



GEOHERMAL
IWG

Iceland
Liechtenstein
Norway grants



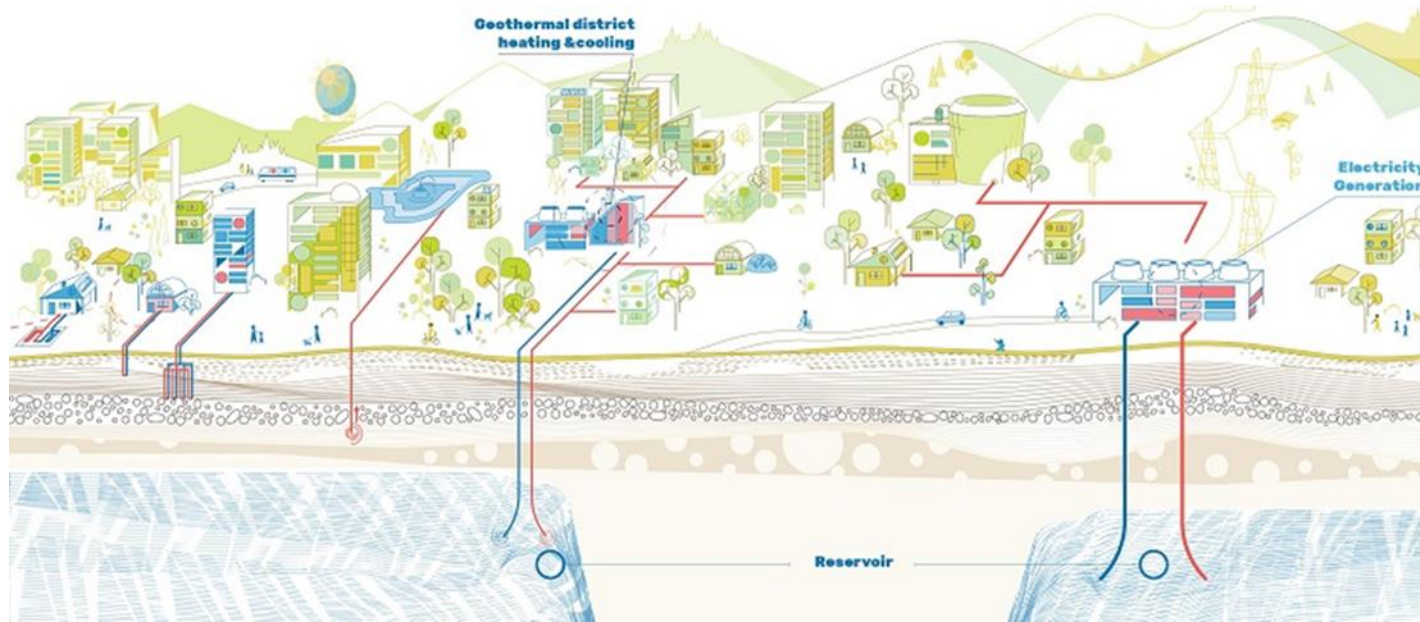
REPUBLIC OF SLOVENIA
MINISTRY OF THE ENVIRONMENT,
CLIMATE AND ENERGY

Prospects of Geothermal Energy in Europe

Philippe Dumas

Geothermal energy: a unique renewable energy

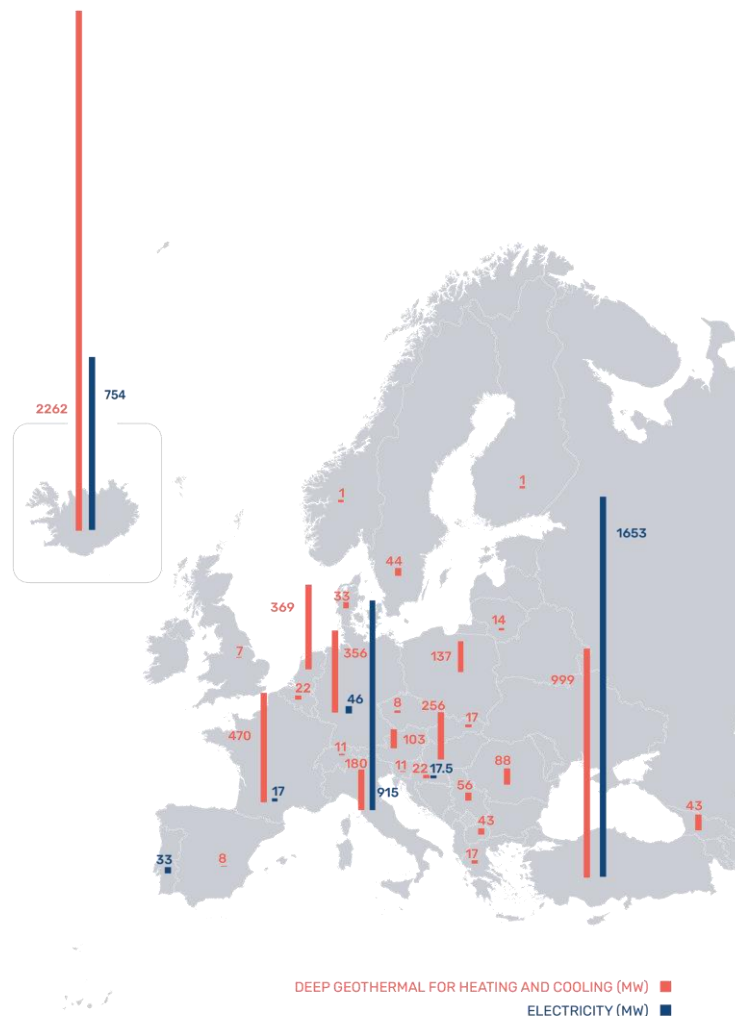
supply electricity, heating & cooling, minerals such as lithium and allow underground thermal storage



Overview

Some key figures

- 142 Geothermal electricity plants: **3,5 Gwe installed** and more than 22 TWh produced
- 395 geothermal DH systems in operation, with **14 new in 2022**: 5,6 GWth capacity
- More than **2.19 millions geothermal heat pumps** in Europe at the end of 2022, record sales in 2022, esp. very large systems (>10Km boreholes cumulated length)





Strategic Research
and Innovation Agenda

Trends in Europe



Heating and cooling major growth sector

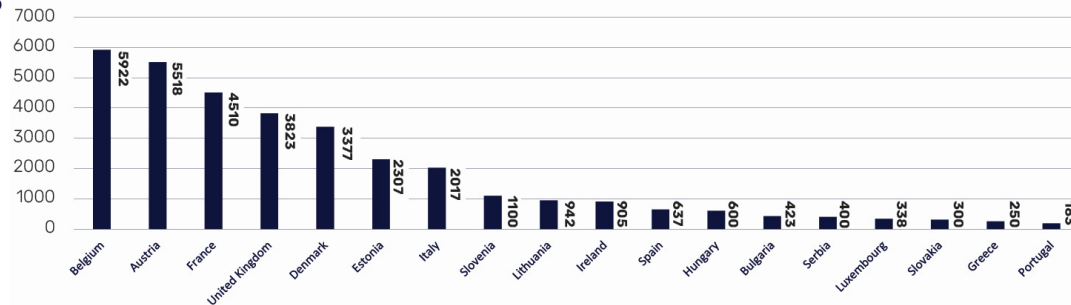
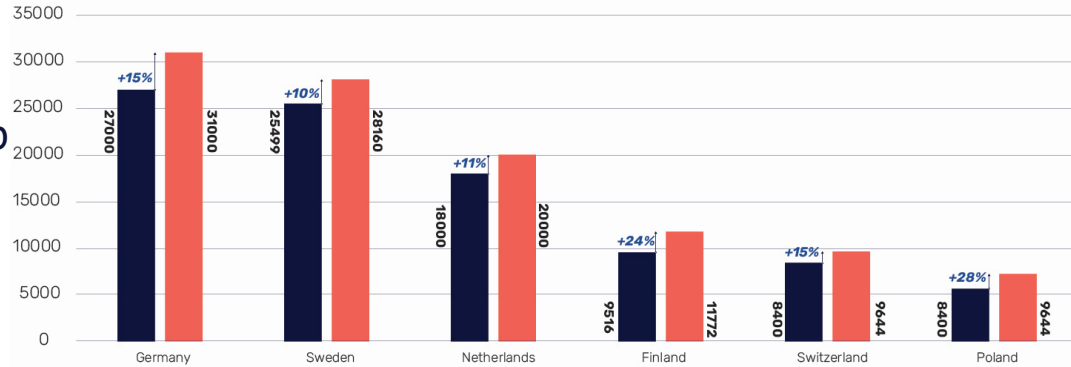
- The **conflict in Ukraine** provoked a rapid policy response focused on decoupling energy imports into heating and cooling so more focus on geothermal HP and DHC (EU consumption of natural gas has dropped by 19.3% between August 2022 and January 2023).
- National and supranational **policy driving change**. For example, Ireland, Germany and Poland launched national roadmaps to aid the rapid growth of geothermal in their countries.
- Main **demand** for geo HP comes from residential (in developing markets) and commercial/public buildings sector (more mature markets).
- Some relative **newcomers** for geothermal DHC systems, such as Ireland, which has three projects in its pipeline.
- GHP and GeoDHC pipeline grew and **expected to continue exponential growth** as heating and cooling gain greater political attention.

Geothermal heat pumps market in Europe



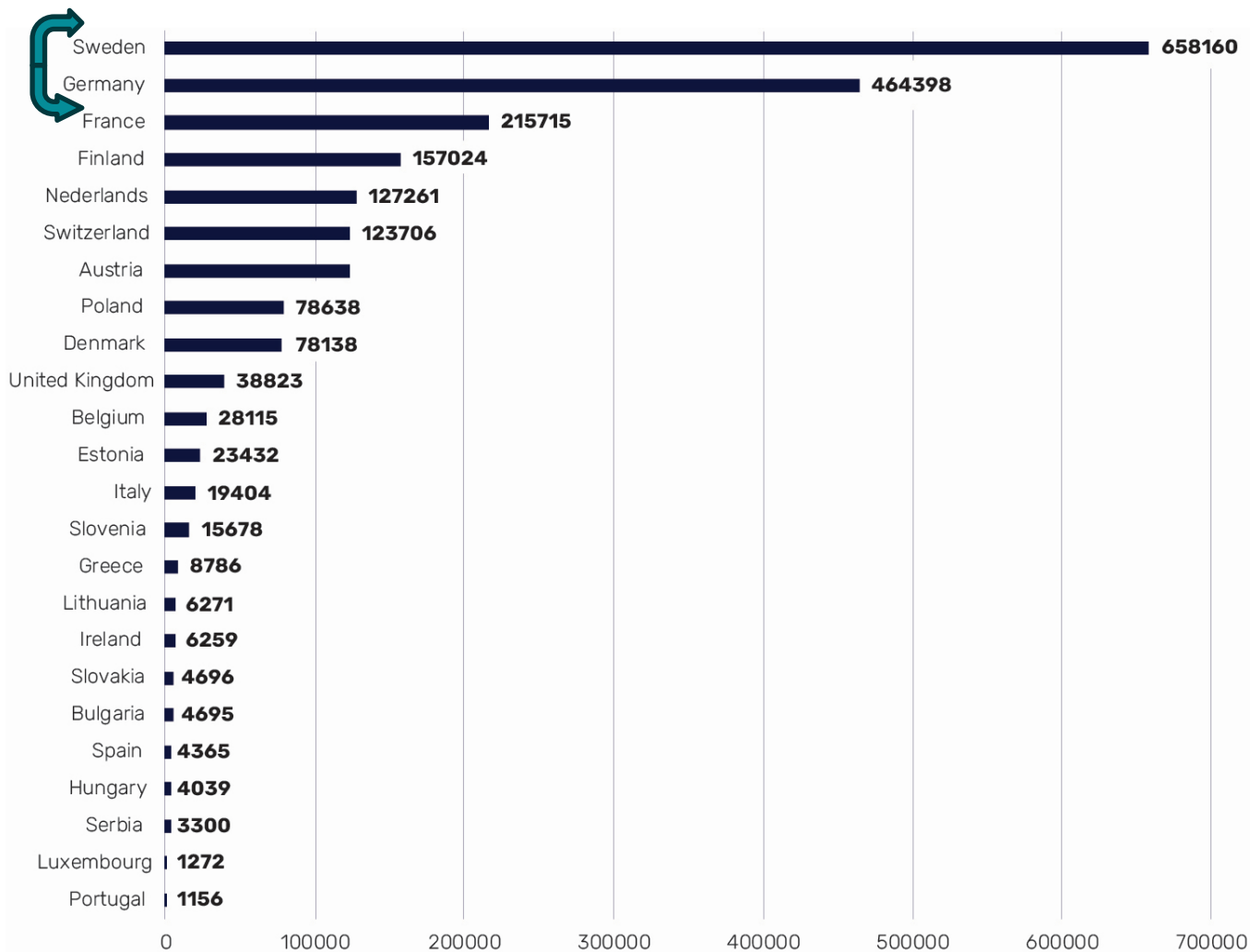
Growing sales in old and new markets

- 2022 witnessed the **largest ever volume of GHP sales**, with more than 141,300 geothermal heat pump systems installed.
- This surpassed 2021, which was the last record year with 120,900 sales...**still concentrated in 6 markets** with >ca. 10 K units/years (accounting for 80%)
- 2022 figures were **17% higher than those in 2021**.

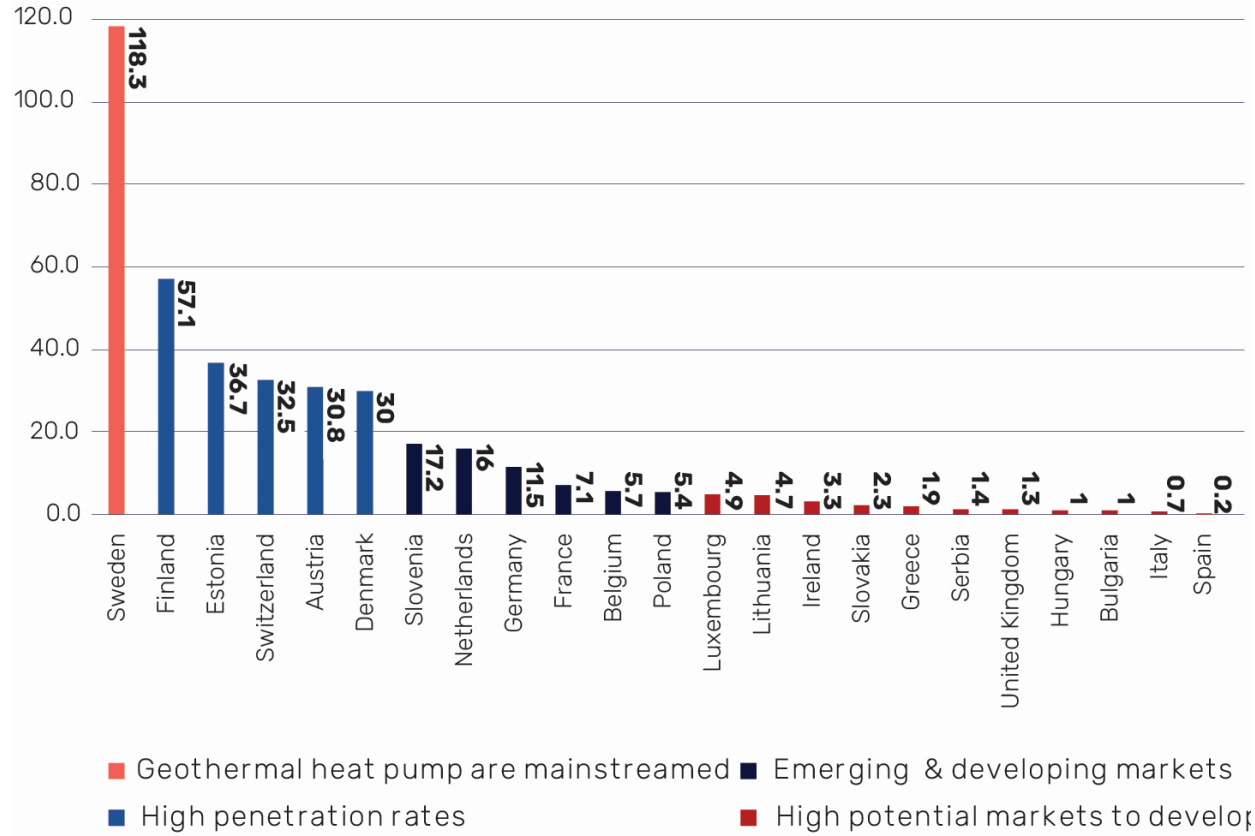


50% of the stock is in 2 countries...

Number of GHPs installed (stock) in 2022 in Europe



Number of geothermal heat pump systems per 1,000 households



Future trends: national roadmaps

- **Poland's national roadmap for geothermal** outlined a target to install over 200,000 geothermal HP in the country, generating 2,4 GW of heating by 2050.
- **Ireland's Policy Statement** to be legislated in 2023/2024 is expected to outline a pathway for a significant contribution to the national target of installing 600,000 heat pumps by 2030.
- The **French geothermal roadmap** aims at doubling the number of geothermal heat pump installations between 2020 and 2025 by installing more than 200,000 systems in 3 years.
- The **Dutch strategy** is to mandate hybrid-heat pumps in combination with a ban on fossil heating from 2026. A 30% subsidy on the total cost of installation is available at zero interest rates for medium to low-income households.

National Geothermal roadmaps

Replicate the existing ones in

- France
- Poland
- Ireland
- Germany
- ...

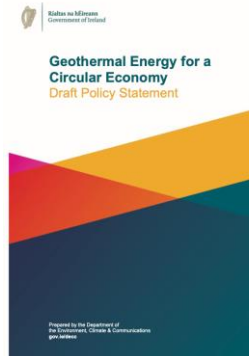


Double Geothermal HP by 2025 & Geothermal DH by 2030



Risk guarantee scheme.

Focus on Geothermal HPs and DHC systems.



Exploration and production licence law by 2024.

600,000 HPs by 2030. Expect half to be geothermal and DHC.



Risk guarantee scheme.

100TWh from 100 new Geothermal HP and Geothermal DHC systems by 2030

Geothermal District Heating in Europe

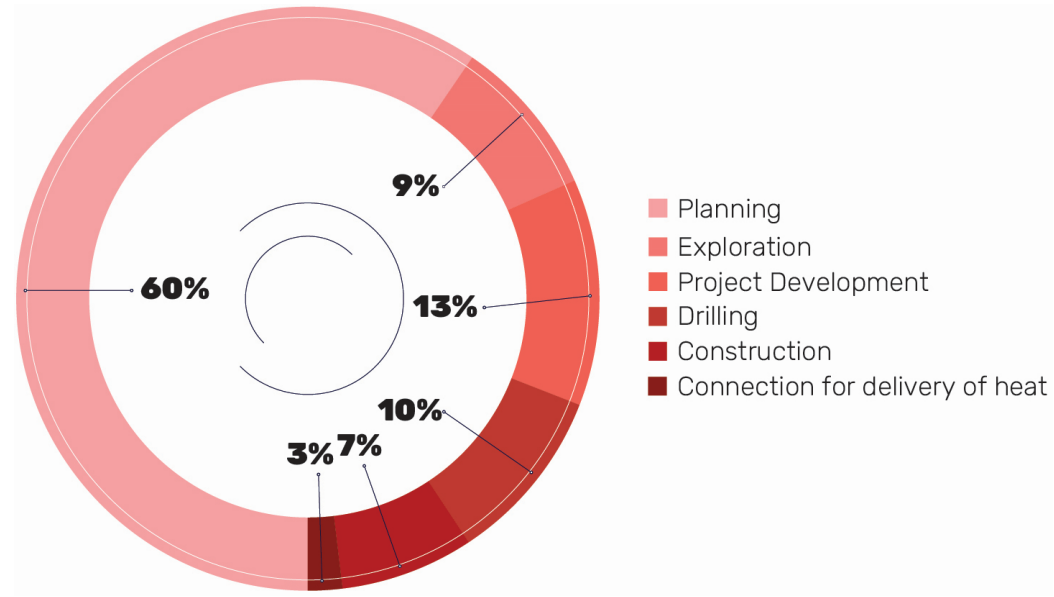


District heating and cooling market share

- **5,608.31 MWth geothermal DHC** coming from 395 systems across all Europe in 2022 (261 in EU countries).
- The **14 new geothermal systems** in 2022 added 105.23 MWth of capacity. 12 of these new systems were commissioned in the EU.
- France remains the largest geothermal district heating country in the European Union and second to Iceland across Europe.
- ❑ France leads also in terms of projects commissioned, with a total of 5 - adding an additional of 48.7 MWth to existing capacity.
- ❑ Two geothermal systems were commissioned in Finland adding a combined 1,3 MWth capacity.
- ❑ Single systems were also installed in Hungary, Italy, Poland, Serbia, Spain and Switzerland.

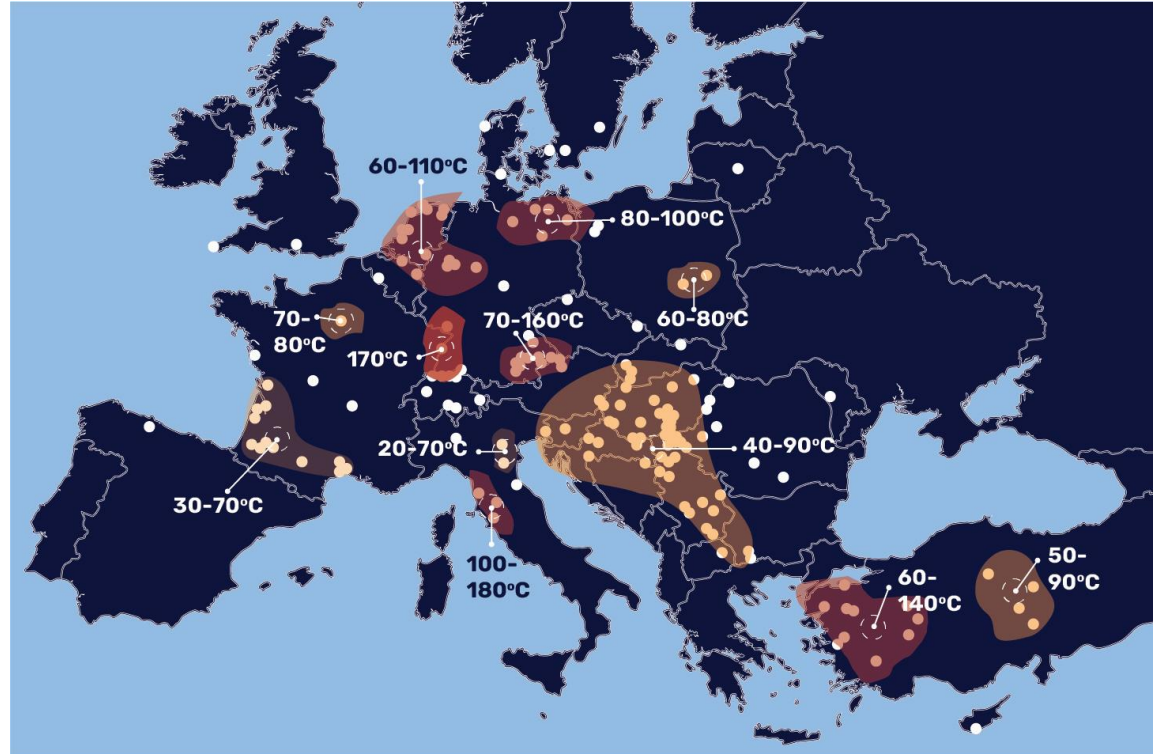
Geothermal DHC project pipeline

- **316 new projects** under active investigation, which add over 744 MW to the operational 5,608 MW capacity.
- **Germany has the largest pipeline** with 102 projects and is followed by France with 24, the Netherlands with 22, Italy and Poland with 21 respectively.
- **Geothermal and agrifood:** new project in Almeria (Spain) to connect local greenhouses and agrifood production sites.



Resource and flow rates

- Most projects centre on reservoirs with temperatures in the 60-80°C range in the EU.
- One of the key trend is the use of large Heat Pumps.
- Greater effort needed for resource mapping.



Geothermal electricity production in Europe



Market situation

- It is available in **8 Member States** and four neighbourhood countries. 1 GW is installed in the EU producing **7,85 TW_h per year** assuming a 80% capacity factor and 2 GW_e in the rest of Europe.
- **Bulgaria** has finance from the Recovery & Resilience Fund to construct two geothermal power plants to support the production of renewable hydrogen. **Greece** and **Spain** are in the process of establishing national regulations and conducting exploration to identify geothermal power potential. **Slovakia** has started constructing its first geothermal power plant.
- It is **resource efficient**. For example, the 16.5 MW_e Velika 1 geothermal power plant in Croatia, provided as much electricity as the 309 MW_e installed capacity of solar PV installations in 2020. The 20 MW_e Slatina 2 geothermal plant started construction in 2021 to more than double Croatia's renewable baseload renewable power output and finance has been agreed for the Slatina 3 power plant. Cindrigo Geothermal Ltd, the owner, is securing licenses for an additional 1,000 MW_e capacity

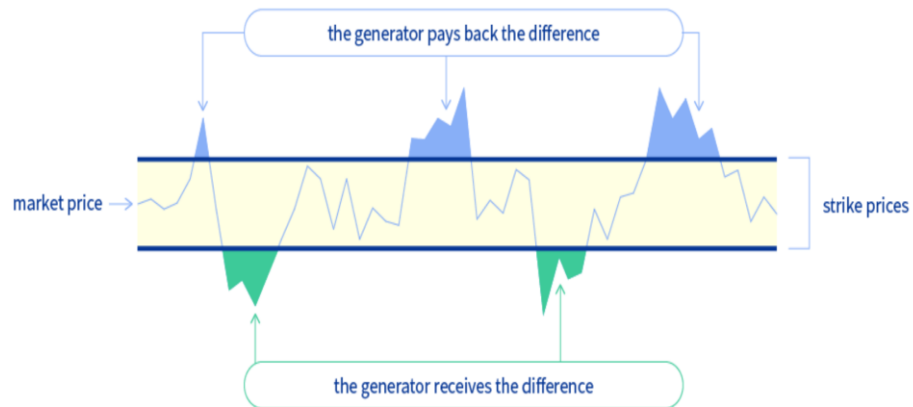
Electricity Market Design

- **How a winter heating crisis led to reform of the electricity market**
 - Energy price crisis caused by reduced Russian gas imports, nuclear and hydro shortages. Ukraine invasion exacerbated this.
 - About 20% of EU electricity generation comes from flexible gas plant.
 - No incentives or fiscal rewards for baseload (geothermal) and predictable (ocean and concentrated solar) renewable energy generation. No support for flexibility, storage or energy savings.
 - Southern European countries had problems because of the heat wave that added greater pressure on their electricity systems.
 - Electricity system also came under pressure from the jump from fossil heating to electric heating. This is *highlighted in the Polish government's national roadmap for geothermal energy published in October 2022*
*"The use of ground source heat pumps is also an important element of energy security. Their high efficiency means that they consume much less electricity than air-source heat pumps, thus **avoiding large power draws from the grid (e.g., during heavy frosts, when using air-source heat pumps)**. When combined with photovoltaics (PV) and thermal energy storage, ground source heat pumps form a complementary and efficient district heating system."*

Contracts for Difference (CfDs)

- **Article 19b – Two-way Contracts for Difference (CfD)**

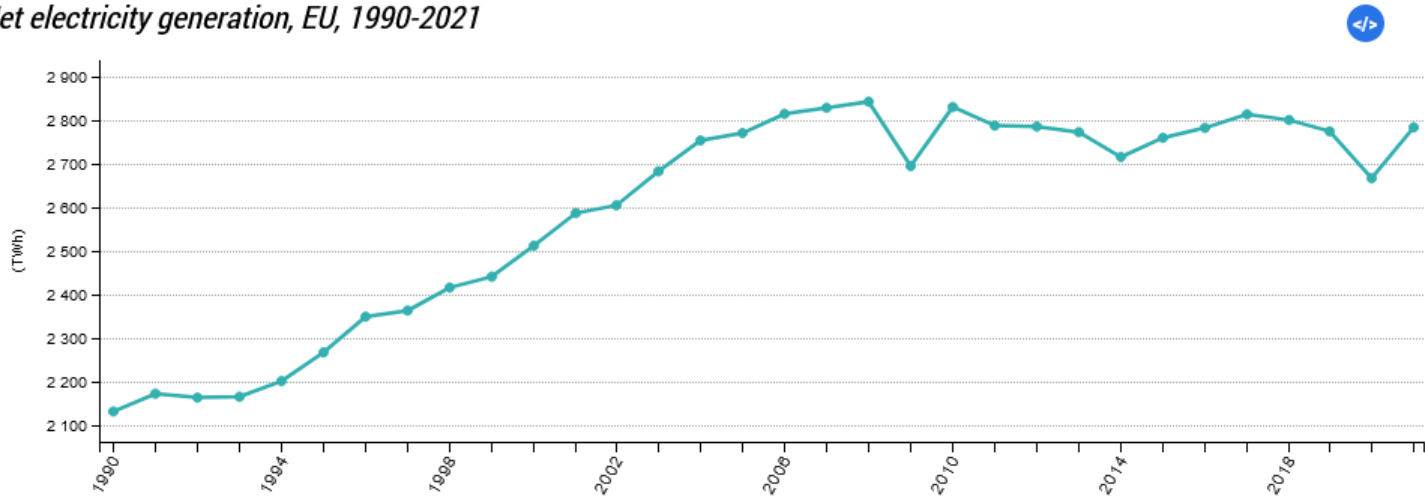
- This is the main way in which governments can finance **new** electricity generation capacity in a few technologies. Geothermal is listed as one of these key technologies.
- Two-way CfDs means the generator receives income when the price of electricity collapsed but consumers receive it, to some extent, when prices go above the agreed ceiling.
- Geothermal producers receive income stability between the strike prices.
- However, this covers **operational costs** not **production** (drilling, etc).
- Indirectly combined geothermal power and heat projects incentivised.



Electricity demand in Europe

The demand in Europe is stagnating. An issue for the power decarbonization and the demand for new geothermal powerplants !

Net electricity generation, EU, 1990-2021



Source: Eurostat (online data code: nrg_ind_peh)

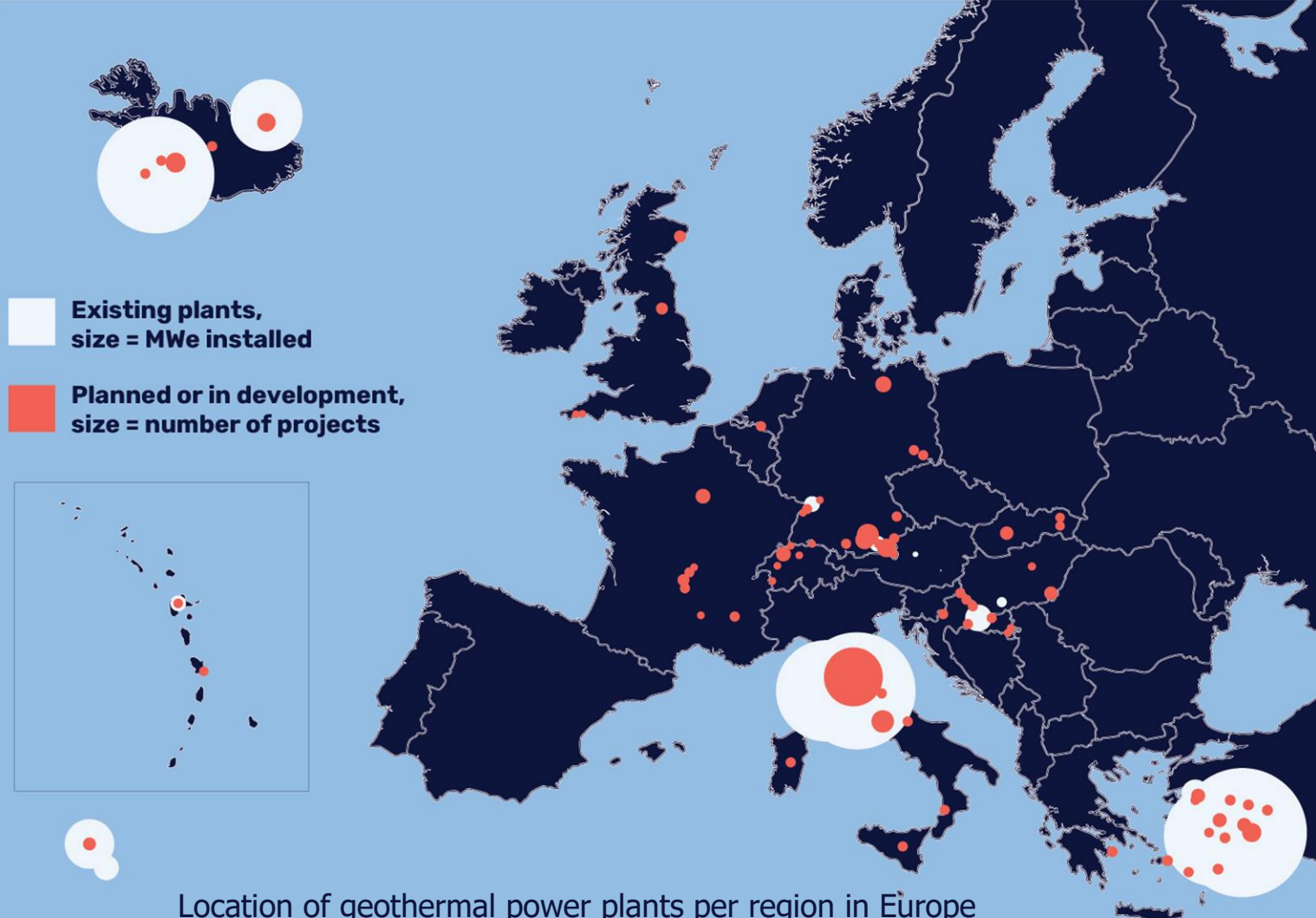
Market analysis

1913 - 2023: Celebrating 110 years of geothermal power

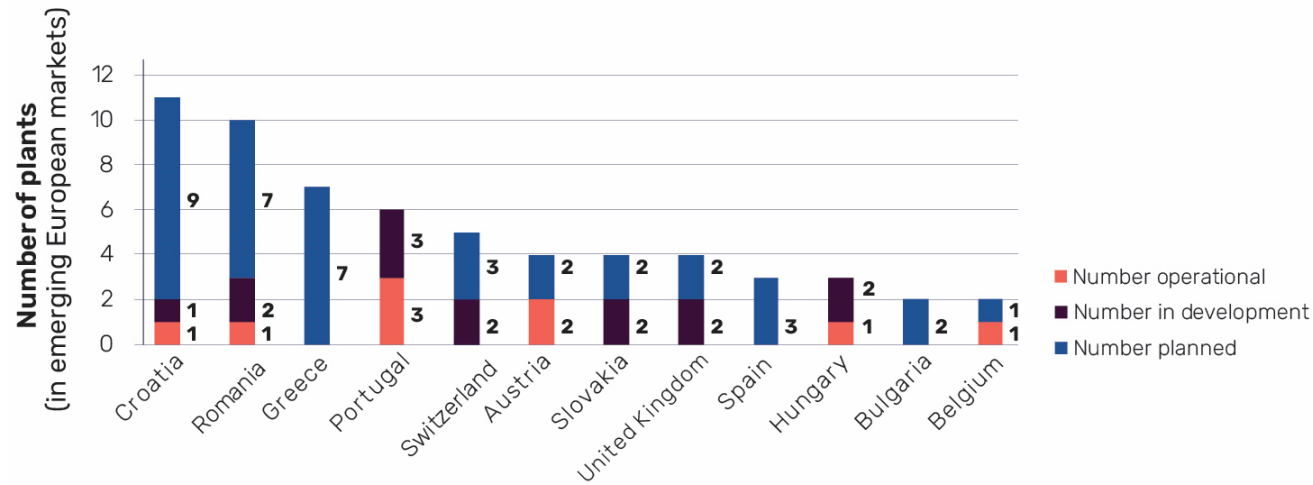
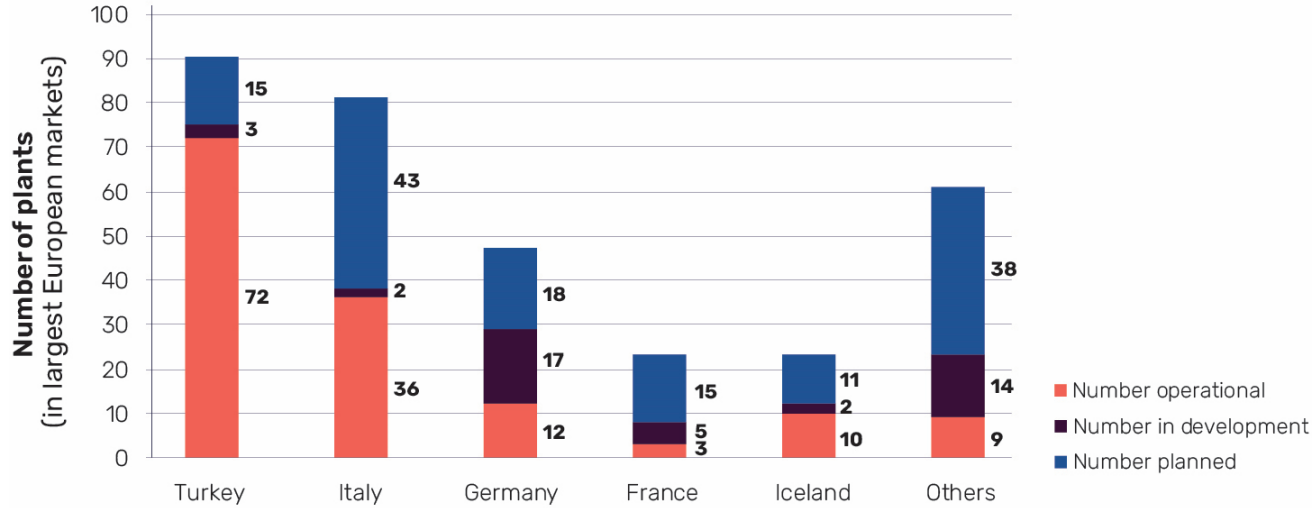
- The oldest geothermal power plant is still in operation is from 1986.
- 4 running plants are from the 80's, 17 from the 90's and 32 plants run from the 2000's.
- 21 power plants are more than 25 years old and 53 are more than 15 years old.

The geothermal electricity market is now entering a new development phase, with many plants to be put into operation throughout the next 5 to 7 years.

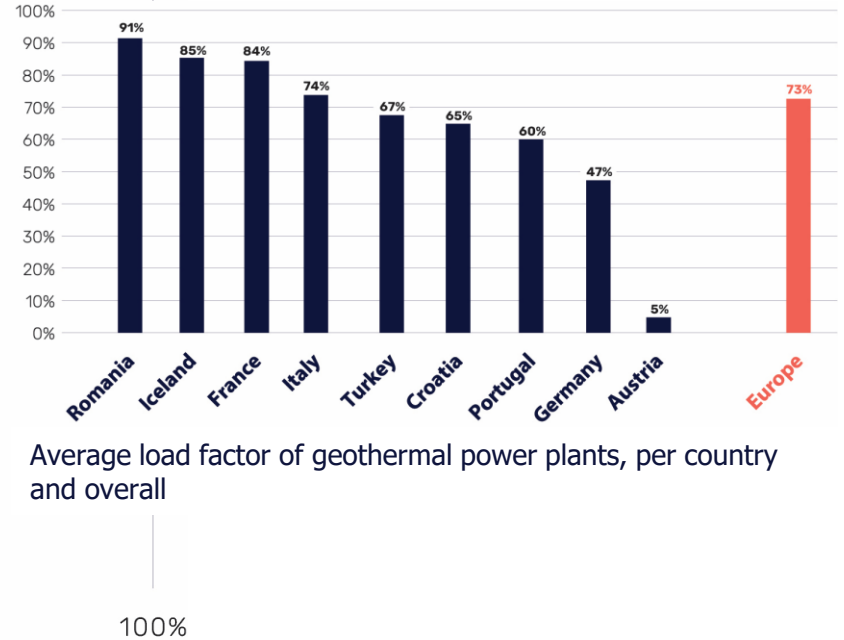
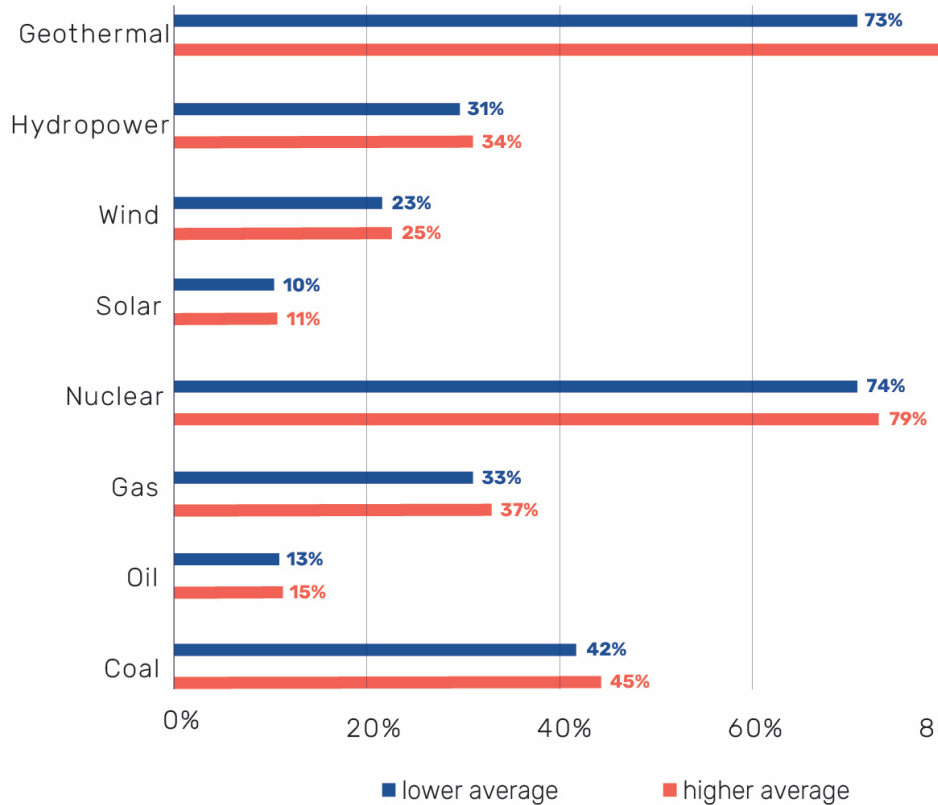
- In total, today, 43 projects are developed and 140 are investigated.



Location of geothermal power plants per region in Europe



Need of Base load for security of supply



Average load factor of geothermal power plants, per country and overall

Average European capacity factor per electricity sources, 2022

Market outlook

The background of the slide is a dark blue gradient. In the lower half, there is a faint, low-angle photograph of a construction site at night. The image shows a complex steel framework for a building under construction, with numerous vertical and horizontal beams forming a grid-like structure. The lighting is dim, suggesting an evening or night setting, with some lights visible in the distance.

First glance of the Market report 2022

more than 30 wells will be drilled in the next 3-5 years **for Geothermal electricity** power plants

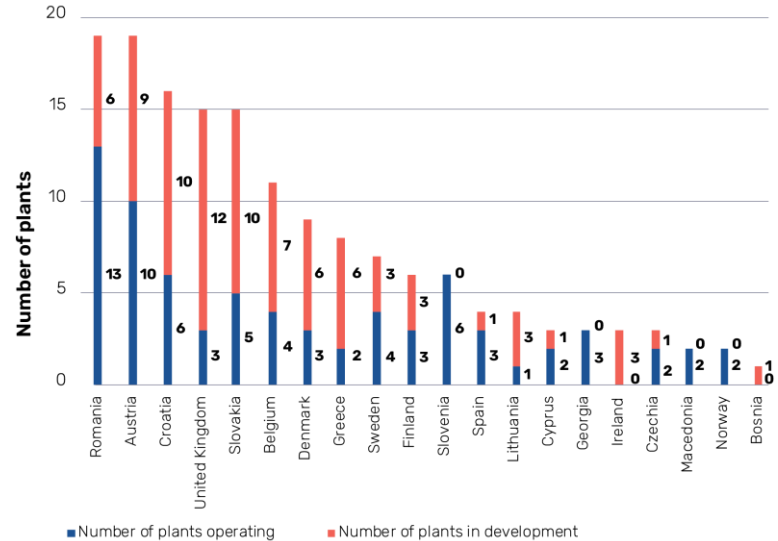
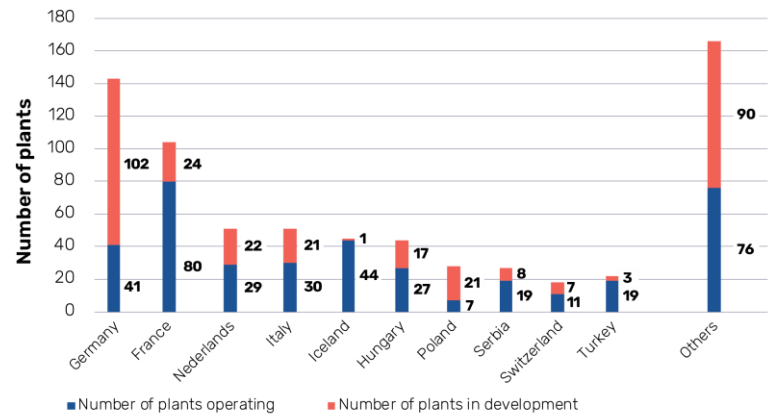
25 plants are under development (construction or extension) and 100+ projects are investigated

more than 100 wells will be drilled **for heating projects**

16 projects are currently (or about to) drilling, 300+ are developed or investigated – typically doublet, but Innargi will drill 19 wells in Denmark, and some extension with triplets

Market development

- 17 geothermal heating systems are expected to be commissioned in 2023. Four are in Serbia; three in Finland; two in the Netherlands and one in Austria, Cyprus, Estonia, Hungary, Italy, Portugal, Slovakia and Spain.
- More than **300 are being developed** or are under investigation.
- These are **typically doublets**, but some projects will drill **multiple wells** as is the case in Denmark. Others will seek **extension** of existing capacity with triplets.



Market situation

Geothermal electricity plants in Europe (EGEC Market Report 2022)

Countries	Operational plants (MW)	Construction(MW)	Planned (MW)
Austria	2 (1.2 MW)	0	2 (? MW)
Belgium	1 (4 MW)	0	1 (2 MW)
Croatia	1 (17.5 MW)	1 (4.3 MW)	9 (103.2 MW)
France	3 (17 MW)	5 (15.5 MW)	15 (97 MW)
Germany	12 (46 MW)	5 (77.55 MW)	17 (155 MW)
Greece	0	0	6 (42.5 MW)
Hungary	1 (MW)	2 (22 MW)	0
Italy	36 (915 MW)	2 (25 MW)	35 (325 MW)
Portugal	3 (33 MW)	1 (5 MW)	0
Slovakia	0	1 (20 MW)	2 (22.4 MW)
Iceland	10 (754 MW)	2 (30 MW)	8 (450 MW)
Switzerland	0	0	2 (5 MW)
Turkey	72 (1653 MW)	2 (31.6 MW)	15 (381.9 MW)
United Kingdom	0	2 (8.15 MW)	2 (5 MW)
EU total	59 (1,051.7 MW)	17 (269.3 MW)	87 (747.4 MW)
Rest of Europe total	82 (2,407 MW)	6 (69.7 MW)	27 (841.9 MW)
Total	141 (3,458.7 MW)	23 (339.1 MW)	114 (1589.3 MW)

Observations on Electricity Market Design

- **The good**
 - Geothermal recognised as an important renewable electricity after wind and solar.
 - Flexibility and demand response to be financially remunerated.
- **The not so good**
 - This still doesn't full support the full services provided to the electricity system from geothermal – grid balancing services, etc.
 - No support for baseload and predictable renewable electricity.
 - Capacity market continues to support existing inflexible capacity which discourages investment in geothermal.
 - CfDs alone are not enough for geothermal. Need additional support for the upfront drilling and construction costs and financial risk mitigation.

Geothermal for Europe, targets to cover...

- 25% of Heating and cooling demand
- 10% of Power generation
- Underground thermal storage for 50% of the DH
- Co-production of minerals: 20% of lithium demand

