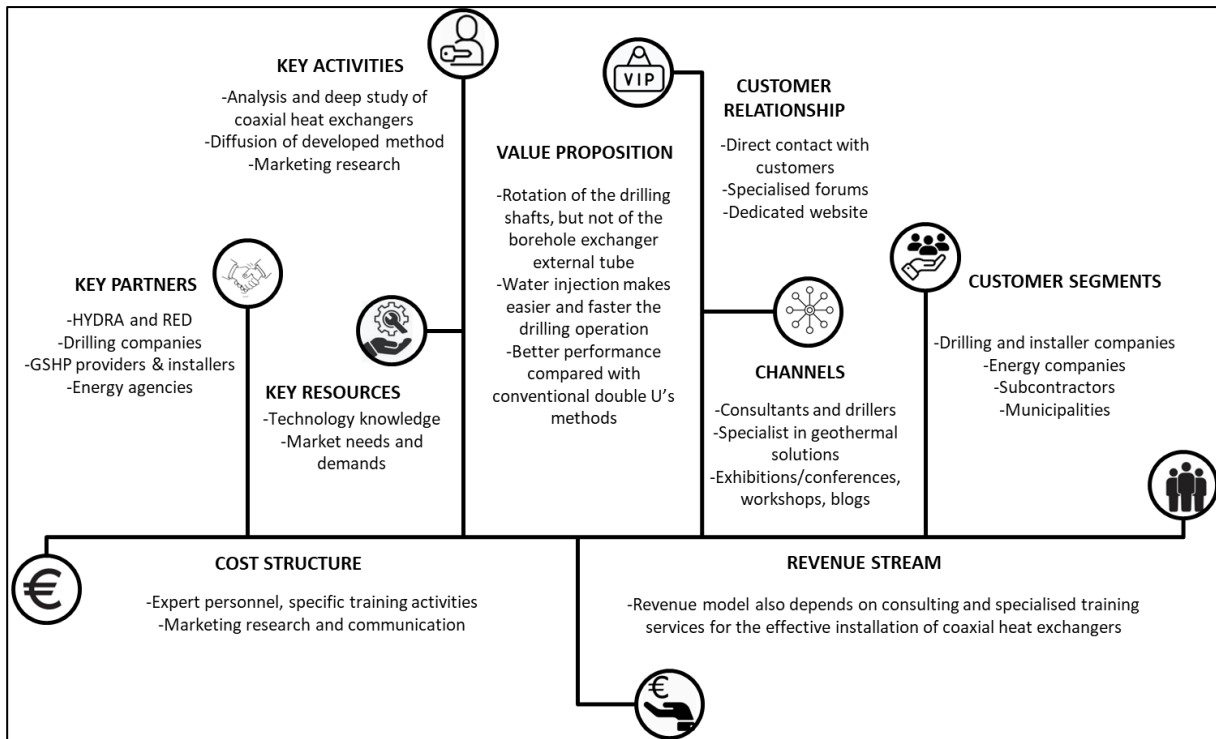


Figure 4.15 Business model Canvas – Hydra-Red innovative methodology

#### General information about the product

The newly developed design of the drill bit includes a few additional components, such as bearings and washers, that decouples the drilling shafts and the external tube of the borehole heat exchanger, in such a way that only the drilling shafts rotate (Figure 4.16A-B).

#### Innovation Content-Benefits and Features

The average rate of penetration was approximately 3 m/min, the time of mounting drilling rods was about 3 minutes. Rotational speed was equal to about 90 rpm, water flow rate was equal to 20 l/min.

The external tube of the coaxial borehole heat exchanger is subjected to lower mechanical stress; therefore, very thick tubes (2 mm against 5 mm thick) can be utilized resulting in a cost reduction of the materials up to 60% (Figure 4.16C).

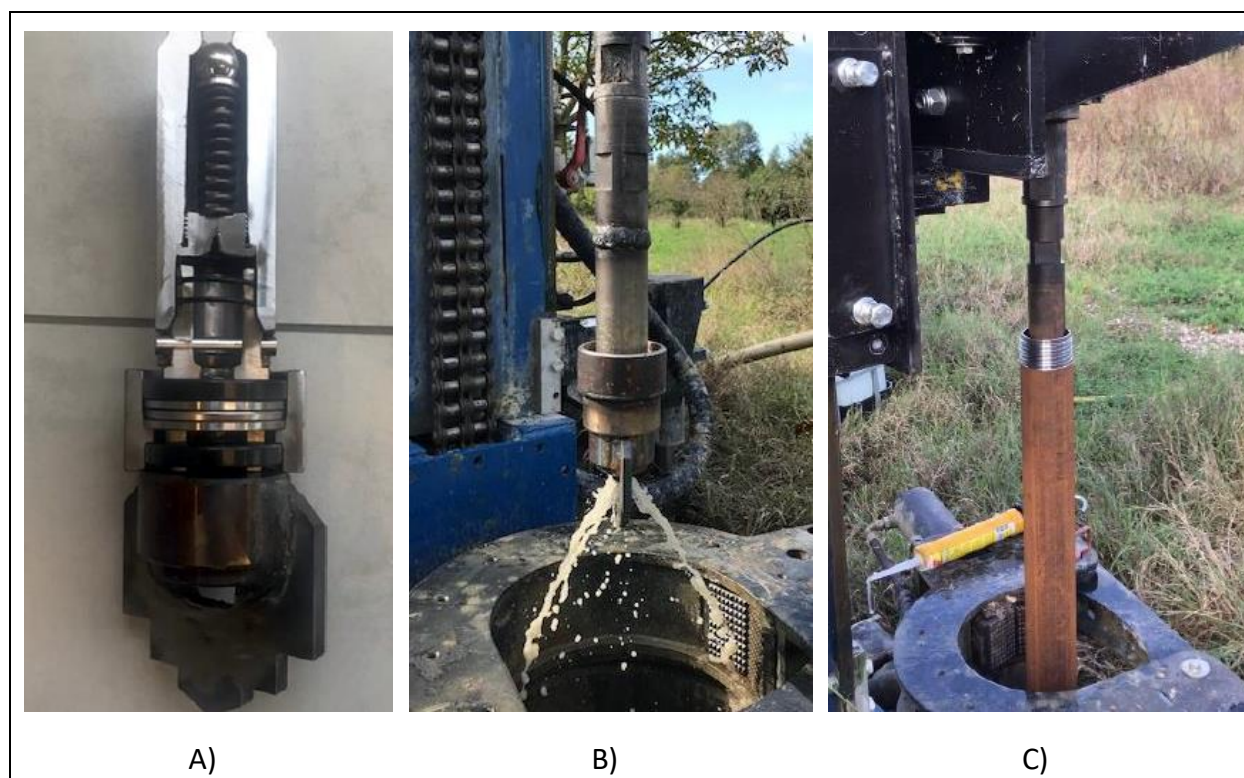


Figure 4.16 Newly drill bit devoted to HYDRA-RED method A) Detail, B) during preliminary drilling test and C) Drilling shaft and external tube of coaxial BHE

### **Advantages for Customers**

The drilling equipment developed here was conceived and designed in order to overcome the following constraints.

- accessibility of the drilling site;
- available space on the drilling site (for drilling rig, storage of drill pipes and equipment);
- local regulations: e.g., noise and fuel emissions, working hours;
- disposal of mud and debris;
- urban pollution.

Preliminary tests of Hydra-Red method in soft unconsolidated underground showed promising outcomes; the newly developed components devoted to such drilling technique seem to be very effective and overall costs of BHE installation may strongly decrease in terms of drilling operation and materials.

### **4.3 Integrated GEO4CIVHIC Solution- Business Model Canvas.**

Different business models as defined in the deliverable D7.3 Business Model to exploit in the market the main stand-alone products developed within the project, are not enough to really assess the GEO4CIVHIC added value. In fact, considering that all the GEO4CIVHIC technologies are designed to be easily integrated, the major added value of the GEO4CIVHIC project is to provide the market with an integrated shallow geothermal system, suitable for heating/cooling of civil and historical buildings.

To enter the market, it will be important not only to focus on the stand-alone product, but also to propose a way, with business modelling activities, to investigate how these results can be integrated into a package with a plug&play approach.

Therefore, in this section the Business Model for the integrated GEO4CIVHIC solution defined will be summarised.

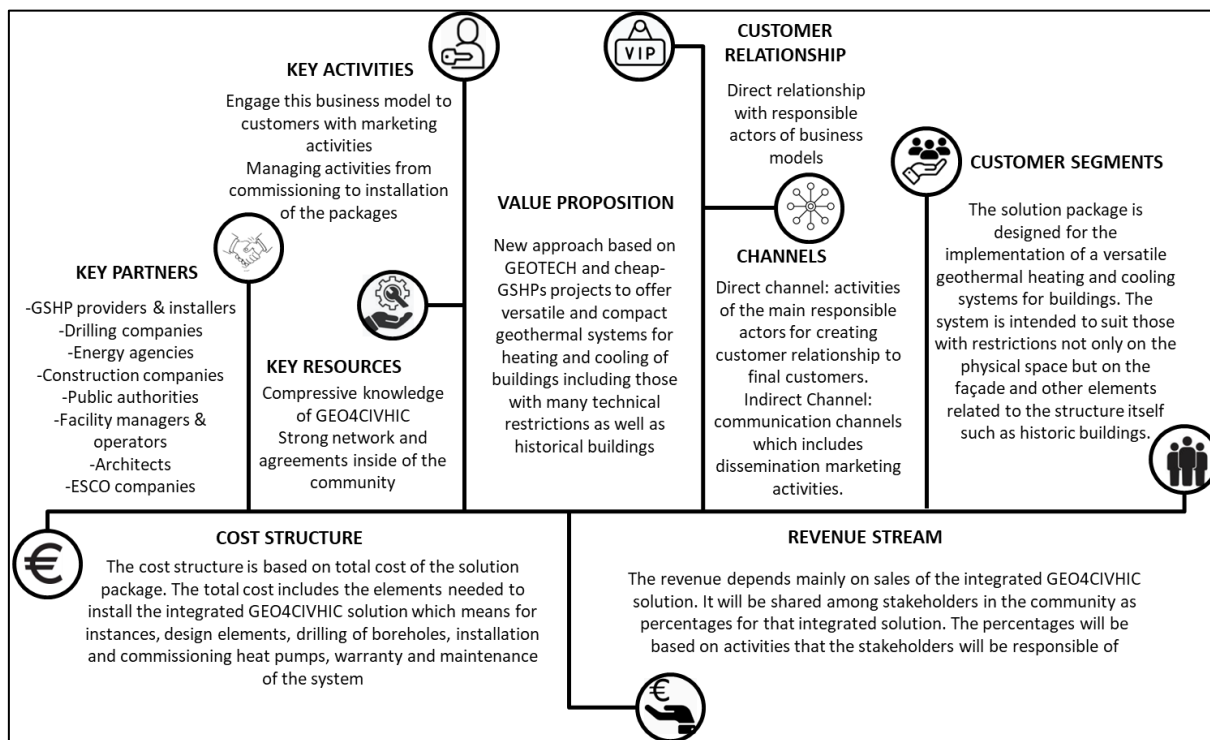


Figure 4.17 Mapping of Integrated GEO4CIVHIC Solution canvas

**Value Proposition**

Value proposition of integrated business model solution is a new approach to offer a versatile and compact geothermal system for heating and cooling of buildings including those with many technical restrictions as well as historical buildings.

The main innovation that the system will engage as a package are:

- Innovative drilling technology that is effective, economic, easy to implement and with reduced environmental impact and resulting in better construction site operating conditions and lower safety risks.
- Well integrated and optimized solutions incorporating state-of-the-art hybrid heat pumps for building including for those with many constrains such as historical environments.

**Customer Segments**

Business model has been built on customer segments which are buildings including those with many constraints due to its historical protection. When the needs of these two customer segments are analysed, it has been seen that the needs of these segments are different in terms of requirements.

## **Customer Relationships**

The types of relationships we entertain with each customer segment is directly related to the main responsible actor of each customer segment. In the business model two main group of actors are determined as main responsible actors. The Group 1 (mainly HYDRA, TERRA, RED) is responsible of the drilling innovative technologies and methodology while the Group 2 (mainly GALLETTI-HIREF, UNIPD) is in charge of the Heat pump innovative units.

The idea behind these main actors which are defined as main responsible ones, is creating efficient channel for the different customer segments. The responsible activities of these two groups of main actors for creating customer relationships are:

- Direct relationship to engage the business model with new customers;
- Direct relationship with engaged customers to manage activities related to the other actors to transform customer requirements and needs to solution packages to deliver final customers;
- Identify the key players in the renewable energy domain (government bodies, associations, commercial property developers, drillers and installers);
- Inform key players of the role that shallow geothermal energy systems can play in meeting renewable targets and informing them of the advantages of the technology developed by the GEO4CIVHIC consortium.

## **Customer Channels**

The main channel is the GEO4CIVHIC consortium through which the business model engages with customers and through which the GEO4CIVHIC companies offer their value propositions. The channels are categorized as direct and indirect channels. Main responsible actors are in charge of managing direct channel for creating customer relationships to deliver value proposition to final customers. The direct channel should act through the identified key players on the market. Indirect channel is communication channel which includes dissemination and marketing activities to engage the value proposition with customers.

## **Key Activities**

The most important key activities performed to implement that integrated business model are marketing activities and managing activities from engaging with customers to installation of the solution package. Marketing activities provide to engage this business model to civil buildings including those historical customer segments. In the business model, for these activities mainly there will be two main groups of responsible actors. Group 1 will be responsible of drilling innovations customer segment while the Group 2 will be responsible for innovative heat pumps customer segment to access to new customers and engage the business model to them. In the perspective of marketing activities, it can be said that they will be representative of the GEO4CIVHIC consortium. This business model offers and integrated system to customer segments that includes managing activities from commissioning to installation of the GEO4CIVHIC solutions (KERs). The consortium will be responsible for plug and play concept with its actors. The activities to build this business model and create value proposition for the market and responsible actors of each activity in the GEO4CIVHIC consortium will be explained with details in the service system map section.

The other activities to promote the value proposition to market are consultancy activities managed by one group which consists of UBEG, RED, GEOSERV, GEOGREEN, SOLINTEL, DIN L-ART MELWA and PIETRE. These consultancy activities will be managed by Group 1 and Group 2 to satisfy customer segment needs and propose market solutions related to these specific needs.

As additional activities to support development of GEO4CIVHIC project package solutions will be managed by universities (UPV, FAU, SUPSI) and research institutes partners (CNR-ITC, TECNALIA, RGS, CRES) of the GEO4CIVHIC consortium.

### **Key Resources**

The solution that includes an integrated plug and play package to apply a shallow geothermal solution depending of the function of the building type, the climate and the geological conditions of the underground, the geothermal system takes into account mainly drilling technology/ methodology and new generation of Heat pumps.

These groundbreaking technologies encompass highly efficient and cost-effective drilling methodologies and machines, specifically tailored for use within built environments. They represent significant advancements and innovations compared to previous projects. This approach simplifies their application in building refurbishments, addressing various constraints, and ultimately reducing drilling costs in diverse geological conditions.

All actors of the GEO4CIVHIC consortium that are responsible for different activities to promote the solution from engaging with new customers to deliver solutions. Strong network and agreements among the actors are a resource for the GEO4CIVHIC consortium to provide value proposition to customers.

### **Key Partners**

As part of the GEO4CIVHIC consortium, all relevant stakeholders are integral members. In addition to the consortium itself, these stakeholders include municipalities, energy associations, consultancy firms, and energy-saving companies (ESCOs) collaborating closely with GEO4CIVHIC.

Furthermore, apart from these primary external partners, there is potential for collaboration with national drilling associations, energy companies, planning authorities, property developers, and mechanical installers. These entities could serve as valuable allies in advancing the objectives and initiatives of GEO4CIVHIC. Their involvement and support can significantly contribute to the project's success and impact within the broader energy and construction sectors.

### **Cost Structure**

In this model, the cost structure is derived from the comprehensive evaluation of the integrated solution. The total cost of this integrated solution encompasses various elements, including expenses associated with the heat pump, drilling technologies and services, installation and commissioning, as well as engagement activities with potential customers. In essence, it accounts for all financial aspects linked to the implementation and operation of the proposed integrated solution, providing a holistic view of the investment required for its successful deployment.

Cost elements that determine total cost of that solution are defined in detail in terms of the activities that all partners should follow to offer the integrated solution for the market. For example, according the main cost elements of the packages can be defined more specifically which consists of:

- Design elements (energy design building and energy design HP system with heat exchangers);
- Drilling and installation of heat exchangers, pipework installation, testing;
- Installation of heat pump system and associated building circuits;
- Commissioning and testing of complete heat pump installation;
- Warranty and maintenance of heat pump installation.

### **Revenue Stream**

The revenue model mainly depends on sales of the integrated package which focuses on every type of built environment, civil and historical. Revenues will be shared among actors in consortium as percentages for the package sales. Percentage will be based on activities that actors will be responsible for.

Revenue elements that determine total revenue of the package should be defined with detail in terms of activities that all partners should follow to offer the integrated solution for the market. For example, main revenue elements of packages can be defined more specifically which consists of:

- Income from design activities;
- Income from drilling and installation;
- Income from heat pump installation;
- Income from maintenance activities (long term income source).

## **4.4 Integrated GEO4CIVHIC Solution in Real Demo-Sites.**

The following subsections include details on the integration of different technologies and methodology in four demo sites that focuses in civil buildings including those with special constrains due to its status of historical condition in addition to differentiated climate conditions, building typology, geological characteristics, etc.

### **4.4.1 Msida Bastion Historic Garden**

The site consists of a lower historical cemetery area with a building located at street level. The building is a 20th century construction with a typical British archetype characteristic of those times. Some technical information of the building and the site are provided in Table 4.2.

Table 4.2 – Msida Bastion Historic Garden demo site description

Name of the building	Msida Bastion Historic Garden
Typology	Small historical building
Useful area m <sup>2</sup>	97,3
Location	Vincenzo Dimech Street, Floriana, Island of Malta.
Year of construction	1935
Climate conditions	Warm (mild winters and hot summers)
Geological data	mostly soft limestone rock

Number of boreholes	8
Depth of boreholes	36 meters
Drilling technology	Innovative technology (JOY 3 GEO4CIVHIC drilling rig + VD80)
Drilling methodology	Novel rotating-vibrating drilling head (HYDRA-RED Method for heat exchangers)
Heat pump	Dual source hybrid Heat Pump (R454B, refrigerant) Power output: 11 Kw, 9 Kw cooling depending on type of source: air or ground source.

The novel drilling methodology and technology performed very well with water as drilling fluid in the soft limestone rock. The speed of penetration achieved high rates up to 1,5 m/min. The average noise of the drilling activities reached up to 77dBA (at 30 m)

#### 4.4.2 Battel family house

The original building has two stories and dates back to the 1960s. The brick walls are not insulated. An expansion at ground floor level was realized in the back of the original building in the years 2008-2009. There is no direct access from the street to the 1000 m<sup>2</sup> large garden, located behind the house. A gas boiler and high temperature radiators compose the heating system. There is no cooling. Some technical information of the building and the site are provided in Table 4.3

Table 4.3 – Battel family house demo site description

Name of the building	Battel family house
Typology	Residential row building
Useful area	170 m <sup>2</sup>
Location	Battelse Bergen 32, 2800 Mechelen
Year of construction	1960
Climate conditions	Mild cold (narrow temperature range between seasons)
Geological data	Alternating unconsolidated layers of clay, sand or mixtures of both (0-13 m sand, > 13 m clay sand /sandy clay / silty sand)
Number of boreholes	4
Depth of boreholes	96 meters
Drilling technology	Innovative technology (JOY 3 GEO4CIVHIC drilling rig + Hydra-RED method)
Drilling methodology	HYDRA-RED coaxial HE configuration (HYDRA-RED drilling methodology.)
Heat pump	High and low temperature Heat Pump (R744, CO <sub>2</sub> refrigerant) Power output: 13,5 Kw, 15 Kw cooling. (COP-3.3 heating mode)

The compact JOY 3 GEO4CIVHIC drilling rig have been transported until the perforation place that has not easy access demonstrating its feasibility to drill in places with many constrains such this one. The average noise of the drilling activities reached up to 54 dBA (at 15 m)

The HYDRA-RED methodology confirmed its potential for a higher energy extraction yield in transitory conditions during the operating cycles of the heat pump.

### 4.4.3 Greystones residential house

The historical residential house from the 1860s comprises a single storey building of 165m<sup>2</sup> in size. The current central heating and domestic hot water system is a 28 kW gas boiler that delivers high temperature hot water to conventional radiators in the building. The historical nature of the building does not allow for major intervention on the fabric and the retrofit measures are focussed on displacing the gas fired boiler and reducing the carbon footprint of the house. An energy demand analysis based on the building fabric and associated heat loss have determined a base load heating demand of 55.34 MWh with a peak demand of 14 kW. Some technical information of the building and the site are provided in Table 4.4.

Table 4.4 – Greystones residential building demo site description

Name of the building	Greystones residential house
Typology	Residential historical building
Useful area	165 m <sup>2</sup>
Location	Church Road in Greystones, Co. Wicklow.
Year of construction	1860
Climate conditions	Cold
Existing HVAC system	Gas boiler Electrical devices
Geological data	3-11,8 meters: Till derived from limestones, > 100 meters: Medium coarse sand with grave Cambrian Aged Greywackes and Quartzite veins.
Number of boreholes	3
Depth of boreholes	97 meters
Drilling technology	Innovative technology (Joy 3 drilling rig + VD-80)
Drilling methodology	HYDRA – TI method (roto-vibro method)
Heat pump	Single source – water to water Heat Pump high temperature (R744 + R513A, refrigerant) Power output: 15 Kw, heating mode.

The JOY 3 GEO4CIVHIC drilling rig successfully demonstrated the potential for implementation of geothermal system in a confined space setting.

Good penetration rates from the drilling method and technology were observed in medium to hard bedrock comprising shales and slates of the Bray Head formation. The average noise of the drilling activities reached up to 99 dBA (at 8 m)

### 4.4.4 Angels' Gate Ferrara

Angels' Gate originally consisted of only the observation tower, to which later was added the lower building, which was formerly used as a military building or base. Its elements are of extreme interest for historical and tourist aspects, even if over time it was subjected to a series of interventions, which adapted the interiors to the very different uses: during the 19th century, the building was used as a slaughterhouse, then a powder magazine, and from 1894 to 1984 as a residential building. Some technical information of the building and the site are provided in Table 4.5

Table 4.5 – Angel's gate building demo site description

Name of the building	Angel's gate building
Typology	Administrative historical building
Useful area	220 m <sup>2</sup>
Location	Northwest Italy, Emilia Romagna region (Via Rampari di Belfiore 1)
Year of construction	1525
Climate conditions	Mild warm
Existing HVAC system	Methane Gas boiler Electrical devices
Geological data	
Number of boreholes	4
Depth of boreholes	96 meters
Drilling technology	"Double-headed" drill rig (determined by the local authorities)
Drilling methodology	HYDRA-RED coaxial HE configuration HYDRA – TI coaxial HE configuration Both installed by traditional drilling methodology
Heat pump	Hybrid dual source high temperature heat pump – geothermal / air-water (R744, CO <sub>2</sub> refrigerant) Power output: 35 Kw, heating mode.

This pilot has demonstrated the feasibility of realizing high temperature heating and cooling systems using geothermal heat pumps achieving good performances also in historic buildings.

## 5 Operating plan

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### 5.1 Key responsibilities of the actors

#### ❖ Central monitoring of the GEO4CIVHIC integrated solutions

The central monitoring is the nerve centre that concentrates the information and specific needs of new customers through the interaction of the consultancy & engineering companies and universities, research centers and associations. This block is composed by the following organisation,

##### — CNR-ISAC

CNR not only has extensive experience in coordinating geothermal-related projects, but also knows the project very well due to his leading role as coordinator of GEO4CIVHIC. CNR's contributions will be focused on environmental and climatic aspects and on Energy efficiency in particular in the field of Cultural/Historical Buildings where from the shallow geothermal energy application there is a total lack in knowledge and non-technical barrier.

##### — UNIPD - DII

UNIPD notably the “Dipartimento di Ingegneria Industriale (DII)” has a high knowledge and expertise in modelling and development heat pump systems, patent development, standards (CEN), regulation knowledge and buildings' energy balance evaluations it has played a key role for GEO4CHIVIC. UNIPD-DII has performed the evaluation of performance in 12 virtual demonstration facilities in a European scenario. The results demonstrated the larger scenario of applicability and efficiency of the innovative solutions developed in GEO4CIVHIC.

##### — RED

RED is leading one of the main work packages of the project which is WP5 on Demonstration of efficiency of installation of shallow geothermal and H&C in individual retrofitted installations”. On top of that, RED is responsible for the energy monitoring system and the evaluation of the results.

#### ❖ Technical GEO4CIVHIC solutions providers

##### — HYDRA SRL (HYDRA)

HYDRA is in charge to produce the compact drilling rig and the semi-automatic feeder, since the business model is a plug and play system, in the model the company will provide the drilling equipment with the specifications required by the customers. The company will be responsible to promote drilling operation services for the integrated solution package as well.

##### — TERRA INFRASTRUCTURE (FORMER THYSSENKRUPP INFRASTRUCTURE)

TERRA INFRASTRUCURE is responsible of manufacturing the efficient vibro drill head VD80, VD105 and spare drilling components in order to be integrated into the Compact drilling rig. The company will provide their drilling equipment. As in the previous company, TERRA will be responsible to promote drilling operation services for the integrated solution package.

### — GALLETTI / HIREF (GALLETTI)

GALLETTI is responsible of manufacturing and deployment of new generation of reliable and efficient dual source heat pump combining two different thermal sources; air and ground (geothermal). In the business model, GALLETTI is in charge of satisfying needs and the requirements for the solution package in terms of dual source heat pump. In addition to supplying dual source heat pump, the company will be responsible for installation of pump and maintenance services.

### ❖ **Consultancy & Engineering Companies**

UBEG, RED, GEOSERV, GEOGREEN, SOLINTEL, DIN L-ART MELWA and PIETRE will be responsible support GEO4CIVHIC consortium to promote the value proposition of the integrated solution with consultancy & engineering activities. On top of that, these companies have double role inside of the consortium to support the value proposition as engineering and consultancy services. As engineering side, these companies can give proposals for satisfying specific requirements of customer segments. In these activities these companies (UBEG, GEOSERV, GEOGREEN, SOLINTEL, DIN L-ART MELWA and PIETRE) will act as product/technical advisors as well. This type of companies will interact closely with the central monitoring and technology providers to satisfy specific customer requirements. Technical opinions, suggestions and market solutions of this group of companies will be very valuable for the customers. In addition, as they are part of GEO4CIVHIC consortium, they have a deep knowledge of the innovations and thus can recommend or directly design installations of buildings and propose efficient market solutions for customer needs. Since these integrated solutions of GEO4CIVHIC will be planned plug and play packages in a customized way, the role of consultancy & engineering companies will be important.

### ❖ **Universities, Research Centers and Associations**

The role of universities (UPV, FAU, SUPSI) and research institutes (CNR-ITC, TECNALIA, RGS, CRES) of GEO4CIVHIC consortium is to manage research and development activities for GEO4CIVHIC project. In addition to research and development activities, universities will have a role dedicated to dissemination and communication purposes. The model developed both for the heat pump and the integrated solution will be used in the production of several scientific publications and they will also be presented in technical and scientific conferences at national and international level.

The following figure shows the system map of the key responsibilities of the all actors in order to take the solutions to the final customers.

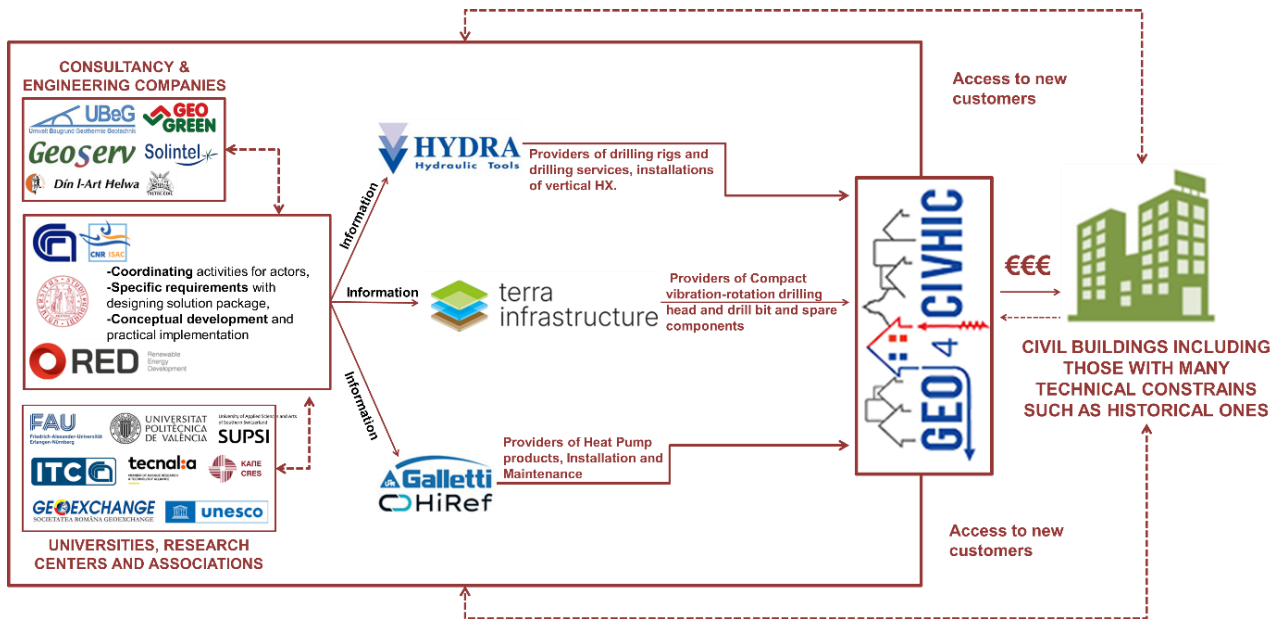


Figure 5.1 System Map - Key Responsibilities of GEO4CIVHIC Integrated Solution

As shown in the Figure 5.1, all activities to promote value proposition map for customer segment will be developed by the GEO4CIVHIC consortium. The relationship between the GEO4CIVHIC consortium and customer segment starts with engagement of the solution with customers.

## 6 Financial Projections

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The financial assessment has been performed based on the Analysis of the Technology Readiness Level (TRL) in conjunction with the Future Discounted Cash Flows (FDCF) analysis because is essential for businesses and organizations engaged in developing new technologies. The integration of TRL assessment and financial forecasting offers several key advantages:

- **Risk Mitigation:** Linking TRL analysis with FDCF statements helps identify potential risks and uncertainties associated with technology development. Early-stage technologies (low TRLs) might have higher risks, leading to delays, unforeseen costs, or even project failure. By understanding the technology's current readiness level and its impact on the financials, organizations can take appropriate risk mitigation measures and set realistic expectations.
- **Resource Allocation:** Effective resource allocation is critical for technology development projects. As the TRL advances, the resource requirements change. By analysing TRL alongside projected P&L statements, businesses can allocate resources according to the technology's maturity and the financial needs of each development stage. This ensures that investments are aligned with the technology's readiness and the expected returns at different TRL levels.
- **Decision-making and Investment Prioritization:** Combining TRL and financial analysis aids decision-makers in prioritizing investment opportunities. Projects with higher TRL levels are generally closer to market readiness and are perceived as lower risk. Organizations can use this information to focus resources on projects with higher TRLs and a more favourable FDCF analysis, increasing the likelihood of success and profitability.
- **Market Entry and Commercialization Strategy:** TRL assessment provides insights into the technology's readiness for commercialization. By aligning TRL analysis with projected P&L statements, companies can strategize the market entry plan and timing. A well-coordinated approach ensures that the financial projections consider market conditions, potential competitors, and the technology's readiness to capture market share effectively.
- **Investor and Stakeholder Communication:** Analysing TRL and projected P&L together allows for more transparent communication with investors and stakeholders. It enables companies to articulate the current status of the technology, its potential financial performance, and the planned path to market. Such clear communication builds confidence in the technology's development and the company's ability to manage financial expectations.
- **Valuation and M&A Opportunities:** For technology-based companies seeking investments or potential mergers and acquisitions (M&A), TRL analysis integrated with financial projections can influence the valuation process. Higher TRL levels often lead to higher valuations, as the technology is perceived to be less risky and closer to commercial success. Proper alignment of TRL and financial forecasts supports negotiations and decision-making in such transactions.
- **Budgeting and Financial Planning:** TRL analysis can guide budgeting and financial planning efforts. As the technology progresses through various TRL levels, the financial

requirements evolve. Integrating TRL milestones into financial planning helps organizations allocate budgets appropriately and forecast cash flow needs based on the technology's expected development trajectory.

In conclusion, analysing the Technology Readiness Level (TRL) alongside FDCF statements provides valuable insights for decision-making, risk mitigation, resource allocation, market entry strategies, and investor communication. It ensures that financial projections are realistic, aligned with technology maturity, and support the overall success and profitability of technology development projects.

## 6.1 TRLs increase roadmap

As it was stated above, the TRL plays a significant role in financial projections, especially for companies or organizations involved in the development and commercialization of new technologies. Here's how TRL importance ties into financial projections:

- **Cost Estimation:** As technologies progress through various TRL stages, their development costs change accordingly. In the early stages (TRL 1-4), costs are generally lower as the focus is on research and basic proof of concept. However, as the technology advances to higher TRL levels (TRL 5-9), costs tend to increase due to prototyping, testing, scaling, and integration efforts. Financial projections need to account for these varying costs based on the TRL milestones.
- **Investment Decisions:** Investors and stakeholders are more likely to invest in projects with higher TRL levels. Advancing through the TRL scale demonstrates that the technology has achieved significant progress, reducing the perceived risk associated with early-stage ventures. Financial projections that align with TRL advancements can be more compelling to potential investors, increasing the chances of securing funding for further development.
- **Revenue Projections:** Financial projections should align with the expected timeline for technology deployment and commercialization. TRL assessments help in estimating when the technology is likely to be market-ready. As the TRL advances, financial projections can incorporate potential revenue streams, market penetration estimates, and sales forecasts based on the technology's expected readiness level.
- **Risk Assessment:** TRL levels indicate the maturity and level of testing a technology has undergone. Financial projections must take into account the inherent risks associated with the current TRL. Early-stage technologies (low TRLs) might carry higher uncertainties and risks, which could impact the projections. Conversely, technologies at higher TRLs tend to have reduced risks, making financial forecasting more reliable.
- **Resource Allocation:** Financial projections need to account for the allocation of resources throughout the development process. Advancing through TRL levels often requires increased investment in research, development, talent acquisition, and infrastructure. By aligning financial projections with TRL milestones, organizations can strategically allocate resources based on the technology's current maturity and projected growth.
- **Time-to-Market Estimates:** Technology Readiness Level assessments provide valuable insights into a technology's expected time-to-market. Financial projections can use this information to estimate when the technology is likely to generate returns or break even. Aligning financial timelines with TRL milestones helps in setting realistic expectations for investors, stakeholders, and the management team.

- **Valuation and Exit Strategies:** TRL progression can influence the valuation of a technology-based company. Higher TRL levels generally command a higher valuation as they reduce technology and market risks. Financial projections can be instrumental in determining the company's worth based on the technology's current readiness and its projected TRL trajectory. Additionally, TRL assessments can guide exit strategies, such as seeking acquisitions or partnerships at specific TRL stages.

In conclusion, Technology Readiness Level (TRL) is a crucial factor in financial projections for technology-based projects. Properly aligning financial estimates with TRL advancements helps in realistic resource allocation, risk assessment, and investment decisions. It also enables companies to set appropriate timelines for market entry and supports valuation and exit strategies, contributing to the overall success of the project.

The following sections present the TRL's increase and the time and resources allocation to take the technologies (KERS) to the market.

### KER 1 — Plug & Play heat pump with variable of fixed speed drivers

This section provides a Technology Readiness level scaling roadmap for KER 1 - Plug & Play heat pump with variable of fixed speed drivers which belongs to GALLETTI. As the objective of the GEO4CIVHIC project was to scale the solutions to TRL 7, it is important to understand what the remaining steps and milestones beyond the project in order are to scale through remaining TRLs and offer a marketable solution. Moreover, this makes it possible to allocate estimated costs to key activities and thus understand the capital expenditures that will have to take place before market launch.

As seen in the following Figure 6.1, the expenses for different actions are listed individually in respective coloured blocks and cumulative expenditures are represented in the orange line. Moreover, time is accounted for in months and observable for each activity and overall TRL milestones. According to projections, the Semi-automatic feeder for drilling rods and co-axial tubes mounting can reach TRL 9 after 108 months and market launch after an estimated **350.000 € (this value corresponds to the capital expenditure, CAPEX that will be used in the next Section 6.2 for performing the Future Discounted Cash Flows (FDCF) analysis for this related technology).**

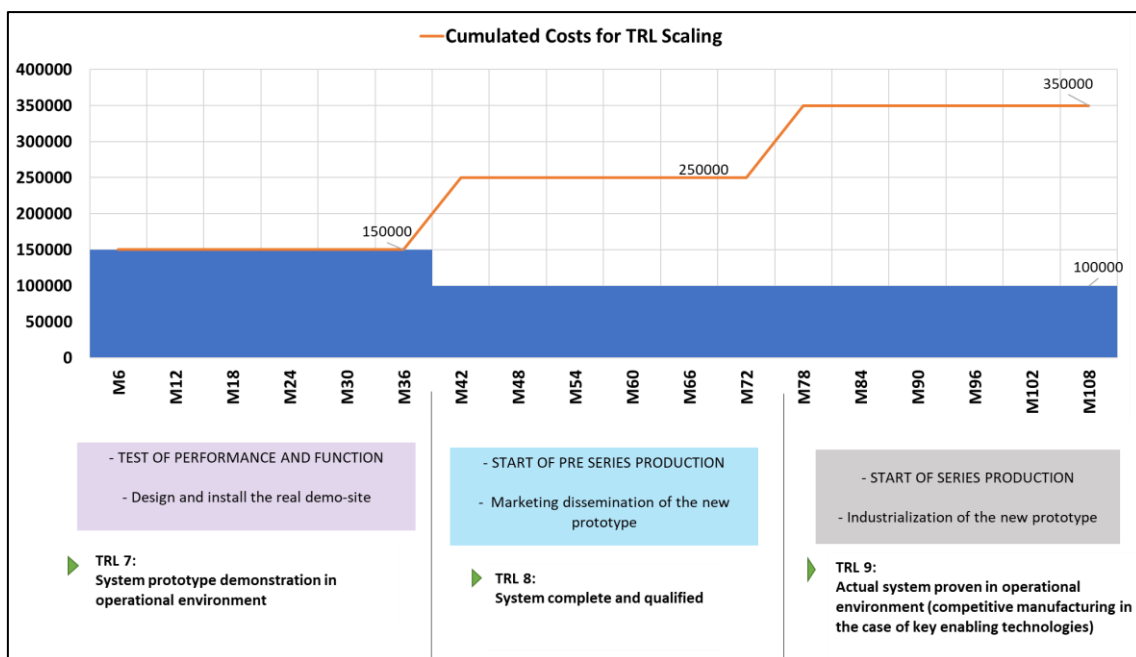


Figure 6.1 TRL increasing for the KER 1 Plug & Play heat pump with variable of fixed speed drivers

## KER 2 — Heat Pump for high temperature application and dual source application parameters

This section provides a Technology Readiness level scaling roadmap for KER 2 - Heat Pump for high temperature application and dual source application parameters which belongs to GALLETTI. As the objective of the GEO4CIVHIC project was to scale the solutions to TRL 7, it is important to understand what the remaining steps and milestones beyond the project in order are to scale through remaining TRLs and offer a marketable solution. Moreover, this makes it possible to allocate estimated costs to key activities and thus understand the capital expenditures that will have to take place before market launch.

As seen in the following Figure 6.2, the expenses for different actions are listed individually in respective coloured blocks and cumulative expenditures are represented in the orange line. Moreover, time is accounted for in months and observable for each activity and overall TRL milestones. According to projections, the Semi-automatic feeder for drilling rods and co-axial tubes mounting can reach TRL 9 after 108 months and market launch after an estimated **200.000 € (this value corresponds to the capital expenditure, CAPEX that will be used in the next Section 6.2 for performing the Future Discounted Cash Flows (FDCF) analysis for this related technology).**

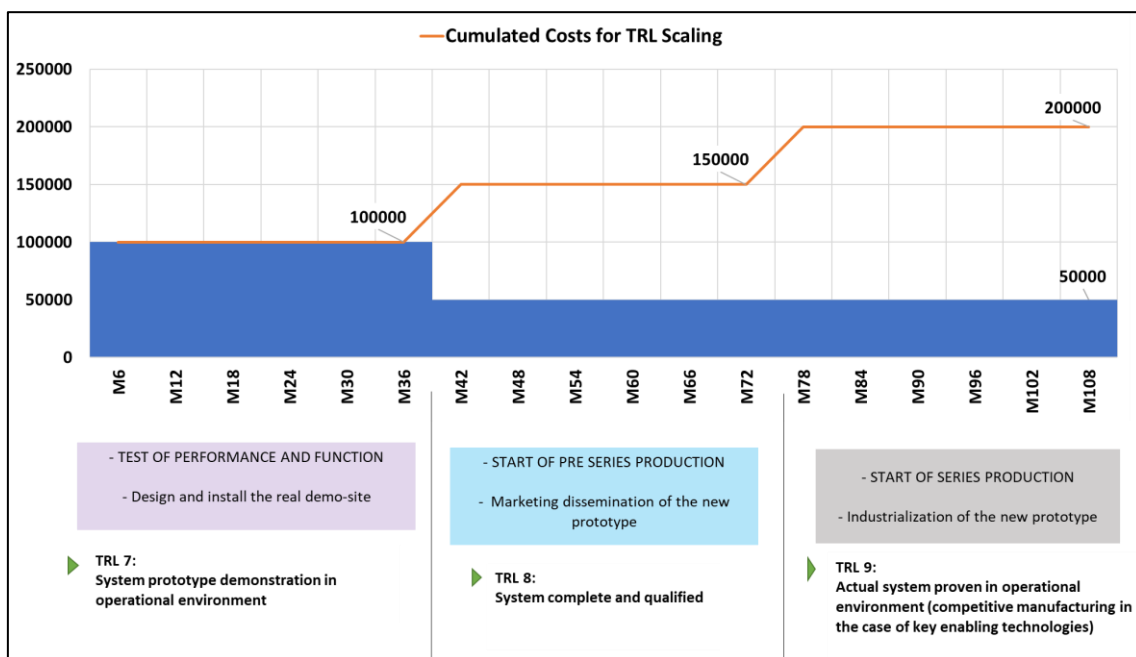


Figure 6.2 TRL increasing for the KER 2 Heat Pump for high temperature application and dual source application parameters

### KER 3 — High temperature heat pumps for renovated civil and historical buildings

This section provides a Technology Readiness level scaling roadmap for KER 3- High temperature heat pumps for renovated civil and historical buildings which belongs to GALLETTI. As the objective of the GEO4CIVHIC project was to scale the solutions to TRL 7, it is important to understand what the remaining steps and milestones beyond the project in order are to scale through remaining TRLs and offer a marketable solution. Moreover, this makes it possible to allocate estimated costs to key activities and thus understand the capital expenditures that will have to take place before market launch.

As seen in the following Figure 6.3, the expenses for different actions are listed individually in respective coloured blocks and cumulative expenditures are represented in the orange line. Moreover, time is accounted for in months and observable for each activity and overall TRL milestones. According to projections, the Semi-automatic feeder for drilling rods and co-axial tubes mounting can reach TRL 9 after 108 months and market launch after an estimated **200.000 € (this value corresponds to the capital expenditure, CAPEX that will be used in the next Section 6.2 for performing the Future Discounted Cash Flows (FDCF) analysis for this related technology).**

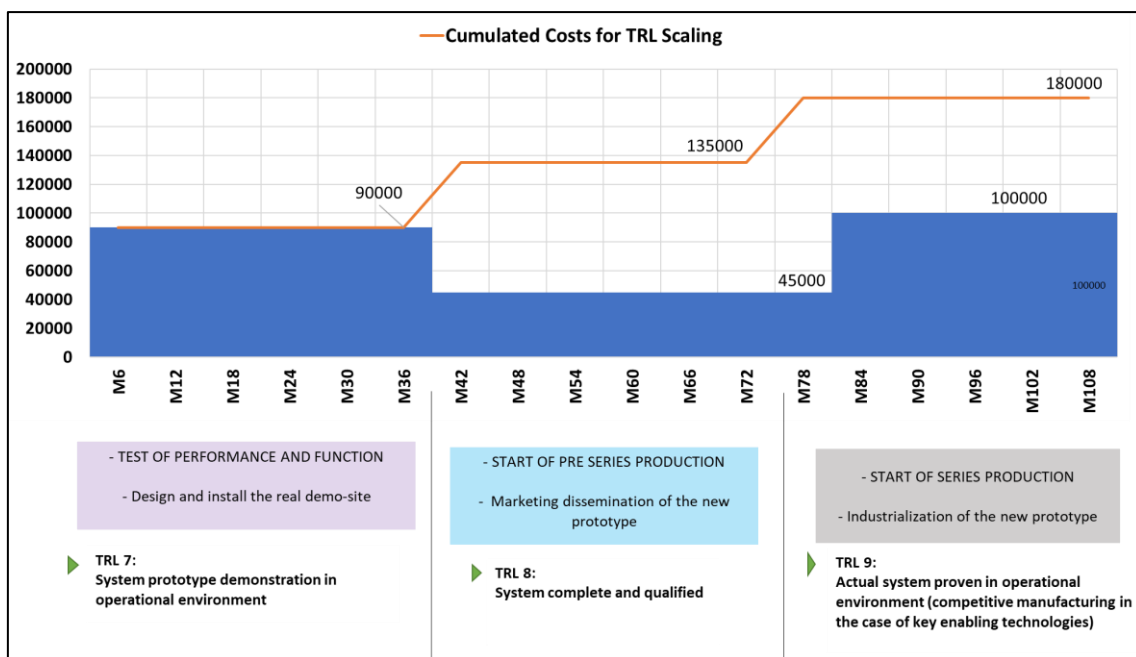


Figure 6.3 TRL increasing for the KER 3 High temperature heat pumps for renovated civil and historical buildings

### KER 5 — Semi-automatic feeder for drilling rods and co-axial tubes mounting

This section provides a Technology Readiness level scaling roadmap for KER 5 - Semi-automatic feeder for drilling rods and co-axial tubes mounting which belongs to HYDRA company. As the objective of the GEO4CIVHIC project was to scale the solutions to TRL 7, it is important to understand what the remaining steps and milestones beyond the project in order are to scale through remaining TRLs and offer a marketable solution. Moreover, this makes it possible to allocate estimated costs to key activities and thus understand the capital expenditures that will have to take place before market launch.

As seen in the following Figure 6.4, the expenses for different actions are listed individually in respective coloured blocks and cumulative expenditures are represented in the orange line. Moreover, time is accounted for in months and observable for each activity and overall TRL milestones. According to projections, the Semi-automatic feeder for drilling rods and co-axial tubes mounting can reach TRL 9 after 24 months and market launch after an estimated **230.000 € (this value corresponds to the capital expenditure, CAPEX that will be used for performing the Future Discounted Cash Flows (FDCF) analysis for this related technology).**

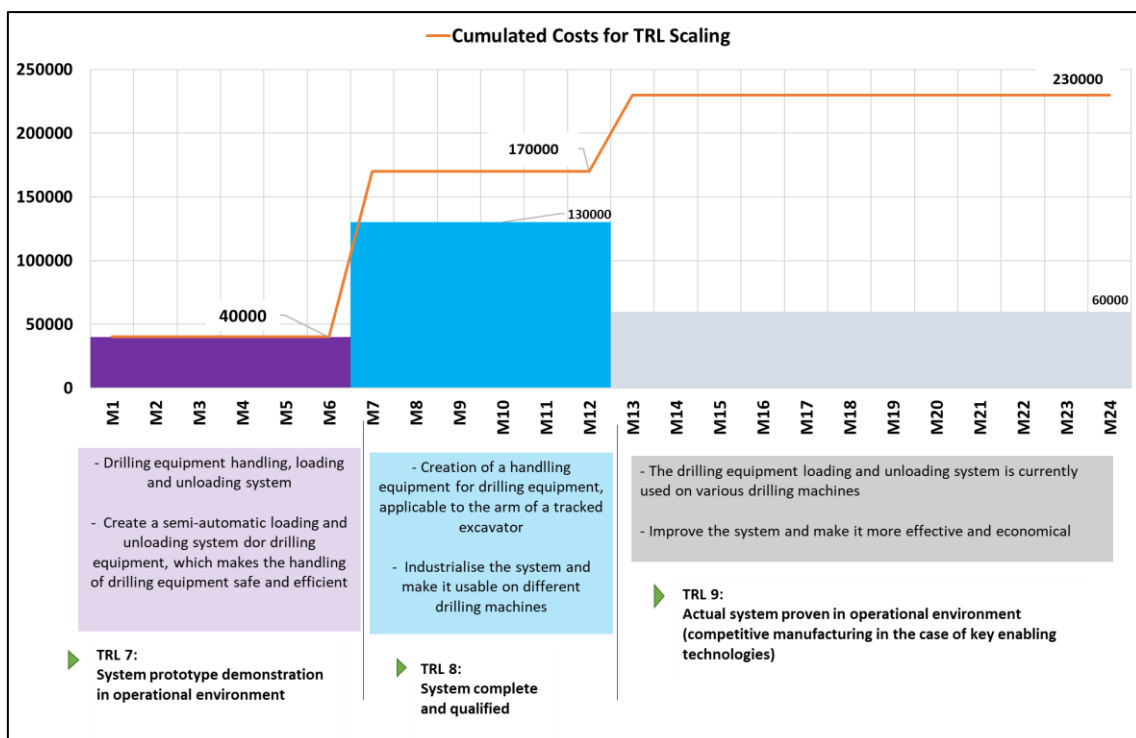


Figure 6.4 TRL increasing for the KER 5 semi-automatic feeder for drilling rods and coaxial tubes mounting

**KER 6 — Compact Vibration-rotation drilling head and drill bit (VibroDrill VD105 & VibroDrill VD80)**

This section provides a Technology Readiness level scaling roadmap for KER 6a and KER 6b - Compact Vibration-rotation drilling head and drill bit (VibroDrill VD80 & VibroDrill VD105) which belongs to TERRA INFRASTRUCUTRE. As the objective of the GEO4CIVHIC project was to scale the solutions to TRL 7, it is important to understand what the remaining steps and milestones beyond the project in order are to scale through remaining TRLs and offer a marketable solution. Moreover, this makes it possible to allocate estimated costs to key activities and thus understand the capital expenditures that will have to take place before market launch.

As seen in the following Figure 6.5, the expenses for different actions are listed individually in respective coloured blocks and cumulative expenditures are represented in the orange line. Moreover, time is accounted for in months and observable for each activity and overall TRL milestones. According to projections, the Semi-automatic feeder for drilling rods and co-axial tubes mounting can reach TRL 9 after 19 months and market launch after an estimated **315.000 € (this value corresponds to the capital expenditure, CAPEX that will be used for performing the Future Discounted Cash Flows (FDCF) analysis for this related technology).**

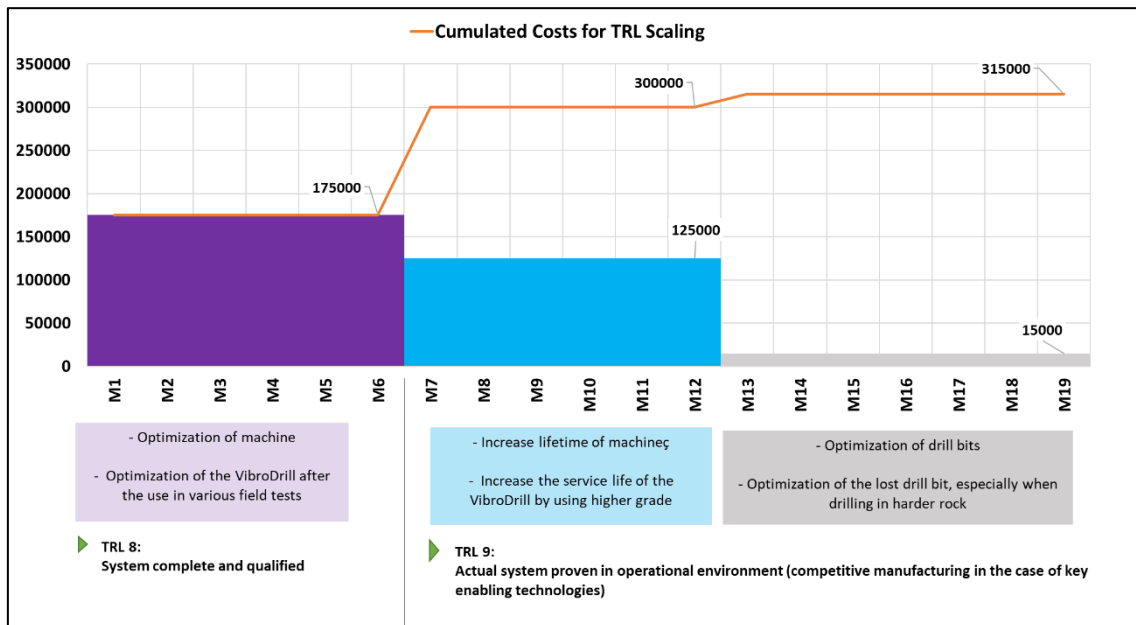


Figure 6.5 TRL increasing for the KER 6 Compact Vibration-rotation drilling head and drill bit (VibroDrill VD105 & VibroDrill VD80)

### Vibratory hammer drill with regard to its excitation cell (Spare drilling component)

This section provides a Technology Readiness level scaling roadmap for the spare drilling component - Vibratory hammer drill with regard to its excitation cell which belongs to TERRA INFRASTRUCUTRE. As the objective of the GEO4CIVHIC project was to scale the solutions to TRL 7, it is important to understand what the remaining steps and milestones beyond the project in order are to scale through remaining TRLs and offer a marketable solution. Moreover, this makes it possible to allocate estimated costs to key activities and thus understand the capital expenditures that will have to take place before market launch.

As seen in the following Figure 6.6, the expenses for different actions are listed individually in respective coloured blocks and cumulative expenditures are represented in the orange line. Moreover, time is accounted for in months and observable for each activity and overall TRL milestones. According to projections, the Semi-automatic feeder for drilling rods and co-axial tubes mounting can reach TRL 9 after 12 months and market launch after an estimated **110.000 € (this value corresponds to the capital expenditure, CAPEX).**

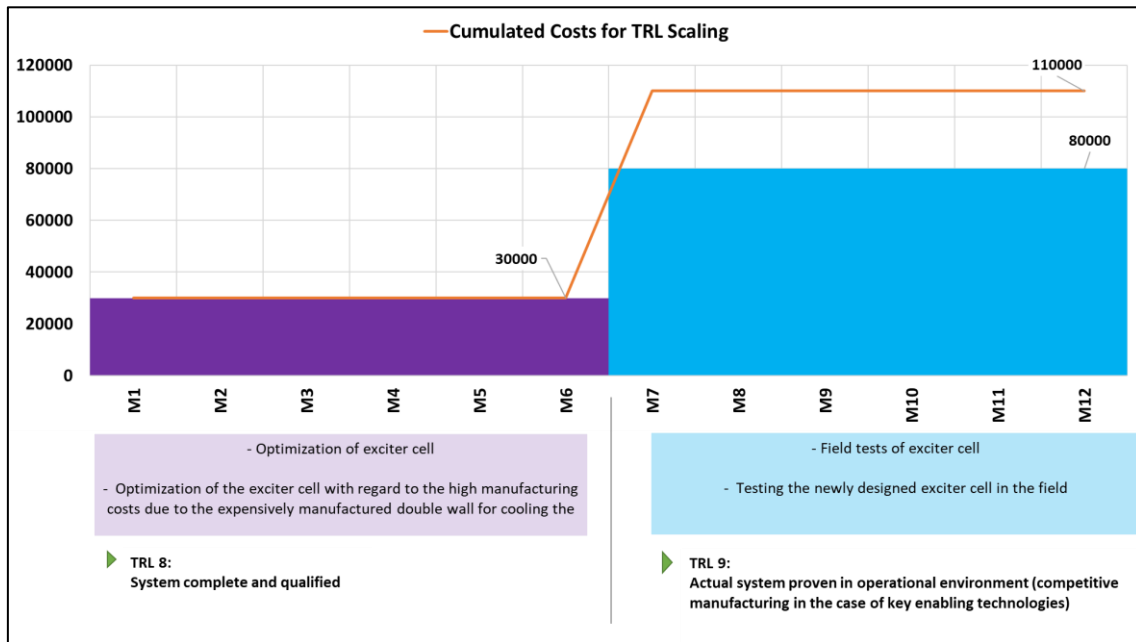


Figure 6.6 TRL increasing for the spare drilling component Vibratory hammer drill with regard to its excitation cell

**Unbalance shafts with regard to changes in frequency and eccentric moment with constant centrifugal force and constant hydraulic input parameters (Spare drilling component)**

This section provides a Technology Readiness level scaling roadmap for the spare drilling component - Unbalance shafts with regard to changes in frequency and eccentric moment with constant centrifugal force and constant hydraulic input parameters which belongs to TERRA INFRASTRUCUTRE (Former TKI) company. As the objective of the GEO4CIVHIC project was to scale the solutions to TRL 7, it is important to understand what the remaining steps and milestones beyond the project in order are to scale through remaining TRLs and offer a marketable solution. Moreover, this makes it possible to allocate estimated costs to key activities and thus understand the capital expenditures that will have to take place before market launch.

As seen in the following Figure 6.7, the expenses for different actions are listed individually in respective coloured blocks and cumulative expenditures are represented in the orange line. Moreover, time is accounted for in months and observable for each activity and overall TRL milestones. According to projections, the Semi-automatic feeder for drilling rods and co-axial tubes mounting can reach TRL 9 after 12 months and market launch after an estimated **15.000 € (this value corresponds to the capital expenditure, CAPEX).**

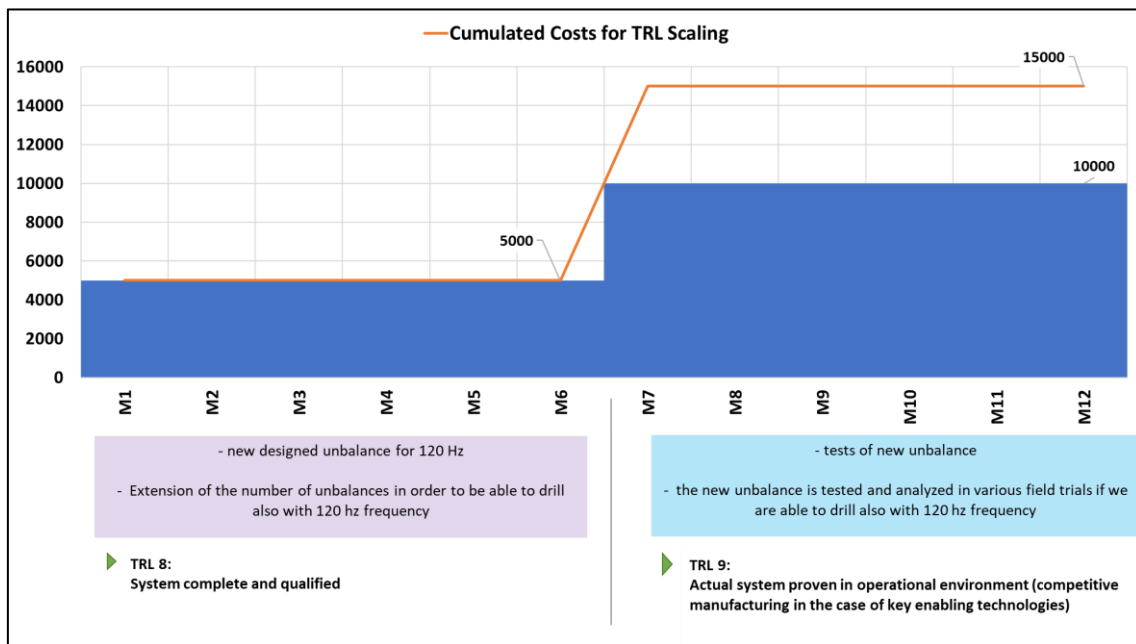


Figure 6.7 TRL increasing for the spare drilling component Unbalance shafts with regard to changes in frequency and eccentric moment with constant centrifugal force and constant hydraulic input parameters

## 6.2 Future Discounted Cash Flows (FDCF) analysis

The FDCF analysis, also known as an income statement or statement of earnings, is a financial statement that provides a summary of a company's revenues, expenses, and profits or losses over a specific period of time, typically a fiscal year or a quarter. The main components of a projected FDCF analysis are as follows:

- **Revenue (Sales):** This section shows the total income generated from the sale of goods or services. It includes both operating and non-operating revenues, such as sales revenue, subscription fees, licensing fees, etc.
- **Cost of Goods Sold (COGS):** COGS represents the direct costs associated with producing or delivering the goods or services sold. It includes expenses like raw materials, manufacturing costs, direct labour, and other production-related expenses.
- **Gross Profit:** Gross profit is calculated by subtracting the COGS from the total revenue. It represents the profit generated before accounting for other operating expenses.
- **Operating Expenses:** This section includes various expenses incurred during regular business operations. It encompasses selling, general, and administrative expenses (SG&A), research and development costs, marketing expenses, salaries, and other overhead costs.
- **Operating Income (Operating Profit):** Operating income is the difference between the gross profit and total operating expenses. It indicates the profitability of a company's core business operations.
- **Other Income and Expenses:** This category includes non-operating income and expenses, such as interest income, interest expenses, gains or losses from investments, and other miscellaneous items not directly related to regular business operations.
- **Profit Before Tax:** Profit before tax is the total income after accounting for both operating and non-operating income and expenses but before accounting for income taxes.
- **Income Tax:** This represents the amount of income tax expense the company is expected to pay based on its taxable income.
- **Net Profit (Net Income):** Net profit is the final result after deducting income tax from the profit before tax. It represents the actual profit or loss earned by the company during the specified period.

The FDCF is a valuable tool for businesses to assess their financial performance, make informed decisions, and communicate their financial health to stakeholders. It helps identify areas of strength or weakness, assists in budgeting and financial planning, and supports strategic decision-making to improve profitability and overall financial well-being.

This section aims to introduce income statements and net present values spanning an 11-year period (consisting of an extra year post-project development/implementation and a subsequent 10 years of operation) based on the respective assumptions for each scenario. As the financial analysis of the Key Exploitable Results (KERs) (KER1-KER6) involves sensitive information, the comprehensive outcomes will be detailed in the confidential Deliverable D7.6 (Section IP Valuation). However, for informative purposes, we will outline the financial indicators that are set to be showcased in the confidential Deliverable D7.6 segment.

Table 6.1 – Foreseen sales of the KER in units over the next 10 years

	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11
<b>Projected unit sales</b>										

Table 6.2 – Estimated price could be applied for the commercialization of the KER

<b>Assumptions</b>	
<b>Estimated Price of service/Product</b>	
<b>Estimated Cost of unit sold (materiels, labor, production costs)</b>	
<b>Inflation</b>	2,50%
<b>Cost of capital</b>	10%
<b>Real discount rate</b>	7,32%
<b>Tax rate</b>	30%
<b>Cost of required depreciable machinery/plant/production assets</b>	

Table 6.3 – Calculation of financial indicators for each KER

<b>Years</b>	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11
<b>Capital expenditures and achieving TRL 9</b>											
<b>Quantity sold</b>											
<b>Revenue</b>											
<b>COGS</b>											
<b>Operating cost (rent, equipment, insurance, development)</b>											
<b>Total cost</b>											
<b>Depreciation (machinery, infrastructure cost divided over useful lifetime)</b>											
<b>EBIT</b>											
<b>Tax</b>											
<b>Net Operating Profit After Tax (NOPAT)</b>											
<b>Operating cash flow</b>											
<b>Free cash flow</b>	€										
<b>Discount factors</b>	€										
<b>DFCF</b>	€										
<b>NPV</b>	€										

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## 7 Conclusion

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The purpose of this deliverable is to assess the European market for the developed GEO4CIVHIC solutions, with the aim of ensuring the successful future commercial exploitation of the project's key results in the segmented European market. To achieve this, the report has explored potential and actual market requirements, competing technologies, barriers, opportunities, and business innovation models.

Key target customers have been identified, considering four aspects: (1) Innovative borehole drilling technology; (2) Innovative heat pumps; (3) New drilling methodologies; and (4) Replicable geothermal heating and cooling system solutions for wide-scale market deployment.

The geothermal market is highly fragmented and varies from country to country, influenced by different building typologies, geological conditions, climates, and energy market shares. Energy consumption plays a crucial role in promoting sustainability, energy security, and economic development. The document includes a summary table of energy consumption in different EU markets, highlighting the residential sector as a significant energy consumer, especially in countries like Germany and Romania. Heating and domestic hot water are the primary energy uses in this sector, with natural gas being the predominant fuel in some countries and electricity in others. The increasing use of renewable energy sources for residential heating and cooling signals a positive trend.

To position the technologies developed in the project, the report provides a list of key features and related prices of similar products available in the market. Additionally, it conducts a comprehensive assessment of why customers would choose GEO4CIVHIC products and technologies, taking into account their main advantages and key success factors.

The report also delves into the stand-alone products corresponding to the seven selected exploitable results. It outlines business models associated with these products, created with input from consortium partners. Furthermore, it presents a business model canvas for an integrated solution that encompasses key exploitation results. An operating plan has been established, defining the key responsibilities of various stakeholders, including central monitoring of GEO4CIVHIC integrated solutions, technical providers, consultancy and engineering firms, universities, research centres, and associations.

Financial assessments have been conducted using a combination of Technology Readiness Level (TRL) analysis and Future Discounted Cash Flows (FDCF) analysis, which is crucial for businesses and organizations involved in developing new technologies. All these analyses provide valuable information on how these stand-alone products can be effectively commercialized in the market in the future. This insight remains relevant even as the overarching concept of the business plan takes shape, based on the chosen business model.

Given the confidential nature of the FDCF analysis and its strategic significance, the results have been thoughtfully incorporated into the sensitive deliverable, D7.6. Specifically, these findings have been seamlessly integrated into the IP valuations section, ensuring both the confidentiality and strategic relevance of this critical information are upheld.

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