GREEN SALINA ENERGY DAYS

Geothermal Energy: the key enabler to EU energy transition

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Abstract Collection

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INTRODUCTION: THE BIG BET OF GEOTHERMAL ENERGY

The latest IPCC report (2023) warns that the actions being taken are not sufficient to address the climate and energy crisis. The demand for clean and renewable energy continues to rise worldwide. While much of this demand is met by wind and solar energy, these resources are intermittent and require balancing. In short, they are not ideal sources to constitute the baseload of an energy system, and they are certainly unable to meet the overall energy needs still centred on fossil fuels. Geothermal energy production, on the other hand, occurs continuously, making it a significant element in managing the overall energy balance logistically and economically.

Geothermal energy posed a real green challenge for a sustainable energy system. Both the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA) agree on the strategic importance of geothermal energy. A study by the Massachusetts Institute of Technology (MIT) highlights that the Earth's geothermal potential could provide green energy to the entire planet for at least 4,000 years. To grasp its potential, consider that the energy necessary to melt 1 km^3 of basalt (an indicative volume of a significant lava flow, such as form Mount Etna) is about a thousand of TWh (approximately 3 times Italy's entire electricity production!).

While much is known about onshore geothermal production, targeted policies to incentivize its development are still lacking (especially in Italy). What is emerging strongly in recent times, globally, is the enormous energetic potential of offshore geothermal energy. Innovations in technology, partly derived from the oil and gas sector, already enable the cultivation of high-enthalpy geothermal fluid reservoirs. The low ecological footprint of offshore geothermal energy could truly classify it as the most important and sustainable energy resource on the planet. Additionally, geothermal fluids can extract strategically important metals and minerals and produce green hydrogen through electrolysis.

In recent years, global researches and projects in offshore geothermal energy, for example, in the Gulf of California (USA, Mexico), Sea of Japan, Indian Ocean (Indonesia, India), North Atlantic (Azores, Iceland), Philippines, Kenya, and New Zealand, have increasingly highlighted the great potential of this resource in both geothermal and mining terms, in marine contexts favouring high geothermal gradients >100°C/km. The Mediterranean Sea also hosts significant marine geothermal areas, spanning from Spain the Sicily channel and the southern Tyrrhenian Sea to Greece and Turkey. The southern Tyrrhenian Sea is undoubtedly one of the most important geothermal areas in Europe, already subject in 2009 of the world's first research permit for the offshore geothermal production in the context of the Marsili submarine volcano.

Marine campaigns in the early 2000s have also shown that almost all seamounts in the southern Tyrrhenian Sea have active hydrothermal systems currently releasing fluids with chemical and physical characteristics indicating a strong magmatic contribution. The fluids, consisting of seawater penetrating deeply into the seamount structures, interact with hot magmatic rocks, heating up to supercritical temperatures. Such systems, if adequately characterised, represent a thermal energy reserve far superior to any other renewable source.

It is important to note the publication in 2024 of a white paper on offshore geothermal energy by the CGG (Centre for Good Governance, a global leader in Earth technology and sciences) with the contribution of the ISA (International Seabed Authority). The text

emphasises that the diversity and breadth of opportunities presented by offshore geothermal resources have the potential to significantly contribute to many of the United Nations' sustainable development goals.

According to the authors of this white paper, geothermal energy is the only form of clean and renewable energy capable of providing sufficient baseload electricity able to replace coal, oil, natural gas, and nuclear energy as primary sources of electricity and energy for transportation. The development of offshore geothermal resources brings together a range of technologies requiring a diverse network of engineering skills and capabilities. This demand will provide greater job opportunities for high-tech figures, an important challenge within the United Nations' Decade of Ocean Science for Sustainable Development (2021-2030).

The IGA (International Geothermal Association) has recently emphasised that Colombia and Indonesia are defining regulatory aspects to incentivize investments in geothermal projects, including high enthalpy ones, to create a favourable investment climate in the sector.

Finally, it is worth mentioning the publication in January 2024 of the European Parliament resolution on geothermal energy (2023/2111 INI), the first official document committing the Council, the European Commission, and the member states to act with policies supporting geothermal energy, not only in terms of regulatory simplification but also to implement financial support policies to geothermal projects, especially in the exploration and technologies.

A decisive paradigm shift in energy choices is underway, and geothermal energy, particularly offshore, is increasingly seen as a significant resource rather than a problem or even a threat. In the REpowerEU plan of 2022 (European energy security plan), there is a goal to triple the geothermal energy by 2030. Recently, the Italian Minister for Environment and Energy Security has also expressed support for rapid geothermal project development, establishing a dedicated technical committee in February 2022 to define the guidelines for a National Action Plan to revitalise geothermal energy.

Geothermal Energy: A winning perspective *(Marit Brommer – CEO of IGA, International Geothermal Association)*

Introduction:
The global energy landscape is undergoing a transformative shift as the urgency to mitigate climate change and transition to sustainable energy sources intensifies. Among the array of renewable energy options geothermal energy stands out as a promising and reliable solution. This abstract explores the winning perspectives of geothermal, highlighting its potential, advantages, and the strategic role it can play in the global energy mix.

Abstract:
Geothermics, the science and technology of harnessing heat from the Earth's interior, offers a stable and continuous source of energy. Unlike solar and wind energy, which are intermittent and dependent on weather conditions, geothermal energy provides a consistent and reliable energy supply, making it an attractive option for baseload energy generation. This reliability ensures energy security, grid stability and a reliable 24/7 source of abundant energy, crucial factors for modern economies. Moreover, remote communities and islands at the forefront of dealing with climate change adverse impacts and often confronted with high-energy prices, would benefit hugely from widespread roll-out of geothermal projects.

One of the key winning perspectives of geothermal is its environmental benefits. Geothermal power plants emit significantly lower levels of greenhouse gases compared to fossil fuel-based power plants. Furthermore, they occupy less land area and have minimal visual impact, preserving the natural landscape. Innovation is leading to scaling-up geothermal through efficient drilling technologies and installing closed-loop production and injection wells which will help mitigate the risk of water contamination and depletion, addressing environmental and public health concerns.

Economically, geothermics offers substantial long-term benefits. The initial investment in geothermal infrastructure can be high, but the low operational and maintenance costs, coupled with the longevity of geothermal plants, result in competitive cost per kilowatt-hour over the asset´s lifecycle. Additionally, advancements in drilling and extraction technologies are driving down costs and expanding the accessibility of geothermal resources, even in regions previously considered non-viable.

Geothermal energy also holds significant potential for direct use applications, such as district heating, greenhouse agriculture, and industrial processes. These applications provide opportunities for energy diversification and local economic development, especially in regions with high geothermal potential. By integrating geothermal energy into various sectors, communities can reduce their dependence on imported fuels, enhance energy resilience, and create sustainable jobs.

The development of Enhanced Geothermal Systems (EGS) represents another winning perspective. EGS technology enables the exploitation of geothermal resources in areas lacking natural hydrothermal reservoirs by artificially creating subsurface fractures to enhance permeability. This advancement has the potential to vastly expand the geographic range of geothermal energy, making it accessible to a larger portion of the global population.

In conclusion, geothermics presents a winning perspective in the quest for sustainable and resilient energy systems. Its reliability, environmental benefits, economic viability, and technological advancements position it as a key player in the renewable energy sector. The future is bright!

EGEC is inviting geothermal industry stakeholders to endorse a letter calling on the European Commission for a geothermal strategy and action plan. *(Giulia Cittadini – Policy Advisor - EGEC Geothermal)*

EGEC is inviting geothermal industry stakeholders to endorse a letter calling on the European Commission for a geothermal strategy and action plan *[ed.: see appendix 1]*. 6 pillars are identified:

1. A target of 250 GWs of new electricity, heating and cooling supplied energy by 2040 in public, residential and commercial buildings; agriculture; transport and manufacturing sectors;

2. Harmonisation and development of new support schemes including cross-border financial risk guarantees. De-risking resource risk is vital for geothermal investments. An EU or regional instrument is required to ensure that all Member States can benefit from such de-risking guarantee schemes.

3. Endorsement of the Geothermal Industrial Alliance. The geothermal industry is prepared to support the effective implementation of EU legislation. This means working with the EU institutions, Member States, financiers, permitting agencies and materials suppliers to galvanise private capital into geothermal investments for households, businesses, industry and farmers.

4. Accessibility of energy demand and geological data. Digitalising all available geological data and the permitting process into accessible and interactive tools is vital for the geothermal sector.

5. Skilling workers, municipal network planners and permitting agencies: A sufficient and adequately skilled workforce will be critical to ensure this accelerated deployment of renewable energy solutions. Additionally, EU guidance on planning local and regional geothermal heating and cooling systems is crucial because it empowers local authorities to select the most appropriate medium to low-temperature heating and cooling based on local renewable resources.

6. Strengthening innovation and leadership of our domestic manufacturing industry. Geothermal relies upon supplies of locally produced materials, skilled professionals and investment-friendly environments. Exponential growth must be planned with a skilled workforce and a resilient supply chain. The European geothermal energy strategy should contain measures on State Aid, industrial policy, research and innovation actions to support European manufacturing.

The Geothermal Energy challenge: If not now, when? *(Bruno Della Vedova – President of UGI, Unione Geotermica Italiana)*

The challenge of achieving climate neutrality is a global issue that requires a gigantic and coordinated endeavour towards greater sustainability and equity of our development model at all scales, with objectives for 2030, 2050 and beyond. The final declaration of the COP 28 in Abu Dhabi last December 2023 showed how much effort it took to share the long-term vision, highlighting the resistance and difficulties regarding the definition of the methods, timeline and resources required for the decarbonization of the economy.

Among all renewables, geothermal energy is unique for its continuity, efficiency, flexibility and minimal environmental impact which can provide electricity, heating and cooling and, in some cases, strategic minerals such as lithium. Geothermal energy can be used truly everywhere (and not only in active volcanic areas), including developing countries, but it struggles to take off because it requires medium-long term policy, development plans, adequate investments and involvement of the territories. There are new technologies being constantly developed (such as horizontal drilling, closed loop systems, fifth generation district heating and cooling, heat storage) leading to a better scalability and profitability of geothermal projects and to increased investment from multinational companies and from investment funds.

However, there is a strong commitment underway at an international level in geothermal energy research, for a substantial improvement in the technological efficiency and minimum environmental impact, which bodes well for the future. In fact, in the last 10 years many ambitious and innovative projects have started, supported by significant public and private investments, as never before. Here I mention some of the most important: Utah Frontier Observatory for Research in Geothermal Energy (2015), Eavor-Lite closed-loop geothermal (2019) in Canada, Krafla Magma Testbed, coordinated by the Geothermal Research Cluster (2020) in Iceland, Zero -Carbon Lithium (2020), Google-Fervo in Nevada (2021), MIT-Quaise Energy spin-out (2022). Of particular interest is also Japan's choice to develop distributed geothermal plants with limited installed capacity (<7.5 MW), in order to minimise the impact of large plants.

The RePower EU Plan, launched in May 2022 in response to the difficulties and disruptions in the global energy market caused by the Russian invasion of Ukraine, called on European countries to save energy, produce renewable energy and diversify energy supply. To achieve these objectives, agreed action plans, projects, investments and coherent and economically sustainable implementation phases are necessary, involving the Public Administration, the economic-productive fabric, research, industry, businesses, professionals and citizens. The Net-Zero Industry Act, part of the EU Green Deal Industrial Plan to strengthen the competitiveness of Europe's net-zero emissions industry, also proposes geothermal energy and ground-source heat pumps as one of eight strategic net-zero technologies. Manufacturing capacity for these strategic technologies is expected to cover at least 45% of annual installation demand by 2030. The need for a European geothermal strategy and action plan is now becoming more and more crucial, being a key enabler to EU energy transition.

In January 2024, the European Parliament voted almost unanimously (96%) for a resolution to ask for a European strategy to support geothermal energy and its disruptive role in energy security and transition: in particular to reduce procedural times, to explore financial de-

risking solutions, to support investments and encourage States to implement appropriate national strategic plans. Several European countries such as Ireland, Poland, Germany and France have approved organic action plans for geothermal technologies and are proceeding rapidly, particularly with regards to thermal uses. Italy is seriously behind schedule: the FER2, notified to Brussels in March 2023, is still stuck somewhere, while the draft of the Integrated Energy and Climate Plan (PNIEC), sent to the European Commission in June 2023, obtained a first evaluation which essentially underlines the inadequacy of the Italian draft, with respect to the measures to achieve the objectives of climate neutrality and resilience for 2030 and 2050. The National Energy and Climate Plans (NECPs) were adopted in 2019 to start the governance of the energy system and to plan climate impact mitigation actions in the countries of the European Union, with a horizon of 2030, with five main strategic objectives: 1) energy security, 2) energy efficiency, 3) decarbonization, 4) internal energy market and 5) research, innovation and competitiveness.

The draft that Italy sent to Brussels was criticised for the absence of a clear strategy on the energy efficiency of buildings, on combating energy poverty and on reducing CO2 emissions. On the renewables front, Italy has presented objectives in line with the minimum targets required to our country, but in any case, they do not adequately take into account the great potential that geothermal energy holds in the field of renewable energy sources, both for the production of electricity and heat. The preliminary plans presented in 2023 have to be updated by June 2024.

To date, electricity production from geothermal sources is only 2.1% of the total, just as heat consumption is satisfied by only 1.35% of geothermal energy. Heat demand represents 50% of energy consumption and is mostly produced by fossil fuels. Geothermal energy can make a great contribution to this transition, especially in cities, industrial districts and remote areas, like the islands.

The Technical Table for Geothermal (TTG) was born on 24 February 2022, under the coordination of UGI-ETS and the Italian Association for the District Heating (AIRU), and is supported by national and international operators in the heating sector (N=10) and the geothermal electric sector (N=16).

The TTG started a positive dialogue with our Ministry for Environment and Economic Development (MASE) presenting a proposal for a National Action Plan for Geothermal, to contribute to the relaunch of geothermal energy as a strategic resource of the country from thermal uses to geothermal production, to the recovery of strategic minerals from geothermal fluids.

The Tuscan-Tyrrhenian area has the largest geothermal potential of the Central Mediterranean region, both on land and offshore. There are excellent opportunities here for electric power production and utilisation of the geothermal heat, though new technologies are required to start promoting the huge untapped potential of the offshore areas. In Tuscany the geothermal energy covers over 30% of the region's electricity consumption. New permits and projects are growing in several other regions thanks to national and international operators ready to develop geothermal projects with the most advanced technologies.

In the next 15 years the development of medium and high enthalpy for electricity generation, with current technology and on the basis of the industrial plans of the operators on the market, could distribute approximately 13 TWh of electricity into the grid annually, equal to 3% of the demand and more than double the current share (Figure 1). On the other

hand, with the diffusion of new thermal production and storage technologies, the thermal uses of geothermal energy could double the energy produced in a few years.

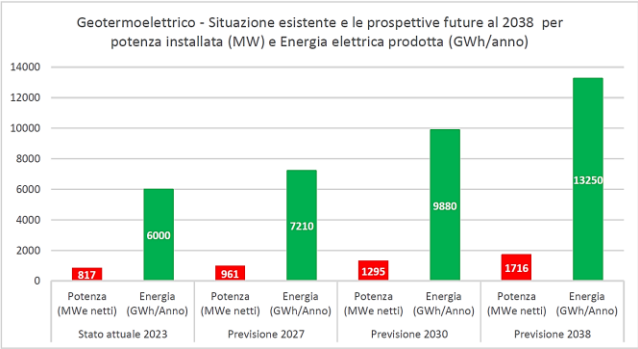

Figure 1: Present status (2023) and future perspectives (2027, 2030 and 2038) for the geothermal power installed (MWe) and estimated energy produced (GWh/y). (TTG Geothermal Proposal for the PNIEC update, 24 may, 2023).

To achieve these objectives, however, it is necessary to define a stable regulatory framework and support measures for the sector so that it can self-sustain on the market. The precautionary estimates carried out by the TTG also envisage the possibility of prospectively replace a large part of boiler and aerothermal heat pump fleet and therefore with a potential production of up to over 28 TWh/year of energy from geothermal heat pumps and a potential of diffusion of district heating of 53 TWh/year, compared to the current 9 TWh, with about 1/3 potentially coming from geothermal energy.

Since the time of Law 896/1986, *Discipline of Research and Cultivation of Geothermal Resources*, geothermal energy in Italy has no longer enjoyed attention. Now, however, it is necessary to quickly make up for the delay of a couple of decades by updating the PNIEC to be sent to Brussels by June 2024. To remove the barriers that prevent its full development and to relaunch the development of the geothermal energy, the TTG carried out four preliminary meetings at the MASE (from November 2023 to February, 2024) on the relevant and crucial topics and actions that we have been proposing for years. Three of them were focused on (i) the simplification of authorization procedures and certainty of the regulatory framework, (ii) on the setup of financial de-risking solutions and introduction of adequate support measures and (iii) on the development of efficient district heating and cooling infrastructures (including geothermal), to allow the acceleration of industrial investments in the medium and long term. A fourth meeting was focused on the actions to promote the presence of the Italian industry in Africa and to propose the creation of a Geo-Training Lab (Strategic plan for Africa, Mattei Plan).

To accelerate the deployment of geothermal technologies, from the borehole heat exchangers, to district heating and cooling infrastructures, to geothermal power plants, the TTG is working in cooperation with MASE to implement appropriate national strategic plans, reducing procedural times, finding financial de-risking solutions, activating incentives and support investments.

The Green Salina Energy Days event is a stimulating multidisciplinary laboratory supported by the Sicilian Region to discuss ideas, understand what holds us back from tapping into this abundant energy source, prepare proposals and roadmaps, attract investors and coordinate

projects among local and national stakeholders to accelerate the energy transition and to demonstrate that the Aeolian Islands could become a best practice example of a carbon neutral archipelago well before 2050.

Exploitation of geothermal energy for the decarbonisation of Greek islands *(Kostas Komninos – General Director – DAFNI Network of Sustainable Greek Island*)

Greece is rich in geothermal resources and one of the most important areas in terms of geothermal energy is found along the volcanic arc of the South Aegean, in which Milos is located. The first high-temperature geothermal field that had been detected was in the island complex of Milos-Kimolos-Polyaigos. Milos is one of the first and most characteristic islands of the volcanic arc of the South Aegean that caused geothermal interest since the 1970s. The Public Power Corporation (PPC) began conducting research on geothermal energy sources in 1973, but insignificant progress has been made over the decades, mainly due to the many errors that hindered its exploitation. A pilot 2 MWe geothermal station operated for about two years in the 1980s in Milos Island but it was eventually shut-down due to technical failures. Another example of efforts for the exploitation of geothermal energy from PPC is the island of Nisyros which has the second highest geothermal field in Greece (350°C/18 bar) and is capable of delivering at least 50MWe. Although Greece has one of the richest geothermal potentials in Europe, it has one of the lowest usage rates in the EU and currently no geothermal electricity is produced in Greece.

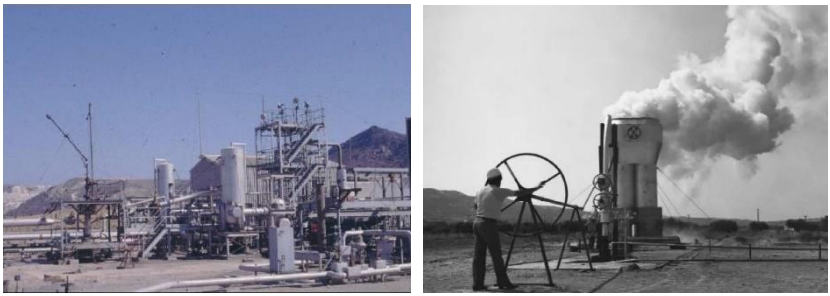

Figure 1: The geothermal station in Milos Island

In Greece, apart from the two aforementioned high-temperature geothermal fields, there are more than 48 low-temperature fields and areas, distributed in other regions of the country. The bulk of exploitable geothermal fields in terms of direct thermal uses (with temperatures up to 90°C) are located in the regions of the Eastern Aegean, Central Macedonia and especially Eastern Macedonia and Thrace, with the certified geothermal potential currently exceeding 200 MW. More recent efforts for geothermal exploitation include the 'Thermopolis' project in Lesvos Island (Polichnitos) which installed a geothermal district heating network with the pilot objective of serving the heating needs of Municipality buildings. The project would be used to draw conclusions for the design of similar applications in other areas of Greece and for the further expansion of the initial system to meet the heating needs of private consumers but it was also shut-down due to technical malfunctions.

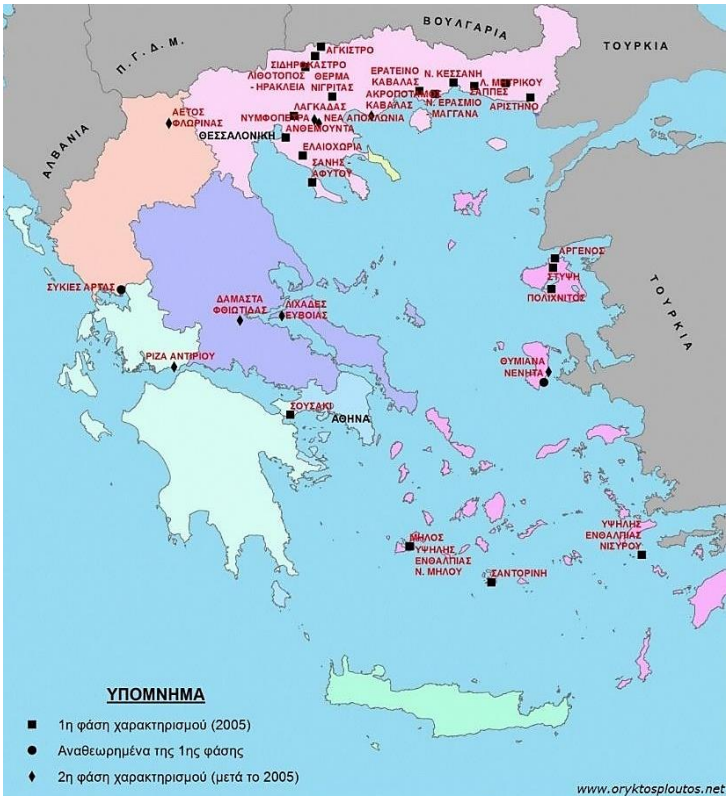

Figure 2: The 45 certified geothermal fields in Greece

Figure 3: The Thermopolis project in Lesvos

PPC's new strategic partner for four geothermal fields (Lesvos, Milos-Kimolos-Polyaigos, Nisyros and Methana) will undertake the financing, construction of the units (8 MW in Lesvos and 5 MW in each of the three remaining areas) and their management. The next challenge is to convince the local community so that valuable time is not lost again. The first exploratory drilling is expected to take place in the geothermal field of Milos so that by 2025 the power plant on the island will be built, while the works in the other three geothermal fields will follow. The new regulatory framework in Greece (although not all regulatory decisions for its implementation have been issued), as well as the high investment interest, show positive prospects for the penetration of geothermal energy in the national energy mix.

Lesvos island geothermal project *(Evangelos Spyridonos – Project Manager Geothermal Projets - PPCR Project Development Department*

PPC started geothermal exploration operations on Lesvos Island in the late 70s. By that time no explicit geothermal legislation existed in Greece.

By 1987, after the appointment of the first geothermal law in Greece (1984), PPC was granted the exploration and exploitation rights (concession lease) for central and NW parts of Lesvos. Geothermal activity on Lesbos is due to Miocene volcanism.

However the main geothermal activities of PPC were focused on Milos and Nisyros Islands, which are part of the active Aegean Volcanic Arc, and no exploration deep drilling was planned for Lesvos, after the completion of the initial geophysical surveys.

Only after the Milos and Nisyros projects were stopped, due to reactions of the locals, PPC focused again on Lesvos. Two wells were drilled by 1999/2000 with depths of 300 m and 1000 m, with measured temperatures between 95 and 105oC. A third well (1400 m depth) was drilled in 2006, after a new geophysical survey (MT-survey) but it failed to spot higher temperature.

The concession was transferred from PPC to PPCR in 2011 and the project started again in 2020. On Lesvos the local communities are supportive to the geothermal project (unlike the case in the southern Aegean Islands).

PPCR is planning to install a small pilot plant (about 150 kW) using the existing wells.

A new seismic survey is planned for 2024, in order to support the decision for deep drilling (according to geothermometer estimations and the geological surveys, a deeper reservoir with temperature between 160 and 220oC is expected deeper than 2000 m).

PPCR has constant communication and consultation with the Municipality of Western Lesvos, to ensure social acceptance and avoid reactions like on Milos and Nisyros Islands.

Raising the great Italian geothermal school: from geothermal fields to the management of energetic budgets. *(Patrizio Signanini – Athanor Geotech Srls*)

A deep analysis of the global energy framework demonstrates that we currently rely substantially on energy derived from the "ancient sun" (oil and its derivatives, with well-known environmental problems) while overestimating the contribution of the "current sun" (solar, wind, hydroelectric, biomass). These exogenous sources can never fully meet the planet's energy needs without causing unsustainable environmental impacts. The real energy challenge lies in harnessing the Earth's heat, an endogenous source par excellence.

Geothermal energy development began in Tuscany more than a century ago, with Italy leading for several decades and creating a school of geothermal excellence. I contributed to this legacy through collaborations with AQUATER-ENI, initiatives of the UNDP (United Nations Development Programme) to train Indonesian (IND-88/009) and Chinese (C.P.R 81/003) geothermal experts, and to develop projects in Bolivia and St. Lucia (Caribbean). I also managed development programs of the Italian cooperation, realising projects to identify geothermal fields in the African Rift (Tendaho, Ethiopia), where the first drillings initiated a long tradition.

The unfortunate abandonment of geothermal energy development in Italy over the past 70 years has caused the country to drop from first to eighth place in the ranking of electricity production from geothermal energy. This has motivated me to dedicate myself to leveraging traditional know-how and enhancing new research and production methods.

In Europe, aside from Iceland and Greece (Santorini), Italy is the only country with active volcanism. Additionally, hydrothermal springs are present in every Italian region, leading to numerous thermal baths. However, Italy currently has only two active geothermal fields, Larderello and Amiata, both in Tuscany-the only Italian region producing electricity through geothermal energy.

It is worth noting that change is occurring. About twenty years ago (2000/2001), an earthquake in the Amiata area led to demonstrations and public calls for the closure of the geothermal field. Thanks to the Seismic Service of Tuscany, this was prevented, and now new drillings are being performed to enhance the geothermal field.

It is time to revive our tradition of studying and framing the context (exploration) to develop geothermal models that allow for the long-term cultivation of identified reservoirs, maximising investment value. For example, the geothermal field in Latera, Latium, developed in the last twenty years, was a failure due to inadequate evaluation of system efficiency parameters, starting with self-sealing issues related to geothermal fluid management.

By conducting detailed geological, hydrogeological, and geochemical studies of geothermal fields, we can achieve an accurate analysis of the system's energy budget. This precise analysis is crucial for recognizing and effectively cultivating geothermal reservoirs, especially offshore.

Geothermal with zero emissions to accelerate decarbonization in Italy

*(*Fausto Batini – *President of Rete Geotermica Italiana)*

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The Net Zero Industry Act of the European Commission (published in March 2023) identifies the geothermal energy as a strategic technology for achieving zero emissions and foresees significant development in the coming years, and the "EU Solar Strategy" it has been defined that to achieve the climate objectives for 2030, the demand for energy covered by geothermal energy must at least triple.

Italy can provide a significant contribution to achieve the European targets for the decarbonization, since only 2% of the heat tapped in the first 5 km underneath its ground could supply up to 10% of the Italian electricity production. Furthermore, the development of the geothermal potential can provide a significant contribution to supply thermal energy, replacing 40% of natural gas, and increase the strategic autonomy (zero dependence for the primary source and for critical raw materials which instead can be extracted from the geothermal fluid), that is key to support the energy transition and European technological independence.

In this framework, technological evolution now allows us to deploy geothermal power plants with no aeroform emissions and no water consumption, through the application of "binary cycle" technology and the complete return of the geothermal fluid into the same reservoir rocks from which they had been withdrawn. This geothermal "zero-emissions" technology is a key driver for the Italian energy transition, as well as for other European countries having already implemented such a solution that ensures high, constant and sustainable production of electrical and thermal energy in multiple applications.

Recently, Rete Geotermica, the Italian cluster of geothermal enterprises, recently presented to the Italian Ministry of Environment and Energy Security a geothermal development plan which envisages the deployment of 44 projects, using "zero-emissions" technology, for a total of 819 MW electric power capacity (Fig.1 - Projects under development @2024).

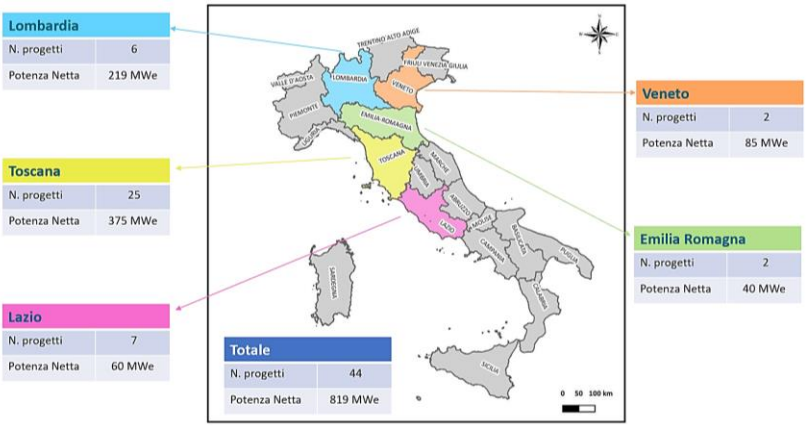

Figure.1 - Projects under development @2024.

The geothermal energy for Saipem: in our DNA, from the past to the future fostering innovation for the energy-mix *(Filippo Abbà – Chief Technology Innovation Officer – Saipem SpA, Mariella Leporini – Technology & Innovation Manager – Saipem SpA)*

Despite its abundance, in 2023 geothermal energy represented only 0.5% of renewables-based global installed capacity for electricity generation, heating and cooling. The growth rate of the sector in the last 15 years has fallen significantly below its potential and nowadays new support schemes are being evaluated for a scale economy of geothermal Energy, in parallel with the continuous development of new technologies.

After a period of limited support from the institutions, there is a global increased and renewed interest in accelerating the development of geothermal resources, considered a strategic clean energy source in view of the path to decarbonization and the improved energy mix, security and sustainability needs.

The IRENA's 2023 World Energy Transitions Outlook report highlights the need to globally add 1,000 GW of renewable capacity per year and identify the geothermal sector as one of those where to increase investments. One of the most widely supported initiatives coming out of the last COP28 held in 2023 is the pledge to triple the world's installed renewable energy capacity by 2030, including geothermal energy. A resolution adopted in 2024 by EU lawmakers calls for a European strategy to accelerate the deployment and investment in geothermal energy, which is also listed among the strategic clean technologies under the Net-Zero Industry Act, alongside nuclear, wind and solar panels.

Saipem recognizes the strategic role of geothermal energy in the energy mix to accelerate the decarbonization of both energy supply and energy consumption.

The large-scale valorization and the exploitation of the geothermal energy represent fields of natural interest for Saipem since they involve the use of technologies, assets and skills close to the traditional core business: as a leader in the drilling and construction of Oil & Gas facilities onshore and offshore, with specific know how and technologies for the execution of large and complex projects around the globe, Saipem have also been involved in the development of projects related to the exploitation of conventional geothermal energy since the 70's. As shown in Figure 1, Saipem drilled many geothermal wells in Italy and around the world and provided technical services (incorporated in 2008 into Saipem SpA through Snamprogetti SpA and Aquater SpA) in the conventional geothermal energy sector.

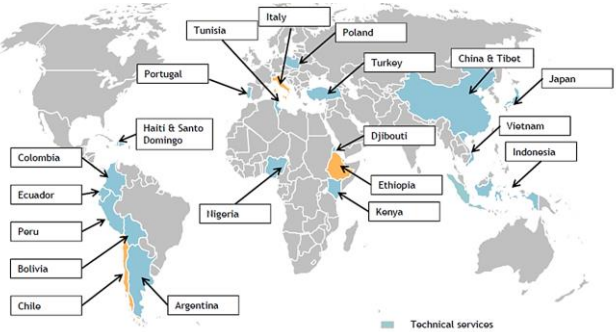

Figure 1. Saipem Track Record in Geothermal Energy

Looking at the future the geothermal energy sector is facing a new paradigm: to enhance production the exploitation of the geothermal resources shall be explored and evaluated beyond conventional use, developing and implementing technologies and unconventional methods of exploration and drilling, including the evaluation of geothermal resources that are currently not economically viable with existing methodologies and moving towards never-exploited geothermal resources such as offshore, combining geothermal with possible co-products in the mineral and metal industry.

In this context and in line with the plan of increasing Saipem role in the energy transition and energy mix, via a continuous upgrade of the skills, technologies and assets necessary for the task, we are focusing on the following four areas of interest:

- offshore geothermal energy: the vast untapped geothermal resources along magmatically expanding centres of the ocean floor, adjacent flooded rift systems, and geothermal fluid reservoirs in submarine volcanic structures could be optimal locations to harvest geothermal resources to generate energy also in combination with the exploitation of co-products such as desalinated water or green hydrogen. Of course, this is not a downhill path: technologies have to be tested, adapted and/or developed, the regulatory framework developed, costs optimised. However, the identification of energy solutions for their large-scale exploitation can make a decisive contribution to the overall energy transition process and the evolution towards renewable, integrated, and sustainable energy production modes. The development of offshore geothermal resources requires high-tech solutions (many borrowed by technology transfer from Oil & Gas) and engineering capabilities that Saipem brings and makes available;
- closed-loop and next-generation systems, wellbore heat exchangers, underground heat storage: as energy storage system and extension of energy conversion to geothermal resources that are poorly exploited or difficult to access, these technologies have the potential to exploit effective geothermal resources in commonly found environments, vastly expanding resource availability and potential commercial adoption;
- CCS with improved efficiency in the capture process by using geothermal energy: analysing the entire CCS chain, the energy consumption of the CO_2 capture process represents a non-negligible penalty in terms of both costs and additional emissions. If the energy required for capture is provided by a carbon-neutral and locally available energy plant, the net carbon emissions and the costs of the capture process are reduced, thus supporting the development of the entire chain. Saipem, a key player in the CCS value chain, owns a solvent-based carbon capture technology, named "CO_2 Solutions", promoted by a proprietary enzyme. One of the key advantages of "CO_2 Solutions" is the low-temperature solvent regeneration that, unlike other CO_2 capture technologies available on the market, allows its integration with low- to medium-enthalpy geothermal energy increasing the benefits of CCS;
- decarbonisation and energy transition of small islands: in line also with the "Clean Energy for EU Islands" programme, geothermal energy can be a powerful catalyst for the energy efficiency and decarbonisation of some small islands not interconnected to national grids and that consist of small, emerged areas developed in an underwater environment rich in geothermal resources. Such islands can therefore become natural laboratories where innovative and economically efficient solutions can also be tested. The possible geothermal utilisation in these areas also aims at considering offshore geothermal energy as a new target for industrial development.

The great challenge of offshore geothermal energy *(Diego Paltrinieri – Athanor Geotech Srls)*

Harnessing the Earth's heat (with an average temperature of 1,000°C) in the marine context, which represents 75% of the Earth's surface, is a significant challenge! Half of the global energy demand could potentially be met by geothermal energy released naturally in underwater volcanic areas.

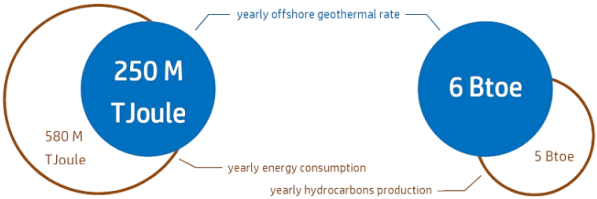

Figure 1: Modified after David L. Williams, 1976 "Submarine geothermal resources"

This is no longer a utopian perspective; its practicability has become evident. There are no longer technological or economic barriers to overcome, but rather a need for awareness of this great opportunity. The International Heat Flow Commission (IHFC) has published the 2023 version of the Global Heat Flow Database, containing about 73,033 data points from 1,414 publications. This collaborative effort between academia and industry compiles authenticated heat flow data to provide a better understanding of the Earth's thermal field.

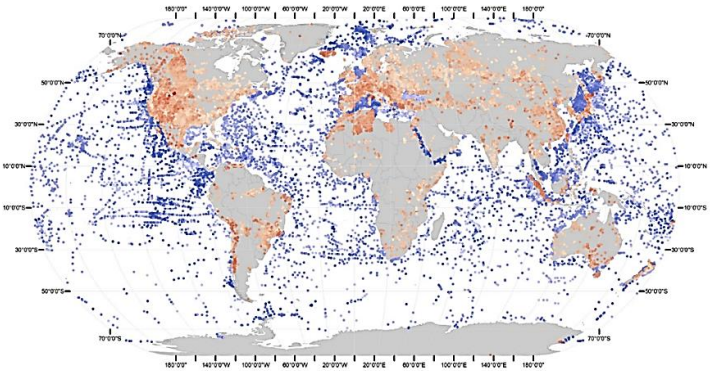

Figure 2: Source: IHFC - Global Heat Flow Database, update 2023

The mid-ocean ridges extend for approximately 65,000 km. Surveys by NOAA and Texas A&M University have identified over 45,000 underwater seamounts globally, covering an area of approximately 28 million km², the size of Africa.

Geothermal energy is often considered an expensive source of electricity. Although geothermal power plants, especially offshore ones, require significant start-up capital and government support during the initial exploration phases, the total capital and operating costs of geothermal power are lower than those of any other energy technology. The potential economic benefits of mineral recovery from geothermal brine have long been identified. Concepts of combined production, including the creation of offshore energy-

mining hubs, could make this resource more economically efficient.

Offshore geothermal energy does not need to be transmitted entirely by cable to shore. The power can be used to electrolyze fresh water from turbine steam condensate to produce transportable green hydrogen or ammonia.

The following figure shows the realistic positioning of offshore geothermal energy in the graph from the McKinsey report (2021) on oil and gas companies' positioning in the energy transition process.

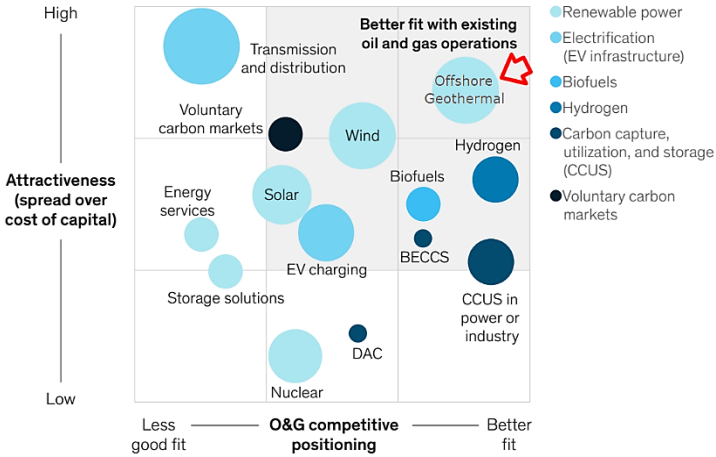

Figure 3: Modified after McKinsey Report 2021, "The big choices for oil and gas in navigating the energy transition"

The overall ecological footprint of offshore geothermal energy is very limited, as geothermal fluids are relatively consistent and chemically benign, being essentially modified seawater. The graph below estimates the geothermal production potential of the southern Tyrrhenian Sea compared to major worldwide geothermal fields.

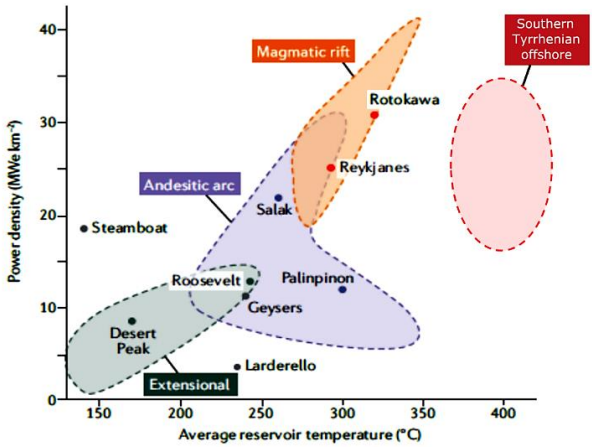

Figure 4: Modified after Jolie et al. 2021 "Geological controls on geothermal resources…"

There are many well-founded technical and logistical reasons to develop offshore geothermal projects, such as:

- Geological offshore conditions favour high geothermal gradients with active hydrothermal systems (convective systems/supercritical fluids >100°C/km).
- Seawater plus sedimentary cover ensures high pressures (P) and high temperatures (T) of the reservoirs and provides recharge.
- There is no need to re-inject fluids, avoiding associated problems.
- Implementation of multi-parameter monitoring networks.
- High-enthalpy fluids allow high yield production: a factor of 10 compared to traditional geothermal wells.
- Offshore drilling technologies, even at high temperatures and pressures, are mature and available.
- Production occurs in a continuous cycle 24 hours a day in all environmental conditions without social impacts.
- Potential cultivation of strategic chemical elements contained in hydrothermal fluids (mining cultivation).

The White Paper "Offshore Geothermal: A Green Energy Resource of Global Significance and Its Responsible Development" published in 2023 by CGG with the collaboration of the International Seabed Authority (ISA), highlights the strategic nature of this resource. It responds to the fundamental criteria of an ideal sustainable electrical energy resource, such as:

- No addition to atmospheric CO_2 - and ideally, it would sequester and actively draw down atmospheric CO_2.
- No use of additional natural land.
- Development at scale and speed under a single best-practice licensing regime, minimising delays.
- Minimal environmental impact, independently monitored under a single protocol for consistency.
- Capable of delivering reliable, steady power, and additional beneficial by-products (such as green hydrogen or ammonia, according to local demand and global economics).
- Use of tried and tested technologies, though potentially in novel combinations.
- No use of critical minerals, and use of materials that are relatively easy to recycle, such as steel.
- No use of freshwater, and it would be a net producer of fresh water.
- No negative impact on existing sea life; it would enhance it, developing aquaculture and enhancing open ocean fisheries.
- Cost-effective.

Geothermal energy in the Aeolian Islands: ongoing work and future projects *(Fabio Di Felice – INGV)*

This presentation, outlines the IRGIE Project (*Inventario delle Risorse Geotermiche delle Isole Eolie*), which was launched by INGV in collaboration with the Regione Siciliana in January 2023 and aims to create an inventory of the geothermal resources of the Aeolian Islands by 2026.

The project's objective is to facilitate geothermal exploration and development activities by identifying the most suitable technologies for the context and estimating the energy production potential, with particular attention to the economic potential of the applications.

The presentation addresses the challenges related to accelerating geothermal development, such as the need for comprehensive mapping of geothermal resources, emphasising the importance of data collection and centralization at the European level.

Additionally, it highlights the necessity to promote geothermal energy, improve local community involvement, and encourage international collaboration to expedite the adoption of innovative technologies.

Finally, a successful strategic model is presented, in which the three main actors - central and local governments, research institutions and universities, and companies in the energy sector - cooperate to ensure the success of geothermal energy initiatives.

Fluids geochemistry as a strategic tool for geothermal energy exploration and exploitation: the results gained for the Aeolian islands *(Franco Italiano – Athanor Geotech Srls)*

It is well known that any geothermal resource is related to the availability of thermal energy, however its exploitation needs an energy carrier: the fluids.

The application of geochemical tools is a cost-effective field survey allowing the detection of areas where thermal fluids are naturally vented. Fluids, in fact, have high mobility migrating through fractures and faults, are fast carriers of information on the physico-chemical conditions at depth and quickly reveal modifications in the equilibrium conditions at depth.

Then coupling the chemical and isotopic features of waters and gases, it is possible to trace the genesis of the fluids, the components, estimate the mixing percentages among the components of different origin and provide early estimation of the thermodynamic equilibrium conditions at depth.

The fluids geochemistry is also a useful tool during the exploitation as it has to keep a balance between thermal energy injection/extraction and fluids extraction/recharge.

Examples of geochemical surveys carried out over areas marked by a wide range of geologic context (i.e. on and offshore environments, active and extinct volcanism, faulted areas, etc.) have shown how geochemical tools work.

The Aeolian islands, a ring-like volcanic arc consisting of 7 islands and 10 seamounts whose dynamics is controlled by active faults. All the 7 islands are characterised by a subduction-related magmatism that is still active. One of the main regional faults moving from the mainland (NW-SE strike-slip fault) splits the arc into two sectors with different levels of

volcanic activity. The eastern sector (islands of Vulcano, Lipari, Panarea and Stromboli) hosts active volcanic islands. Contrastingly, the western sector (including the islands of Salina, Alicudi and Filicudi) has been considered extinct since long time. The geochemical investigations carried out from the middle 80's, had shown a widespread presence of thermal manifestations over almost all the islands. However, despite the absence of on-shore volcanic manifestations as in the case of the islands of Filicudi and Alicudi, submarine hydrothermal activity is recognizable from shallow to deep offshore around all the Aeolian islands.

Geothermal Project in the Vulcano Island *(Franco Caselli – Geolog Srl/Ignis H2 Energy Inc.)*

Geolog is an Italian company, world leader in energy and geothermal services. Since its founding in 1982, the company has developed its own technical and economic solutions for lithological analysis of fluid formation to improve the drilling and completion of wells. Ignis H2 Energy was recently created for the exploration and development of geothermal resources in Turkey, USA and Indonesia.

Geolog has received the preliminary award from the Sicily Region for a geothermal exploration permit on the island of Volcano. The permit has an area of 2 km², the work program comprises a first phase with the acquisition of a 3D seismic survey and a second phase with the drilling of a vertical coaxial geothermal well completely cased at an estimated total depth of 700 m.

The permit has significant geothermal potential given the presence of geothermal reservoirs within the volcanic system that characterises the island. In the past, Agip drilled four wells for geothermal exploration. In 1982, the well Isola di Vulcano, located in the western part of the volcano reached a total depth of 2050 m, without encountering hydrothermal fluids but reaching a bottom-hole temperature of 420°C.

Geothermal energy is the first and foremost, a renewable energy source that allows the reduction of emissions of CO_2, fine dust and other polluting emissions, also due to the absence of combustion processes. Other advantages of geothermal energy concern the stability and continuity of production, which is in no way influenced by atmospheric factors such as temperature or seasons. However, the drilling rate of success in geothermal exploration is not very high and the rate of return is very low.

Green Islands PNRR program, Panarea Island – Geothermal plant for the production of electricity and integration with the desalination plant *(Carmelo Prestipino – Enerstudio)*

The Municipality of Lipari, as part of the Green Islands program of the PNRR, has planned for the Island of Panarea, with measures III.A and V.A, the construction of a desalination plant and a plant for the production of electricity from geothermal sources.

The initiative is an example of perfect integration of two technologies: ORC (Organic Rankine Cycle) turbines applied to geothermal energy for the production of electricity and Reverse Osmosis for the production of desalinated water. The construction of the two plants, installed in proximity to each other, allows for optimization from an energy and environmental perspective.

Considering the compatibility of the seawater flows for the cooling of the ORC condenser with the feed flows of the desalination plant, a single seawater intake can be created to serve both plants. The seawater will be used to cool the condenser of the ORC turbine, and then sent to the reverse osmosis plant for the production of desalinated water. The increase in seawater temperature after passing through the ORC exchanger will increase the efficiency of the reverse osmosis plant, increasing the percentage of permeate production. Moreover, the excess seawater flow necessary for cooling the ORC condenser can be used to dilute the brine that will be discharged back into the sea, with all necessary precautions. Given the potential of the geothermal plant and the planned technology, the construction falls under small local uses pursuant to Article 10 of Legislative Decree 22/2010, with a simplified authorization procedure. Finally, considering the annual need for drinking water, the electricity required for the reverse osmosis process is entirely covered by the electricity production of the geothermal plant.

APPENDIX 1

For the attention of:
Ms Ursula von der Leyen, President of the European Commission

CC:
Mr Maros Sefcovic, Executive Vice-President
Ms Kadri Simson, Commissioner for Energy
Ms Elisa Ferreira, Commissioner for Cohesion and Reforms
Mr Thierry Breton, Commissioner for Internal Market
Mr Janusz Wojciechowski, Commissioner for Agriculture
Mr Wopke Hoekstra, Commissioner for Climate Action
Ms Mariya Gabriel, Commissioner for Innovation, Research, Culture, Education & Youth
Ms Ilze Johnson, Secretary-General

Wednesday 5th June 2024

Dear President von der Leyen

The need to prioritise a European geothermal strategy and action plan

Geothermal is a vital renewable energy solution for Europe. It provides baseload renewable electricity, heating, and cooling. It is the least-cost energy storage solution and the most sustainable means of extracting lithium as well as other minerals. Geothermal is a major consumer of European steel, cement, chemicals and skilled professionals. We are proud to be *'Made in Europe'*.

Whilst the sector continues to grow yearly, this growth rate falls significantly below its potential, and the requirements of the EU's binding climate neutrality target. This puts our competitiveness, security and prosperity at risk. We call on you to urgently correct this situation.

We call upon you to prioritise a **European Geothermal Energy strategy** and an **action plan** for implementation by the industry and Member States. This should be based on six pillars:

i) A target of 250 GWs of new electricity, heating and cooling supplied energy by 2040 in public, residential and commercial buildings; agriculture; transport and manufacturing sectors;
ii) Harmonisation and development of new support schemes including cross-border financial risk guarantees;
iii) Endorsement of the Geothermal Industrial Alliance;
iv) Accessibility of energy demand and geological data;
v) Skilling workers, municipal network planners and permitting agencies;
vi) Strengthening innovation and leadership of our domestic manufacturing industry.

There is considerable political will for a European approach to geothermal. The European Parliament and Committee of Regions voted with almost unanimity in favour of a European strategy

on geothermal to remove the bottlenecks that prevent every sector in all countries from benefitting from this local, reliable and vital energy resource. Simultaneously, Member States such as Austria, Croatia, France, Germany, Hungary, Ireland and Poland introduced national strategies to accelerate geothermal investments and nurture local supply chains whilst tackling the food, energy and climate crises.

Furthermore, we recommend the **Mission Letters** for the Commissioners responsible for energy, climate, agriculture, sustainable industrial growth and regions are granted a mandate to develop geothermal in their portfolios. This ensures a holistic approach to geothermal and ensures that our industry, farmers, cities, and rural areas benefit from low-cost and abundant geothermal energy supplies.

We look forward to working with you to deliver this geothermal strategy and action plan.

Yours sincerely

Mr Philippe Dumas, Secretary General, European Geothermal Energy Council

APPENDIX 2

European Parliament
2019-2024

TEXTS ADOPTED

P9_TA(2024)0049

Geothermal energy

European Parliament resolution of 18 January 2024 on geothermal energy (2023/2111(INI))

The European Parliament,

The European Parliament on January 18th, 2024 approved an important resolution on geothermal energy "P9_TA(2024)0049 Geothermal energy - European Parliament resolution of 18 January 2024 on geothermal energy (2023/2111(INI))". The full text can be downloaded at the link: https://www.europarl.europa.eu/doceo/document/TA-9-2024-0049_EN.pdf.