ORC GEOTHERMAL POWER PLANTS: AN ANALYSIS OF THE STRUCTURE AND TRENDS OF THE EUROPEAN MARKET

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ABSTRACT

Geothermal energy is among the main applications of ORC technology, and it is arguably one of the energy sources where the ORC deployment potential is least fulfilled in Europe. Moreover, as the European Union is engaging in the decarbonisation of its energy system by the middle of the century, the use of geothermal energy for power generation is set to increase rapidly.

This paper, based on the findings of the European Geothermal Market Report, an annual publication by EGEC which provides a thorough analysis of the market for geothermal power generation and heating and cooling, will provide an analysis of the ORC turbine market for geothermal energy. The paper will notably explore the merits of ORC technology, justifying a rapid popularity in the geothermal sector. It will also assess the market dynamics, looking at historical data, key manufacturers, capacity installation and so on which have been analysed by EGEC over the past decade across publication of the European Geothermal Market Report.

The year 2020 was especially market with COVID-19 impacts, which had a strong impact on developments in many parts of Europe. This did not however stop developments in Turkey which continued its rapid scale up geothermal power capacity with 8 plants commissioned. Beyond the impact of the year 2020 on the industry, developments across Europe have been largely hindered by the lack of a consistent and reliable regulatory framework to enable the development of new resources and support investments in new geothermal plants.

The paper will also assess the potential for geothermal electricity in the coming decade, and how this would translate for the ORC sector in light of recent market trends, ongoing technology innovation in the geothermal sector and policy driven prospects.

1 INTRODUCTION

Geothermal energy is among the main applications of ORC technology, and it is arguably one of the energy sources where the ORC deployment potential is least fulfilled in Europe. Moreover, as the European Union is engaging in the decarbonisation of its energy system by the middle of the century, the use of geothermal energy for power generation is set to increase rapidly.

The market for geothermal ORC plants is quite diverse in Europe, with many different manufacturers competing in a rapidly growing sector. The technology, which meets many of the requirements of this specific renewable energy source, has gained rapidly in market share compared to so-called conventional technologies.

Like many industries in Europe, the geothermal industry suffered the consequences of the COVID 19 epidemics pandemic in 2020. Positive trends from previous years came to a standstill, hopefully only momentarily. Several projects got stopped in their tracks, various others faced delays. For many developers, 2020 was a difficult year, as they having to faced delays in their ongoing projects and the

greater hesitation from the part of investors and potential customers. COVID-19 changed how we interact globally for years to come, and has forced economies to look for local resources, including energy.

The European geothermal electricity sector faced challenges in 2020, which somehow reflect the general trends of the past decade and open the discussion as to where is the industry headed in the new one. This paper, based on the findings of the European Geothermal Market Report, an annual publication by EGEC which provides a thorough analysis of the market for geothermal power generation and heating and cooling, will provide an analysis of the ORC turbine market for geothermal energy. The paper will notably explore the merits of ORC technology, justifying a rapid popularity in the geothermal sector. It will also assess the market dynamics, looking at historical data, key manufacturers, capacity installation and so on which have been analysed by EGEC over the past decade across publication of the European Geothermal Market Report.

2 OVERVIEW OF THE EUROPEAN GEOTHERMAL ELECTRICITY MARKET IN 2020

Overall, there are 3,5 GWe of geothermal electricity capacity throughout Europe, distributed over 139 power plants.

In 2020 Turkey became the strongest geothermal power market in the world. In a major break with previous years, no other European countries have commissioned a geothermal power plant during the year 2020, confirming a worrying signal regarding the growth of other European geothermal power markets.

Beyond the probable impact of the COVID19 pandemic, which disrupted the geothermal industry, the geothermal electricity sector is marked by general policy uncertainty, and suffers from unclear permitting and licensing frameworks throughout Europe, which hamper the implementation of new projects.

Turkey added 165 MWe of new geothermal electricity capacity in 2020, bringing the total installed capacity to 1,7 GWe. Italy and Iceland continue to be two other largest users of geothermal electricity, with respectively 916 MWe and 754 MWe of installed capacity, corresponding to 6 TWh and 5 TWh of geothermal electricity produced.

Other countries that use geothermal electricity in Europe include Germany (40MWe), Portugal (32 MWe), Croatia and France (both 17 MWe). We are however seeing many countries that are looking to develop their national geothermal resources for electricity production.

There are 154 projects planned or in development in Europe, which are distributed across 16 European countries as shown in figure 1. It is challenging to estimate the capacity to be deployed with these projects, as in most cases there is a high degree of uncertainty regarding the future capacity of a given project. Considering the average size of binary systems deployed recently (which represent the bulk of upcoming installations), we can however estimate that these 154 projects represent between 1 and 2.5 GWe of geothermal power capacity to be deployed.

In Turkey, thanks to the confirmation of the extension of the support scheme programme in 2020, there are 13 projects currently in construction and 14 at the planning stage. Italy, where uncertainties linked with an unclear licensing and permitting framework have had a strong impact on project development, 35 projects are at the planning stage, highlighting the large potential that remains to be developed in the country.

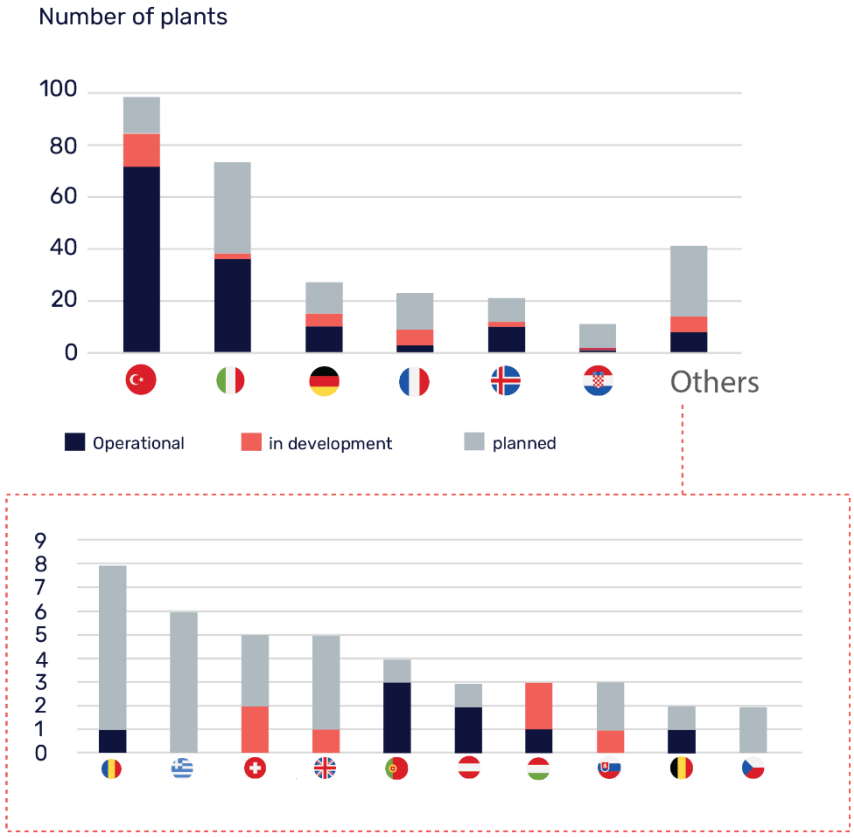

Figure 1: Number of geothermal power plants per European country – operating, in development and planned (EGEC Geothermal Market Report 2020)

Beyond traditional markets, several countries are currently developing geothermal power plants: the UK is on the verge of commissioning its first project in Cornwall, while Croatia which commissioned its first geothermal power plant in 2019 has 10 projects currently planned or in development. Slovakia and Switzerland are other notable countries looking to commission their first geothermal electricity plants.

Despite some notable milestones such as the commissioning of the first geothermal power plants in Hungary, Croatia or Belgium, and the expansion of installed capacity in Portugal and Germany, the past decade is to a large extend a cautionary tale for the European geothermal electricity industry. Despite the setting of national objectives for geothermal electricity capacity deployment in the National Renewable Energy Action Plans adopted in 2009 by European Union Member States, no EU country has met its objective by 2019 according to data reported to EUROSTAT for the assessment of the progress towards such targets. The EGEC Market Report 2020, which notes that no geothermal power plant has been commissioned in the EU in 2020, allows to consider that this objective has been missed. To a very large extend, the failure to meet these national objectives is attributable to a lack of suitable policy and regulatory framework, from inadequate permitting and licensing procedures to an absence of stability and predictability in support schemes for geothermal power plants.
The EGEC Geothermal Market Report 2020 and past editions give a clear assessment of the failure to implement European deployment objectives for geothermal power plants. To a large extent, market barriers were compounded by regulatory uncertainty – with a stop and go effect resulting from frequent changes in support and regulatory framework, including retroactive decisions with negative impacts.

The barriers to the development of the geothermal power market in Europe are directly linked to this unstable regulatory framework and the only partial implementation of objectives laid out at the European level in 2010 with the Renewable Energy Directive. Additional barriers, including the fragmentation of the European market between many different national regulatory and support framework makes the replication of best practices more challenging. several European countries, a lack of knowledge of geothermal resources due to an absence of exploration and mapping also represents a key barrier to the uptake of geothermal power plants. European countries are mostly medium or low temperature countries, which requires a high degree of technological maturity for various innovation from the past decades in the geothermal sector, including for binary turbines. This for instance allowed recent developments in Croatia or Belgium. Overall, the lack of a stable regulatory framework consistent with a high degree of ambition – which allowed for instance the uptake of the Turkish geothermal market – is the main barrier to geothermal power plant developments.

3 BINARY TURBINES ENABLING MARKET DEVELOPMENT IN EUROPE

The geothermal turbine market reflects the shift in the resources that are now exploitable for geothermal power production. While flash and dry steam turbines remain typically the largest turbines in terms of capacity, binary turbines represent the bulk of new addition in all types of markets, having demonstrated their performance in high temperature markets as well as in lower temperature ones. They represent most of the capacity addition, the only flash turbine commissioned in 2020 corresponding to a flash/binary hybrid system.

The market continues to be dominated by the same manufacturers of turbines (figure 2), with Exergy, Ormat and Atlas Copco being responsible for all new turbines commissioned in 2020, with Ormat consolidating its lead in installed capacity – primarily in the Turkish market, and Exergy catching up in MWe installed with historical flash turbine manufacturers.

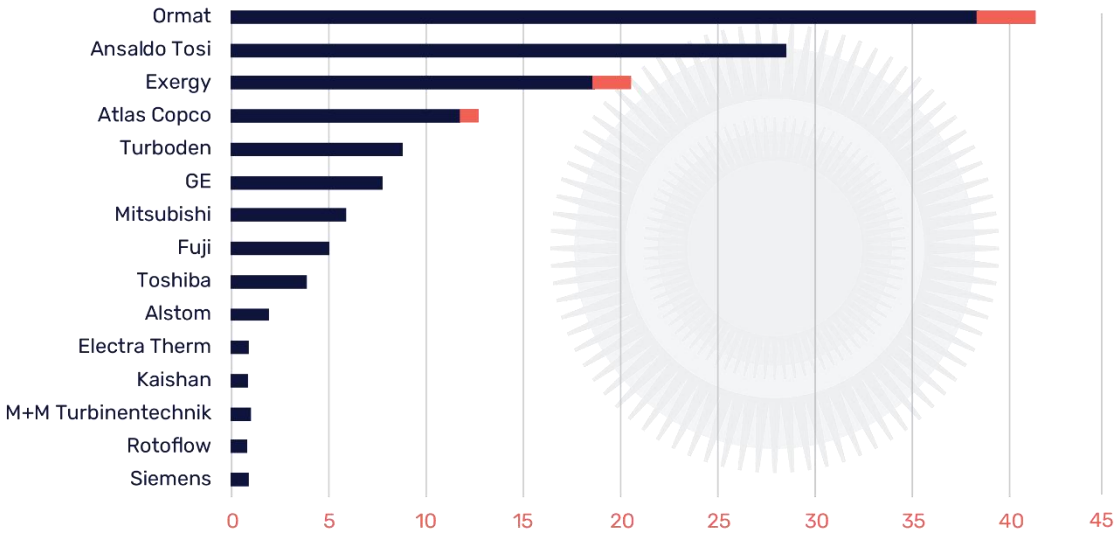

Figure 2: Number of installed geothermal turbine by manufacturer highlighting 2020 additions in red (EGEC Geothermal Market Report 2020)

Over the past two decades, binary turbines emerged from being an innovative technology scarcely deployed compared to flash or dry steam, to widely dominating the market (Figure 3). Moreover, the binary turbines rapidly evolved in scale, and now represent the bulk of capacity addition. The rise of binary turbines can be attributed to two parallel trends: first binary turbine technology progress allowed their application in a wider range of geothermal power plants and allowed this technology to be

competitive with other turbine technologies. Moreover, binary turbine technologies provide additional benefits to geothermal power plant operators, the first one being the possibility to develop power plants on hot water brine resources. This wider range of technical possibilities enabled by binary turbines also allows operators to implement this technology to answer to raising environmental concerns. Binary turbines are for instance deployed to answer concerns linked to local air emissions around geothermal plants, allowing for an easier reinjection of non-condensable gases.

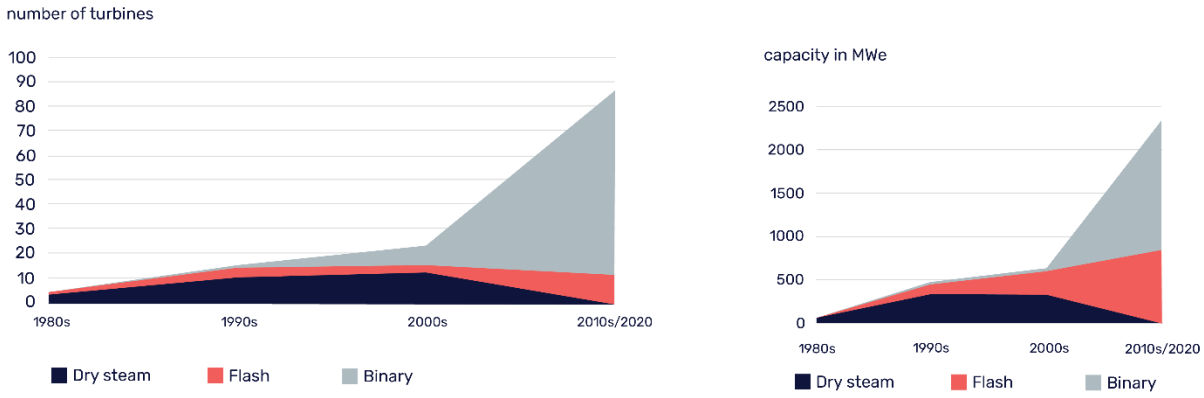

Figure 3: Evolution of geothermal power plant turbine installation by turbine technology in number of turbines and capacity deployed (EGEC Geothermal Market Report 2020)

As highlighted in Figure 4, over the past 10 years, no country in the world has been as successful in building its geothermal electricity sector as Turkey, which went from 93 MWe of geothermal power plant capacity in 2010 to 1,7 GWe at the end of 2020. Italy and Iceland have expanded their use of this resource to a much lesser degree over the past decade. Other European markets offer a very mixed pictures for the geothermal electricity industry. France, a promising market in 2010 did not add any geothermal power plants in 10 years. Germany did install quite a few power plants; however delivery is much below the anticipated potential and objectives. Despite some positive signals with countries such as Hungary, Croatia and Belgium developing their first geothermal power plants, the market uptake of geothermal power plants did not progress as much as expected a decade ago, notably with regards to innovative technologies such as EGS.

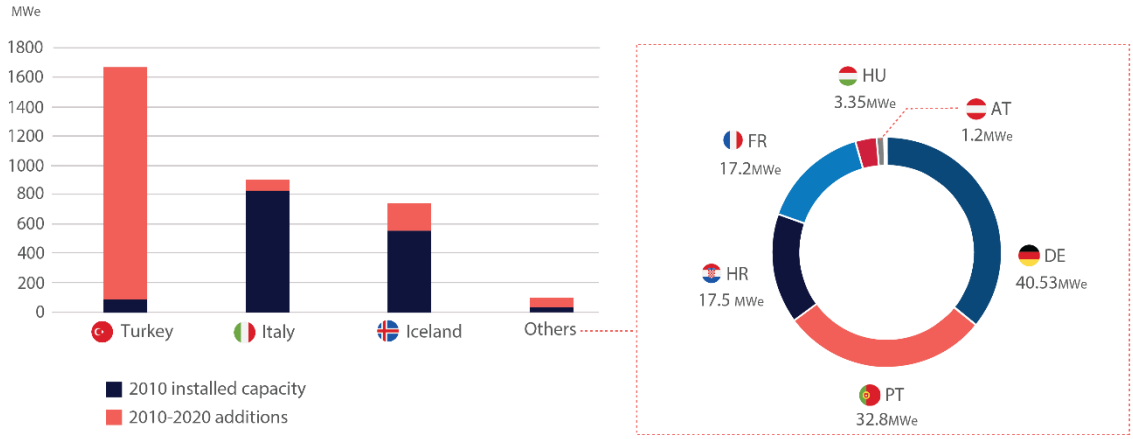

Figure 4: Geothermal electricity capacity addition between 2010 and 2020 (EGEC Geothermal Market Report 2020)

The coming decades may look quite different, provided the right conditions are set to allow the geothermal electricity industry to consolidate across new markets. The Turkish case is a valuable example of an extensive geothermal electricity capacity appearing over little more than a decade thanks to suitable support and regulatory frameworks. There are as many planned projects as there are operational power plants across Europe, on top of which 41 plants are currently in development. Turkey is set to consolidate its place as a leading global geothermal power market. The Italian market is set to unlock an important wave of developments, doubling the number of plants, but depends on a streamlining of the permitting framework that has been leaving projects in limbo for nearly a decade. France and Germany may overtake the steadily expanding Icelandic geothermal power industry in the number of operating projects, however in the case of France recent decisions by the Government to stop support to geothermal power plant threaten this prospect. Several countries are also set to commission their first geothermal power plants over the coming years, and may build up rapidly an extensive domestic capacity. Greece, Croatia and Spain are likely to be very dynamic markets in the coming decade if the policy framework is right.

4 CONCLUSION

Geothermal power plants are a valuable resource to support the drive to decarbonise the European energy system, notably as they are a reliable baseload electricity generation solution. The market has been driven by several leading countries which allowed developers to scale up production and technologies to progress towards market maturity. However the geothermal industry has shown its vulnerability to external disruption until it reaches the sufficient scale. Stop and go policies, as have been observed in France or Germany have negated the realization of a large potential. Regulatory uncertainty around licensing and permitting continue to blog the resurgence of the historical Italian geothermal power industry which is now mainly active in export markets.

The Turkish model however proves that ambitious geothermal policies can be delivered. Several countries now looking to tap into this resource can become new market leaders if they learn from the best practices of the past decade and emphasise predictability and certainty for geothermal power plant developers.

REFERENCES

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