

The Legal Governance of Geothermal Energy in Europe: A Historical Review and an Indicator Analysis

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Abstract

Along with decarbonization, the importance of renewable energy has increased significantly in the European Union (EU) since the turn of the century, and even more during the war in Ukraine. This study is an indication of how legislation making can be more a driver than an obstacle for innovation. The applied methodology includes an in-depth review of ca. 200 pieces of the EU legislation of the last half century, and a text mining exercise in the EU EUR-LEX database to provide a quantitative set of scores independent of the subjective expert judgment. The historical review of the EU law (“acquis”) reveals that many aspects of the geothermal value chain are covered by the acquis. The quantitative text search of EU policy documents and legal pieces indicates how the intensity of policy making correlates with major drivers on energy and on renewable energy. The regulatory environment of exploration and extraction of high enthalpy geothermal energy is similar to that for hydrocarbons, so some EU member states apply the Hydrocarbons Directive (Annex 32) voluntarily. The legislation on low enthalpy geothermal projects is more detailed regarding technical safety, water management, environment and energy efficiency. Because of conflicts with other emerging subsurface resource uses, such as groundwater/gas/carbon storage and urban underground infrastructure, there is a need for coherent regulatory practices. The broader coverage of this value chain is restricted by the current lack of acquis on spatial development, financial instruments, and geological assets. Addressing these is left to the respective sovereign regulations of member states.

Keywords

Geothermal Energy, Renewable Energy, Legal Governance,

1. Introduction

In the EU decarbonization efforts, and the price volatility and supply disruptions of fossil fuels caused by the Ukraine war induced an increased focus on renewable energy, including geothermal energy. In 2019, the renewable energy share in the EU gross final energy consumption was 19.7%, achieving the 2020 target of 20%, with a renewable share of 34% in electricity production (Eurostat, 2022). Geothermal energy accounted for 8% of the renewable mix, investment in heat pump installations increased 12% in 2020 during the pandemic (IEA, 2020).

The scientific literature on the regulatory framework of geothermal energy projects focuses on the EU member states' (MS) governance (Goodman et al., 2009; Lund & Tóth, 2020; Tsagarakis et al., 2020), on the social license to operate (Soltani et al., 2020; Barich et al., 2022), and on power plants life cycle assessment analysis (LCA) (Tomasini-Montenegro et al., 2017; Tosti et al., 2021; Carrara et al., 2023; Blanc et al., 2020), with less attention on the EU acquis (Hámor, 2006; Hahnlein et al., 2010; Angelino, 2017; Dumas, 2019). One reason is that MS have sovereign disposition over fuels, minerals, geothermal and groundwater resources on their territories because the proprietary decisions on the exploitation of these dominantly national assets are out of the scope of the EU primary law, i.e., the Treaty of the Functioning of the EU (TFEU (1957, last consolidated version 2016)) (Christmann et al., 2014; Hámor, 2004; Hámor et al., 2020; Hámor et al., 2021a; Hámor et al., 2023; Hámor-Vidó et al., 2021). The history of the EU energy policy has also been published in numerous works (e.g. Matlár, 1997).

The policy context highlighting the relevance of this work is 1) the strengthened exploration and extraction of intra-EU geothermal resources induced by the principles of sustainable and safe energy supply, social and economic resilience, open strategic autonomy, circular economy, and criticality of technology raw materials (European Commission, 2015); and 2) the Energy Union Regulation (2018) (Annex 145), which is to integrate, amend, replace numerous planning, reporting and monitoring provisions embedded in current sectoral energy and climate acts, to introduce a streamlined and harmonized approach.

This study 1) provides a most complete historical review of the development of the acquis relevant to geothermal energy, identifying ca. 180 legal pieces (listed in the Annex), 2) which is supported by a representative quantitative search of indicative terminologies in the EUR-LEX database; and 3) presents an interpretation of the above results with regard to the value chain coverage by the acquis that allows for conclusions about highlighting regulatory gaps at the EU level. This is the fifth thematic analysis in line (Hámor, 2020; Hámor et al., 2020; Hámor et al., 2021a; Hámor et al., 2023) to show that text mining in massive le-

gal datasets serves as a reliable independent parameter, its time series provides a firm support to subjective historical reviews on sectoral policy and legislation making. Understanding the nature of policy and legislation making by scientists and engineers is increasingly important since it became a driver for innovation, for example in case of green energy and e-mobility. This interdisciplinary article is to bridge the mutual knowledge gaps of both jurists, scientists and engineers active in the promotion of green energy solutions.

2. Methods

The EU *acquis* is “*supranational*” law. Its primary legislation is of treaties and international conventions. Treaties regulate the thematic scope of the EU law, the tasks of EU entities and the legislative, executive and judicial procedures. According to Art. 288 of the TFEU, secondary law comprises: 1) regulations, directly applicable in all MS; 2) directives, binding as to the objectives to be achieved, while ensuring for national authorities the choice of format and regulatory tools to be applied; and 3) decisions, mandatory for specific topics and addressees. Union competences are governed by the principles of subsidiarity and proportionality. In areas which do not fall within its exclusive competence, the Union acts only if and in so far as the aims of the targeted action cannot be efficiently achieved by MS, either at central, regional or local level, and where they would instead, by reason of the scale or effects of the proposed action, be better achieved at Union level (TFEU Art. 5). According to the rule of conferral, the EU steps in within the limits of the competences set in the TFEU. The legal pieces identified as relevant for geothermal energy are listed in the Annex to this paper. The scientific literature and the cited policy documents are indicated in the List of References of this publication.

For studying the EU law, the EUR-LEX information center was used, and relevant works (Hámor, 2004; Hámor et al., 2020; Hámor et al., 2021a; Hámor et al., 2023; Hahnlein et al., 2010; Angelino, 2017; Dumas, 2019; Mitchell et al., 2016) were reviewed. For the quantitative trend analysis, as an independent indicator approach, the advanced search functions of the database were applied with the “*all documents*” choice which comprises all legal pieces and policy documents in a broad sense. The text search was applied to both document titles and text bodies for the terms “*energy*”, “*renewable energy*”, “*geothermal*”, and “*heat pump*”. The studied historical timespan is 1970-2022. This methodological approach was invented by Hámor (2020) on national scale, and extended by Hámor et al., 2020; Hámor et al., 2021a; Hámor et al., 2023 on the EU scale. However, it is noted that the EUR-LEX search engine has errors for the previous century’s poorly scanned documents. A limited number of documents are uploaded retroactively. Nevertheless, the statistical credibility, i.e. thousand scale scores in the ten thousand all documents scale, is convincing, and this indicator complies with the “RACER” criteria set of the EU (relevant, accepted, credible, easy to compute and monitor, robust against manipulation) (European Com-

mission, 2009). The value chain chapter uses the system boundaries and value chain stages slightly modified after Blanc et al. (2020).

3. Results

3.1. A Historical Review of Geothermal Energy in the EU Law

3.1.1. The Early Years (1950-1999)

An objective of the Rome Treaty (1951), a precursor of the EU, is “to promote a policy of using natural resources rationally and avoiding their unconsidered exhaustion.” The Euratom Treaty (1957) has provision on radioactive minerals access, calling for a “common supply policy on the principle of equal access”. In TFEU, energy and environment are sectors of “shared competence”, therefore the EU may act but MS cannot so long as the EU is taking steps (“pre-emption”). The earliest directives on environment were on dangerous chemical substances, waste management, water, nature conservation, accidents, impact assessment (Annex 2, 4, 6, 7, 11, 14, 17) during the 1970-80s. The Environmental Impact Assessment (EIA) Directive (Annex 17, 104) identifies geothermal drilling as an activity for which the MS decides whether to make it subject to an assessment. The Groundwater Directive (Annex 12) provides an option for MS on whether to permit re-injection into the original aquifer of water used for geothermal and other purposes.

The mining industry, as well as the upstream of the oil and gas industry (i.e., exploration and extraction), enjoyed a distinguished position (Annex 1) also as an exclusion in the scope of environmental directives, but hydrocarbons’ downstream (distillation, refining, storage) was regulated by the Seveso I Directive (Annex 14). The *acquis* on technical safety and worker health was also introduced (Annex 13, 19).

During the early decades the energy legislation was limited to reporting obligations and financial support of energy projects and public procurement rules (Annex 3, 5, 8, 9, 15, 16, 20, 21, 23) usually with the explicit reference to geothermal energy as a renewable energy resource (“*alternative energy*” was also in use at that time). Decision 75/51 (Annex 5) is the first piece in the *acquis* mentioning geothermal energy, and Regulation 729/79 is the first and as yet only monographic piece which covers exclusively the geothermal sector (Annex 5, 10). The enhanced use of renewable energy has been an objective of the energy policy since 1986 (European Council, 1986). This principle prevailed in the following decades, as shown by the adoption of numerous legislation. This legal framework defined realistic quantitative objectives, with positive outcomes, such as the dramatic growth of heat pumps market and other low enthalpy applications. The preparation for a European energy union started in 1994 with numerous policy documents (European Commission, 1994, 1995, 1997).

The 1990s brought a growing legitimacy of environment protection. The Amsterdam Treaty (1997) introduced an up-to-date policy by integrating the principles of sustainable development and the “*prudent and rational utilisation*

of natural resources.” Beyond the laws on the different emissions, and environmental compartments (Annex 25, 27, 31, 33, 36) an array of “horizontal” law was published, such as access to information, risk assessment methodologies, integrated pollution prevention and control, eco-management scheme, and product safety (Annex 22, 30, 34, 35, 28). The Regulation on ozone depleting substances is relevant to circulating fluids in heat pumps (Annex 31).

In the field of energy, the concepts of interlinked transmission grids and efficiency were introduced (Annex 24, 26). A specific Directive deals with worker safety for drilling in the minerals-extracting industries (Annex 29), and another one on the conditions for granting exploration and production of hydrocarbons (Annex 32).

3.1.2. Major Developments in Energy and Climate Regulatory Fields (2000-2009)

After the turn of the last century, the energy sector and renewables were increasingly covered by the acquis in a broad spectrum, also in harmony with the new climate policy (Annex 43, 53, 79, 82, 85, 96). The Renewables Directive set national indicative targets for renewables (Annex 42), and its by-laws set details on co-generation, including geothermal power plants, on energy efficiency, eco-design criteria, ecolabels, and national renewable energy plans (Annex 56, 67, 84, 88, 95, 999). Legislation was backed by a numerous roadmaps and performance assessments of the renewable sector (European Commission, 2004, 2006). The Directive on Buildings Energy Performance (Annex 48) directed MS to develop national energy renovation strategies where geothermal technology, incl. heat pumps, must be considered. As a result, a set of technical requirements was published (Annex 48, 71, 73, 75), and the legal definition of heat pump was created: “*a device or installation that extracts heat at low temperature from air, water or earth and supplies the heat to the building*”. Two major milestones, the Energy Community Treaty (Annex 70) and the Lisbon Treaty (2007) were approved and practically the entire energy sector became subject to EU legislation, such as those covering taxation rules, statistics, trade, public procurement, critical infrastructures, gas market, minimum stocks of oil, and energy infrastructure (Annex 54, 60, 64, 74, 76, 77, 81, 86, 87, 97). Eventually, the amendment of the Renewables Directive in 2009 (Annex 84) provided a definition on geothermal energy: “*energy stored in the form of heat beneath the surface of solid earth*” which ensures a broad interpretation for geothermal applications without any temperature limitations, in contrast to some national legislation in force at that time (Goodman et al., 2009).

The Opinion of the European Economic and Social Committee (2005/C 221/05) is the only monographic political document that deals exclusively with geothermal energy. It calls for “*legislation to promote private investment (e.g., laws on the sale of electricity to the grid, heating and air-conditioning systems) designed to provide initial, tapered support for commercial launches...*”.

The Energy Community Treaty (2006) and the Lisbon Treaty (2007) created

an integrated market in gas and electricity with a consolidated regulatory and market environment capable of motivating investment in grids, power production and cross-country transmission networks, so that all have access to resources and supply. Later it progressed to a higher level by reinforcing security of supply through transnational grids, the promotion of renewables and improving efficiency, and the de-carbonization of the energy mix in line with international climate conventions.

This period is also characterized by a widening scope of environmental legislation. The novel Water Framework Directive (Annex 38) introduced the river basin scale complex management concept, covering also thermal groundwater bodies. Geothermal reinjection remained an option, not an obligation (Article 11), indicating that the Directive is focusing more on water quality than the quantitative aspects. Its “daughter” directives comprise relevant references on polluting substances, and groundwater protection (Annex 45, 68). Other environmental legislation covered noise, pollutant emissions registers, impact assessment, product safety, information access, worker exposure, public participation, liability, air quality, chemicals safety, eco-management schemes, and bird protection (Annex 37, 47, 39, 62, 41, 50, 51, 58, 52, 72, 57, 59, 65, 83, 89). All these are relevant for developing and operating geothermal projects, especially high enthalpy ones, and some refer explicitly to geothermal or heat pump activities (Annex 37, 38, 79, 82). Surprisingly, well-control equipment of geothermal wells, pressurized transmission systems, steam engines, compressors and pumps are excluded from the scope of the Directive on pressure equipment (Annex 125, 159).

The waste management acquis also expanded, with new pieces published on the Waste Catalogue, statistic entries, electronic waste, landfills, packaging waste, the waste framework as it defines end-of-waste and by-products, and quantitative recycling figures for construction and demolition waste (Annex 40, 46, 49, 36, 55, 63, 78, 80). In addition, rules on the extractive waste stream were released (Annex 66, 90-94). Beyond heat pumps disposed of and classified as electronic waste, the most crucial issue in the waste acquis relevant to geothermal projects is the interpretation of drilling muds. The Extractive Waste Directive (Annex 66) has a definition on the extractive sector, the interpretation of which is debatable for geothermal drilling (“*extraction of mineral resources (i.e., ‘a naturally occurring deposit in the earth’s crust of an organic or inorganic substance, such as **energy fuels**, metal ores, industrial minerals and construction minerals, but excluding water’)* for commercial purposes, **including extraction by drilling boreholes**”), but there is a distinct entry for drilling mud in the EU Waste Catalogue (Annex 40).

In 2008 the Raw Materials Initiative (RMI) (European Commission, 2008) introduced three pillars: 1) access to reserves on international scale, 2) reinforcing supply from EU sources, and 3) improving resource efficiency and recycling. Efforts on regulating the domestic pillar were opposed by MS claiming to retain

supervisory authority of this original asset within their sovereignty. Nevertheless, the list of critical raw materials, the Resource Efficiency Roadmap, and the European Innovation Partnership on Raw Materials were released (e.g. [European Commission, 2012a](#)).

3.1.3. Diversification of the Regulatory Scope, the Green Deal (2010-2022)

Law making in the recent past is characterized by the enhanced diversification of the energy and environment acquis, the modernization through amendments, the “smart” regulation approach, and novel policies which have not manifested into laws but address topics relevant to geothermal sector such as on unconventional hydrocarbons, non-fuel raw materials, circular economy, and open strategic autonomy.

The new energy legislation focuses on infrastructure, export credits, accounting, research, state aid, concession, procurement, labelling, statistics, internal market rules, resilience, climate change mitigation, and district heating, many of which have explicit citations on geothermal energy (Annex 106, 118, 144, 121, 162, 103, 107, 117, 120, 122, 123, 124, 139, 140, 173, 154, 163, 167, 168, 174). The most remarkable development regards heat pumps covering practically all aspects (Annex 108 - 110, 113, 114, 116, 126-129, 131-134, 151, 169, 179). The best environmental performance standards for the different sectors require the consideration of geothermal energy and heat pumps supply (Annex 137, 141 - 143, 148, 155 - 157, 171, 172). Heat pump technology is acknowledged by the EU Strategy for Energy System Integration (COM (2020) 299) as a prime technology for decarbonizing domestic heating, hot water generation, and to cool buildings and industry. According to Eurostat, heat pumps represent half the increase in renewably-sourced heating and cooling between 2016 and 2018. A number of policy documents were published on the planning and monitoring of the renewable sector, and its role in the future ([European Commission, 2011b, 2012b, 2016, 2021a, 2021b](#); [European Parliament, 2012b, 2024](#)).

The classic environmental fields have been fine tuned (Annex 101, 102, 104, 130, 136, 138, 149, 150, 158, 152, 160 - 162, 177), and with some delay, the circular economy concept was adopted [33]. The US shale gas success did not generate precaution in EU policy makers, the issue brought attention in 2011 when France set a ban on hydraulic fracturing. The Commission and the Parliament issued numerous reports and communiqués but this field remained on the level of a recommendation ([European Commission, 2011a, 2012c, 2014](#); [European Parliament, 2012a](#)). During the same period, deep geothermal projects’ (e.g., HDR) hydraulic fracturing sometimes induced earthquakes ([Goertz-Allmann et al., 2011](#); [Soltani et al., 2020](#)).

In 2019, the new growth strategy *Green Deal* was “to transform the EU into a fair and prosperous society”, and a competitive economy with no emissions of greenhouse gases by 2050, and where economic growth is decoupled from resource use. The new climate legislation aims at the reduction of GHG emissions

by 55% by 2030, as compared to 1990 levels (Annex 145, 147, 151). The clean energy sector is assisted by the cohesion funds, the Horizon Europe programme, the Connecting Europe Facility, the LIFE programme, the Innovation Fund, the Modernization Fund, and the Social Climate Fund.

In 2022, the Regulation on a framework to accelerate the deployment of renewable energy (Annex 178) is the first breakthrough piece interfering with sovereign public administration procedures which prescribes concrete permitting deadlines for power plants and heat pumps and provides the option of classifying them as projects for “overriding public interest”. Among the recent initiatives, acknowledging the needs for the high-tech materials in the transition to green economy, a draft Critical Raw Materials Act was released in March 2023.

4. Discussion

4.1. Historical Trends, as Indicated by Quantitative Indicators

As described in the methodology chapter above, an independent quantitative parameter, an indicator of the historical trends was applied to support or to counterbalance the occasionally subjective assessment of the researchers. Text mining is not novel but the authors were the first to use it in the EU legislation database for relevant and specific terminologies. The scores of the thematic text search in the EUR-LEX database are shown in **Figure 1**. As indicated earlier

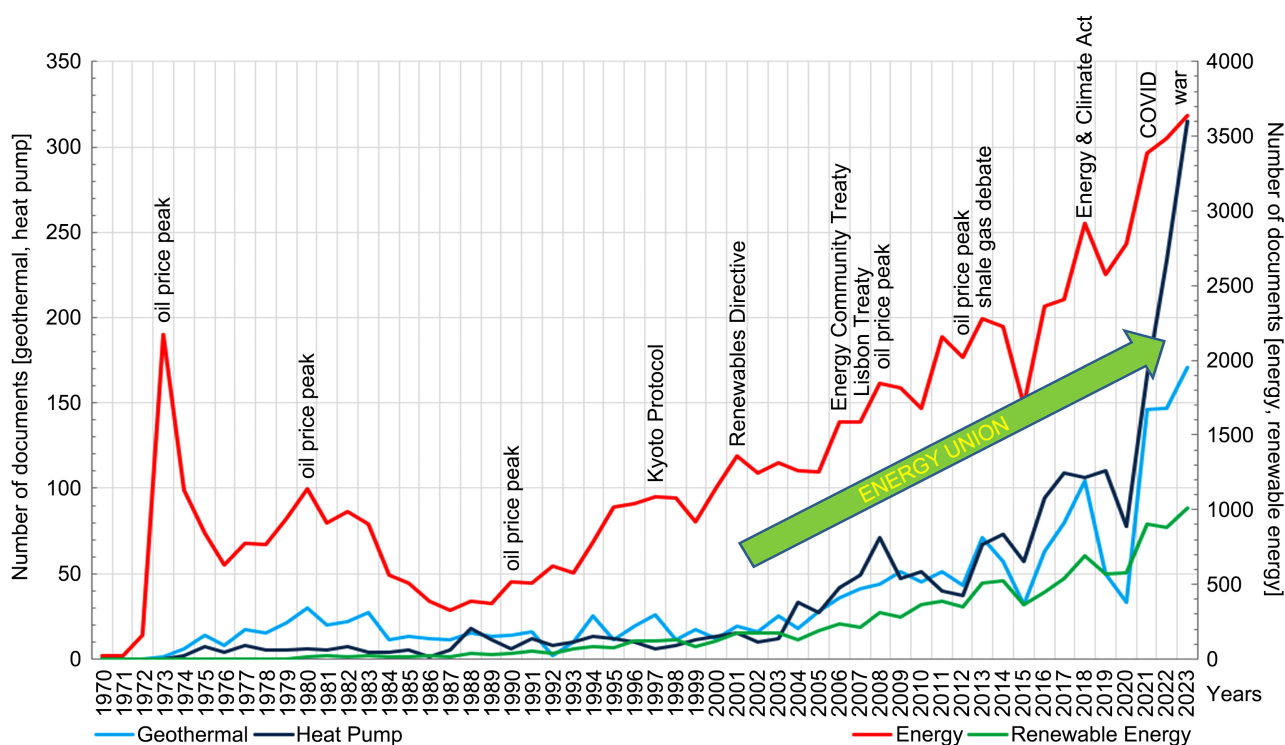


Figure 1. The trend of “energy”, “renewable energy”, “geotherm” and “heat pump” related documents and legal texts in the EU during the last half century and its major policy drivers such as oil price fluctuations, adoption of major laws, political debates and other crises (COVID, war). Please note the different scales on the left and right axes for the different terms. Legend: “energy” in red, “renewable” in green, “geotherm” in deep blue, “heat pump” in light blue.

(Hámor et al., 2021a), the frequency of energy related documents are indicative of the political focus generated by the oil price peaks of 1973-74, 1980, 2011-14; the establishment of the Energy Union by the Lisbon Treaty during 2006-2009; and shorter periods of political turbulences such as the 2008 economic crisis, the discussion over unconventional hydrocarbons and hydraulic fracturing in 2011-2014, and the Ukraine war. Negative minimums, such as occurred in 2015, may be a reflection of the change in administration at EU bodies, which produce most of the documents in the database. With the current methodology it would be too demanding to study all 80 k documents and screen the overlapping effects of the above drivers.

Nevertheless, the time-wise curves of the rest of the data show a relatively good correlation with energy and each other, and a stable increasing trend over the last 30 years. Surprisingly, documents on geothermal energy and heat pumps pop up a few years ahead of renewable energy in 1973 and 1974, respectively, as in the seventies the term “alternative energy” was already in use. The growing importance of renewables is clear: whilst two decades ago 10% of the energy docs dealt with renewables, in 2022 the proportion was up to 30%.

The curves indicative for the renewables correlate fairly well, and the definite increase starts in 2003 with directives on renewables, energy performance of buildings, and power co-generation. Since 2004, there are more mentions of heat pumps and then geothermal energy, which is reasonable with regard to the legislative topics as listed in the Annex. As described by the historical review of the acquis, the number of publications has skyrocketed since 2020 due to the political response to COVID and war crises, which also accelerated the full development of the Climate and Energy Union. Due to this, the attention on heat pumps has tripled during the last three years. The effects of policy drivers and legislative actions presented in the historical review above have a clear reflection on the document statistics, as shown on **Figure 1**. It is concluded that independent quantitative text-mining results can be used as objective indicators for monitoring verbal disciplines such as policy and legislation making.

4.2. Subsurface Conflicts and Synergies

Hámor-Vidó et al. (2021) introduced a new classification system of underground natural resources, and highlighted the potential conflicts among them, disregarding other environmental issues on the surface. The clusters with white fonts at **Figure 2** indicate the conventional exploitable geological resources, the ones in black are the types of underground space (i.e., geological formations) which can be in conflict with geothermal energy extraction. Very likely, groundwater is the environmental compartment and natural resource which is in most competition with geothermal energy. Open geothermal systems which use groundwater may disturb the hydrodynamic balance of drinking water reserves, and shallow heat pumps may cool down and desiccate the soil and subsoil of local vegetation. Inappropriate reinjection of used thermal fluids may pose a risk to groundwater

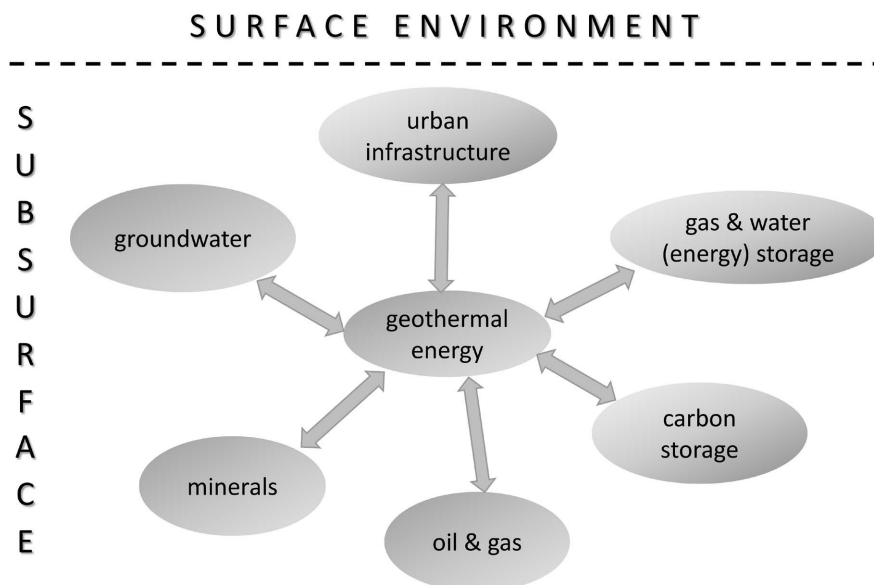


Figure 2. Major physical, environmental and permitting interactions/conflicts for geothermal energy and other underground resources.

quality and pressure conditions, and for this reason, stakeholders called for detailed guidelines on the implementation of the Water Framework Directive (Hámor, 2006). Badly designed, poorly cemented drillholes may intersect and connect protected aquifers with shallow contaminated ones or deep saline ones.

The geothermal sector has much less interactions with solid mineral extractions. One obvious source of potential conflict is again groundwater, since both open cast and underground mines often induce a local groundwater depression due to the extensive pumping of water either to make mine voids dry for operations or by the use of water for mineral processing techniques (Hámor et al., 2021b; Garbarino et al., 2021). Conversely, it is not a conflict but a potential synergy when deep-seated metalliferous ores and geothermal energy can be co-produced by leaching metals from the mineralized rock and recovering them at surface, allowing for the co-production of energy and metals (Hartai & Madarász, 2019). In addition, mines are increasingly used as geothermal reservoirs after the extraction is terminated (Verhoeven et al., 2014; Chudy, 2022). The use of exploited oil and gas fields for geothermal projects is another familiar theme. In numerous countries the exploration and extraction of hydrocarbons and geothermal energy are both permitted through concession tenders and contracts, where the mining acreage is designated in 3D spatial dimensions (Hámor et al., 2021a). The mining plots of both and their protective safety pillars (i.e., hydrodynamic security zones) can be very close or overlapping, competing for the same underground space. In this case, usually the “first come, first served” principle prevails. Moreover, geothermal wells may produce inert (N_2 , H_2S , CO_2) or even combustible gases (H_2 , CH_4) as by-products, sometimes only flared off. The reverse is also possible, when hydrocarbon wells produce thermal water which is not utilized.

Energy storage of gas and water, and the disposal of carbon dioxide, are utilizations which usually target the same geological formations and similar geothermal projects. According to Hámor-Vidó et al. (2021), this conflict could be solved by establishing 3D inventories of potential underground space host formations which are integrated into national or regional spatial planning, allowing for the criticality assessment of their potential use in course of strategic impact assessments.

Conflicts with the subsurface urban infrastructure are physical in nature. The density and the lack of high-resolution 3D maps of underground objects require prudent planning and cautious drilling for ground-source heat pumps and deeper geothermal systems. Hydraulic fracturing is not an option in urban environments. Moreover, there are conflicts within the sector, as for example where heat pump systems in residential areas may cool down neighbors' land, which is why in Germany local regulations prohibit the installation of heat pump collectors closer than 6 meters from property boundaries (Goodman et al., 2009).

4.3. The Value Chain Context

The front-end of the geothermal energy value chain is not regulated completely by the EU law (Table 1). Similarly to what Hámor (2004) and Christmann et al. (2014) found in the case of minerals, and Hámor et al. (2021a) in the case of hydrocarbons, elements of geothermal-resource exploration are covered, such as technical safety, workers health, and impact assessment of drilling. The positive example is the mandatory publication of concession calls on hydrocarbons, but that Directive (Annex 32) has no obligation on geothermal calls. Italy and Hungary applied it on a voluntary basis. Under the aegis of the Water Framework Directive (Annex 38), the delineation and designation of thermal groundwater bodies is a routine exercise by MS, although an EU standard for an inventory of geothermal reserves is lacking. The UN ECE Framework Classification on Geothermal Energy¹ is the first international initiative which could lead to a harmonized approach. This could also support the environmental spatial data service as required by the INSPIRE Directive (Annex 72).

The major legal concern is related to geothermal drilling, although yet an exceptional technique: on hydraulic fracturing, the classification of drilling muds, the reinjection of fracking fluids, proppants, and production water; and the debate as to whether fracking fluids and proppants are under the scope of the Chemicals Regulation ("REACH", Annex 65) regulation (Durling et al., 2017). If yes, it should be more precise on registration of fracking fluids and drilling muds. With regard to earthquake risks generated by fracking, the Directive on Construction Products (Annex 44) has only a general requirement on mechanical resistance and stability, and there are standards for geotechnics and seismic design, Eurocodes 7 and 8, respectively. The Extractive Waste Directive (Annex

¹<https://unece.org/sustainable-energy/sustainable-resource-management/unfc-and-geothermal-energy> (accessed 10 February 2023).

66) and its implementing decisions, the Waste Framework Directive (Annex 80), and the European Waste Catalogue (Annex 40) are applicable for drilling muds and rock chips, but the classification of fracking fluids (incl. proppants) is unclear, as well as naturally occurring radioactive materials (NORM) in regards to drilling tools and fluids. The Industry Emissions Directive's (Annex 101) scope also has uncertainty with regard to fracturing fluids. The Seveso Directive (Annex 14, last amendment is 2012/18) on industrial accidents is applicable for drilling mud and fracking fluid disposal above a volume threshold of dangerous substances.

The development phase of geothermal projects is rather well covered by the acquis. The environmental legislation covers the majority of environmental compartments and pollutant emission typologies, with the exception of soil and subsoil. The attempts to approve a soil directive failed in 2006 (Montanarella, 2015) but in 2023 a new draft was released. Emissions are regulated by directives, but MS have a certain degree of freedom to publish their national threshold values for non-priority substances. A major flaw is the lack of a law on spatial development and land use planning. This can lead to conflicts with other utilizations of underground space. The only legal document mentioning the risk of collision with geothermal projects is the Directive on the Geological Storage of Carbon Dioxide (Annex 85).

At the production/operation stage the raw material supply to technologies and installations remains a subject of political documents. The safe supply of raw materials was apparently not thought critical in the case of geothermal technologies (Carrara et al., 2023). In this context, EU is committed to life-cycle and circularity assessments, including recyclability and reusability of products. A recent European Commission Communication (2021) found that heat pumps have no specific vulnerabilities in this regard, apart from the $\geq 60\%$ import dependence of aluminum and zinc. As concerns power plants, the raw material supply for permanent magnets at the turbine and generator, and the copper supply for the heat exchanger, can be of concern.

Geothermal power plants are subjects to nature conservation law. If such a project may affect a Natura2000 biodiversity conservation site in a significant manner (Annex 27, 89), a prior appropriate assessment must be prepared. However, the functioning of these rules is uneven across MS (Hámor et al., 2021b). As concerns the groundwater context, Hahnlein et al. (2010) and Tsagarakis et al. (2020) revealed that the national laws across the EU are heterogeneous, and although the Water Framework Directive (Annex 38) classifies heat input into the aquifer as pollution, guidelines are vague. Article 11 (3. j) of the Directive leaves some room for interpretation: "*Member States may authorize reinjection into the same aquifer of water used for geothermal purposes.*" In many MS this is not an option but an obligation, in line with sustainable and circular groundwater reservoir management principles.

Surprisingly, well-control equipment of geothermal wells, pressurized

Table 1. EU legal governance on the geothermal sector across its simplified value chain, indicating major legislation gaps, examples for good legislation, and an expert estimate on the level of coverage by the legislation as indicated by “+”.

	Exploration & project planning	Production of materials, components, technology	Construction, commissioning	Operation, maintenance	Distribution, transmission	Decommissioning, recycling, disposal
Coverage by EU law	+	++	+	++	++	+++
Major gaps	fracking, inventory & protection of reserve, financial risk	raw materials supply	spatial and land use planning	pressure equipment, reinjection	hot water & steam pipelines, financial tools	re-use of wells
Good examples	confined permitting, hydrocarbon concession calls	heat pump technology	technical standards of products	energy efficiency, environ. emissions, technical safety, workers health	electricity grid, env. & econ. accounting & reporting	waste management

transmission systems, steam engines, compressors and pumps are excluded from the scope of the Directive on Pressure Equipment (Annex 125, 159).

Geothermal power generation, heat pump technology, and energy transmission grids are well regulated on EU scale, although there are no explicit references on pipelines for thermal water or steam. The general EU technical and product safety rules must be applied. Workers health and safety are covered in depth by the *acquis*. The *acquis* on project finance, concessions, economic accounts, statistics, procurements, and taxation is detailed, and these pieces clearly list all geothermal projects in their scope.

The back-end part of the value chain of such projects is increasingly coming into the focus of the legislation. Discarded heat pumps are classified as electronic waste in the WEEE Directive (Annex 105) with ambitious recycling targets. The decommissioning of geothermal power plants is covered by the waste *acquis*, recycling targets for construction and demolition waste exist in the Waste Framework Directive (Annex 80), and criteria for metal scrap are regulated. Landfills are to be avoided but have been a traditional legislation subject since 1999 (Annex 36). The application of the EIA Directive (Annex 104) may imply post-closure monitoring. In this study, the downstream secondary value chains (electricity and heat use, cooling, balneology, drying, dyeing, melting, etc.) are out of scope and beyond the system boundary.

A “horizontal” issue is the permitting procedures at all stages of the value chain. The *acquis* is rather limited on public administration details. According to Articles 41 - 42 of the Charter of Fundamental Rights (2000), persons have right to have their affairs handled impartially within a reasonable time by the authori-

ties, inter alia 1) to be heard, before any measure which would affect him/her adversely; 2) access to his/her dossier; 3) the authority must justify its decisions; and 4) compensation for any damage caused. As a close analogue, the Strategic Implementation Plan² of the European Innovation Partnership on Raw Materials (European Commission, 2012a) calls for efficient regulatory framework with streamlined granting procedures. Christmann et al. (2014) set a list of themes to be governed at EU level, such as good governance, stable and transparent regulatory framework, undistorted market conditions, defining “*mineral deposits of public importance*”, etc.. They proposed mandatory publication of calls on exploration of critical minerals, similar to the Hydrocarbons Directive (Annex 32). This Directive ensures an open and fair competition for the improvement of supply security. The administrative procedure can either be

1) a “licensing round” model initiated either by the authorities or an applicant; or

2) an “open door” approach where the publication is not mandatory if the acreage is available already, or was published but without allocating, or the plot was given back by the client, or the plot is contiguous to an active concessional one.

According to Hámor et al. (2021a), Italy and Hungary voluntarily publish calls on geothermal energy projects in the Official Journal of the EU.

Specific to geothermal energy, the Kistelek Declaration (Hámor, 2006) signed by distinguished experts and politicians called for a Commission communication fostering MS to adopt a coherent legislation and permitting system, establish inventories of geothermal resources, and introduce harmonized financial instruments; a legal definition of geothermal energy and details on reinjection criteria in the acquis; preparing a best available technology reference document on geothermal energy. The definitions on geothermal energy and heat pump are available now, and numerous communications have been published, but reinjection remained in the competence of national jurisdiction.

Common rules for access to finance are important for a competitive market, therefore the revision of state-aid guidelines for energy projects is on-going. Complicated and lengthy permitting procedures affect competitiveness, and licensing delay is a major barrier for decarbonized energy systems. Simplification and streamlining of licensing procedures are needed to facilitate efficient deployment and investment safety. To this end, a recent piece (Annex 178) provides a waiver for MS such that the commissioning and operation of plants and installations for the production of renewable energy, and their connection to the grid, the grid itself and storage assets are presumed as being in the overriding public interest, so that MS may restrict the application of some EU legislation (Natura2000, Water Framework Directive) (Annex 27, 89, 38) in accordance with their national energy and climate plans. In addition, it sets out that permitting can't exceed six months in the case of power plants, and three months for ground

²https://single-market-economy.ec.europa.eu/sectors/raw-materials/eip_en.

source heat pumps.

The historical efforts to establish EU legislation for soil and subsoil, quantitative water management, non-fuel minerals, and land use planning failed for simple reasons: these resources represent the fundamental (critical, strategic) material assets of a country, and the subsidiarity principle rules when such legal drafts are presented. These aborted attempts indicate that specific EU legislation on geothermal energy is not a realistic option at present and may not be needed because many elements of the value chain are covered by the *acquis*. Nevertheless, a specific communication or guidance document would support the harmonized management of resource assessment and reporting, the technical requirements of reinjection, and the criteria of good (“do-no-harm”) or best environmental performance. It is important to note that many but not all of the above discussed gaps are covered by the national legislation, as analysed in the frame of numerous EU projects such as GTR-H, and GEOENVI³.

As a summary, the EU mandate on geothermal value chain is restricted by member states’ sovereign laws on spatial development and geological assets. The regulatory framework of high enthalpy geothermal projects is similar to that for hydrocarbons. The intensity of EU documents on the geothermal sector correlates with various policy drivers. Increasing conflicts among subsurface resources call for a more coherent regulatory framework.

5. Conclusion

This work is one in a series of thematic interdisciplinary studies on subsurface geological resources which assess EU policies by means of analyzing legal documents supported by quantitative text mining. The assessment of the ca. 180 legal piece and the statistical interpretation of the text mining of ca. 100 k documents accurately reflect the major global economic and political (societal) drivers of policy making over the last 52 years. The results also show the major historical trend of the development of the Energy and Climate Union since the turn of the century, and the relative and absolute growing focus on renewables and geothermal energy within the overall energy topic. The peaks of the time wise text score correlate with major forms of turbulences, such as oil price booms, economic and war crises, and the shale gas debate, as well as with major legislative milestones such as the laws on renewables, the Lisbon Treaty (2007), and the Energy and Climate Act (Annex 145).

Despite this two decades long stable commitment of bringing energy and climate issues to the forefront of EU policy and legislation, there are still numerous areas of conflict between the geothermal sector and other competing underground natural resources uses, the resolution of which may require additional EU level measures, or at least guidelines promoting harmonized MS national laws and permitting practices.

³<https://www.geoenvi.eu/> accessed on 16th February 2024.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Annex

A selected list of EU legislation relevant to the geothermal energy sector in a historical order

Note: The below titles are significantly simplified for easy reading, for the authentic version EUR-LEX shall be consulted. All amendments are not listed hereby. The entries in italics are no longer in force. The entries underlined have explicit reference to geothermal energy, heat pumps or drilling. The words in bold aim at indicating the major subject.

- 1) *Directive 64/428 concerning the attainment of freedom of establishment and freedom to provide services in respect of activities of **self-employed persons in mining and quarrying***
- 2) *Directive 67/548 on the **classification, packaging and labelling of dangerous substances***
- 3) *Regulation 1056/72 on investment projects in **the petroleum, natural gas and electricity sectors***
- 4) *Directive 75/442 on **waste***
- 5) *Decision 75/51 adopting an **energy research and development programme***
- 6) *Directive 76/464 on pollution caused by **dangerous substances discharged into aquatic environment***
- 7) *Directive 76/769 on the use of certain **dangerous substances and preparations***
- 8) *Regulation 1302/78 on granting of financial support for projects to **exploit alternative energy sources***
- 9) *Regulation 1303/78 on granting of financial support for demonstration projects for **energy-saving***
- 10) *Regulation 729/79 on the implementation in the **geothermal energy sector** of Regulation 1302/78 on the granting of financial support for projects to exploit alternative energy sources*
- 11) *Directive 79/409 on the **conservation of wild birds***
- 12) *Directive 80/68 on the protection of **groundwater** against pollution caused by dangerous substances*
- 13) *Directive 80/1107 on the **protection of workers** from the risks related to exposure to chemical, physical and biological agents at work*
- 14) *Directive 82/501 on the **major-accident hazards of certain industrial activities (SEVESO I)***
- 15) *Regulation 1972/83 on the granting of financial support for **demonstration projects** relating to the exploitation of **alternative energy sources** and to **energy saving and the substitution of hydrocarbons***
- 16) *Regulation 3640/85 on the promotion, by financial support, of demonstration projects and industrial **pilot projects in the energy field***
- 17) *Directive 85/337 on **assessment of effects** of certain public and private projects on the environment*

- 18) Regulation 2658/87 on statistical nomenclature and on the **Common Customs Tariff**
- 19) Directive 89/391 on measures in **the safety and health of workers at work**
- 20) Directive 89/440 on procedures for the award of **public works contracts**
- 21) Regulation 2008/90 concerning the promotion of energy technology (**Thermie programme**)
- 22) *Directive 90/313 on the freedom of access to information on the environment*
- 23) *Directive 90/531 on the **procurement procedures of entities operating in the water, energy, transport and telecommunications sectors***
- 24) *Directive 90/547 on the transit of electricity through **transmission grids***
- 25) *Directive 91/689 on **hazardous waste***
- 26) *Decision 91/565 concerning the promotion of **energy efficiency***
- 27) Directive 92/43 on the **conservation of natural habitats and of wild fauna and flora**
- 28) *Directive 92/59 on general **product safety***
- 29) Directive 92/91 on minimum requirements for **the safety and health protection of workers in the mineral-extracting industries through drilling**
- 30) *Regulation 793/93 on the evaluation and control of the **risks of existing substances***
- 31) *Regulation 3093/94 on substances that deplete the **ozone layer***
- 32) Directive 94/22 on the conditions for granting and using authorizations for the **prospection, exploration and production of hydrocarbons**
- 33) *Directive 96/29 on basic safety standards for the **protection of the health of workers and the general public against the dangers arising from ionizing radiation***
- 34) *Directive 96/61 concerning **integrated pollution prevention and control (IPPC)***
- 35) *Decision 97/264 on certification allowing voluntary participation by companies in the industrial sector in a Community **eco-management and audit scheme (EMAS)***
- 36) Directive 1999/31 on the **landfill of waste**
- 37) Directive 2000/14 on the **noise emission** by equipment for use outdoors
- 38) Directive 2000/60 establishing a framework for Community action in the field of **water policy**
- 39) *Decision 2000/479 on the implementation of a **European pollutant emission register (EPER)***
- 40) Decision 2000/532 establishing a **list of waste**
- 41) Directive 2001/42 on **assessment of effects of certain plans and programmes on the environment**
- 42) Directive 2001/77 on the promotion of electricity produced from **renewable energy sources in the internal electricity market**

- 43) Directive 2001/81 on **national emission ceilings for certain atmospheric pollutants**
- 44) Directive 2001/95 on general **product safety**
- 45) Decision 2455/2001 establishing **the list of priority substances in the field of water policy**
- 46) Regulation 2150/2002 on waste statistics
- 47) Directive 2002/49 on the assessment and management of **environmental noise**
- 48) *Directive 2002/91 on the energy performance of buildings*
- 49) *Directive 2002/96 on waste electrical and electronic equipment (WEEE)*
- 50) Directive 2003/4 on **public access to environmental information**
- 51) Directive 2003/10 on health and safety requirements regarding the **exposure of workers to the risks arising from physical agents**
- 52) Directive 2003/35 on **public participation in respect of the drawing up of certain plans and programmes relating to the environment**
- 53) Directive 2003/87 establishing a scheme for **greenhouse gas emission allowance trading**
- 54) Directive 2003/96 on the taxation of energy products and electricity
- 55) Decision 2003/33 establishing criteria and procedures for the **acceptance of waste at landfills**
- 56) *Directive 2004/8 on the promotion of cogeneration based on a useful heat demand in the internal energy market*
- 57) Directive 2004/35 on **environmental liability** with regard to prevention and remedying of environmental damage
- 58) Directive 2004/37 on protection of workers from risks related to exposure to **carcinogens or mutagens at work**
- 59) Directive 2004/107 on **arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air**
- 60) Regulation 184/2005 on Community statistics concerning balance of payments, international trade in services and foreign direct investment
- 61) Directive 2005/36 on the **recognition of professional qualifications**
- 62) Regulation 166/2006 on the **European Pollutant Release and Transfer Register**
- 63) Regulation 1013/2006 on shipments of waste
- 64) Regulation 1893/2006 establishing the statistical classification of economic activities (NACE)
- 65) Regulation 1907/2006 on the **Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)**, establishing a European Chemicals Agency
- 66) Directive 2006/21 on the management of waste from extractive industries
- 67) *Directive 2006/32 on energy end-use efficiency and energy services*

- 68) Directive 2006/118 on the **protection of groundwater against pollution and deterioration**
- 69) Directive 2006/123 on **services in the internal market**
- 70) Decision 2006/500 on the **Energy Community Treaty**
- 71) Regulation 1516/2007 establishing standard leakage checking requirements for stationary refrigeration, air conditioning and heat pump equipment containing fluorinated greenhouse gases
- 72) Directive 2007/2 on **Infrastructure for Spatial Information in the European Community (INSPIRE)**
- 73) Decision 2007/742 on ecological criteria for the award of the *eco-label* to electrically driven, gas driven or gas absorption **heat pumps**
- 74) Regulation 213/2008 on the Common Procurement Vocabulary of **public procurement**
- 75) Regulation 303/2008 on requirements for the **certification of companies and personnel as regards stationary refrigeration, air conditioning and heat pump equipment containing certain fluorinated greenhouse gases**
- 76) Regulation 451/2008 establishing a new **statistical classification of products by activity (CPA)**
- 77) Regulation 1099/2008 on **energy statistics**
- 78) Regulation 1272/2008 on **classification, labelling and packaging of substances and mixtures**
- 79) Directive 2008/50 on **ambient air quality and cleaner air**
- 80) Directive 2008/98 on **waste**
- 81) Directive 2008/114 on identification and designation of **critical infrastructures and assessment of the need to improve their protection**
- 82) Regulation 1005/2009 on **substances that deplete the ozone layer**
- 83) Regulation 1221/2009 on the voluntary participation in **eco-management and audit scheme (EMAS)**
- 84) Directive 2009/28 on the **promotion of the use of energy from renewable sources**
- 85) Directive 2009/31 on the **geological storage of carbon dioxide**
- 86) Directive 2009/73 concerning common rules for the internal market in **natural gas**
- 87) Directive 2009/119 on **minimum stocks of crude oil and/or petroleum products**
- 88) Directive 2009/125 on **ecodesign requirements for energy-related products**
- 89) Directive 2009/147 on the **conservation of wild birds**
- 90) Decision 2009/335 on **technical guidelines for the establishment of the financial guarantee concerning the management of waste from extractive industries**
- 91) Decision 2009/337 on the definition of the **criteria for the classification of extractive waste facilities**

- 92) Decision 2009/358 on **regular transmission of the information and the questionnaire related to the management of waste from extractive industries**
- 93) Decision 2009/359 on the **definition of inert extractive waste**
- 94) Decision 2009/360 on the **technical requirements for extractive waste characterisation**
- 95) Decision 2009/548 establishing a template for **National Renewable Energy Action Plans**
- 96) Decision 406/2009 on **greenhouse gas emission reduction commitments up to 2020**
- 97) Regulation 617/2010 on the notification on investment projects in **energy infrastructure**
- 98) Regulation 1089/2010 as regards **interoperability of spatial data sets** and services
- 99) *Directive 2010/30 on the indication by **labelling** and standard product information of the consumption of energy and other resources by **energy-related products***
- 100) Directive 2010/31 on the **energy performance of buildings**
- 101) Directive 2010/75 on **industrial emissions (integrated pollution prevention and control)**
- 102) Regulation 691/2011 on European **environmental economic accounts**
- 103) Regulation 1233/2011 on guidelines in the field of **officially supported export credits**
- 104) Directive 2011/92 on **assessment of effects of certain public and private projects on environment**
- 105) Directive 2012/19 on **waste electrical and electronic equipment (WEEE)**
- 106) Regulation 347/2013 on guidelines for **trans-European energy infrastructure**
- 107) Regulation 549/2013 on the European **system of national and regional accounts**
- 108) Regulation 811/2013 on the energy **labelling of space heaters**, combination heaters, packages of space heater, temperature control and solar device and packages of combination heater, temperature control and solar device
- 109) Regulation 812/2013 on the energy **labelling of water heaters**, hot water storage tanks and packages of water heater and solar device
- 110) Regulation 813/2013 implementing Directive 2009/125 with regard to **ecodesign requirements for space heaters and combination heaters**
- 111) Regulation 1253/2013 as regards **interoperability of spatial data sets and services**
- 112) Directive 2013/59 on **basic safety standards for protection against the dangers arising from exposure to ionising radiation**
- 113) Decision 2013/114 on **calculating renewable energy from heat pumps from different heat pump technologies**

- 114) Decision 2013/135 to prolong the validity of the **ecological criteria for the award of the EU Ecolabel** to certain products
- 115) Decision 2013/529 on **accounting rules on greenhouse gas emissions** and removals resulting from activities relating to land use, land-use change and forestry and on information concerned
- 116) Decision 2013/633 in order to prolong the validity of the **ecological criteria for the award of the EU Ecolabel to electrically driven, gas driven or gas absorption heat pumps**
- 117) Council Decision 2013/743 on **Horizon 2020** - the Framework Programme for Research and Innovation (2014-2020)
- 118) Regulation 256/2014 concerning the notification of **investment projects in energy infrastructure**
- 119) Regulation 517/2014 on **fluorinated greenhouse gases**
- 120) Regulation 651/2014 declaring certain categories of **aid compatible with the internal market**
- 121) Regulation 1113/2014 establishing the form and technical details on **energy infrastructure**
- 122) Directive 2014/23 on the **award of concession contracts**
- 123) Directive 2014/24 on **public procurement**
- 124) Directive 2014/25 on **procurement by entities operating in the water, energy, transport and postal services sectors**
- 125) Directive 2014/68 on **pressure equipment**
- 126) Decision 2014/314 on the criteria for the award of **Ecolabel for water-based heaters**
- 127) Decision 2014/363 on **electrically driven, gas driven or gas absorption heat pumps**
- 128) Regulation 2015/2402 reviewing harmonised **efficiency reference values** for separate production of electricity and heat
- 129) Regulation 2015/2067 on minimum requirements for mutual recognition for the **certification of natural persons** as regards stationary refrigeration, air conditioning and **heat pump equipment**, and refrigeration units of refrigerated trucks and trailers, containing fluorinated greenhouse gases and for the **certification of companies** as regards stationary refrigeration, air conditioning and heat pump equipment, containing fluorinated greenhouse gases
- 130) Directive 2015/996 establishing common **noise assessment methods**
- 131) Regulation 2016/172 as regards specification of the **energy products**
- 132) Regulation 2016/879 establishing detailed arrangements relating to the declaration of conformity when placing refrigeration, air conditioning and **heat pump equipment charged with hydrofluorocarbons** on the market and its verification by an independent auditor
- 133) Regulation 2016/2281 on **ecodesign requirements for energy-related products**, with regard to air heating products, cooling products, high temperature process chillers and fan coil units

- 134) Regulation 2016/1872 on the “Prodcom list” of industrial products
- 135) Directive 2016/943 on the protection of undisclosed know-how and business information (**trade secrets**) against their unlawful acquisition, use and disclosure
- 136) Directive 2016/2284 on the reduction of national emissions of certain **atmospheric pollutants**
- 137) Decision 2016/611 on the reference document on best environmental management practice, sector environmental performance indicators for the **tourism sector**
- 138) Regulation 2017/997 as regards the hazardous property HP 14 ‘**Ecotoxic**’
- 139) Regulation 2017/1369 setting a framework for **energy labelling**
- 140) Regulation 2017/2010 on **energy statistics**, as regards the annual and monthly energy statistics
- 141) Decision 2017/175 on establishing EU Ecolabel criteria for tourist accommodation
- 142) Decision 2017/302 establishing best available techniques for the intensive rearing of poultry or pigs
- 143) Regulation 2018/848 on organic production and **labelling of organic products**
- 144) Regulation 2018/1504 on **investment projects in energy infrastructure**
- 145) Regulation 2018/1999 on the **Governance of the Energy Union and Climate Action**
- 146) Regulation 2018/2066 on the **monitoring and reporting of greenhouse gas emissions**
- 147) Directive 2018/2001 on the promotion of the use of **energy from renewable sources**
- 148) Decision 2018/813 on the sectoral reference document on best environmental management practices, sector environmental **performance indicators** for the **agriculture sector**
- 149) Decision 2018/1147 establishing **best available techniques** (BAT) for **waste treatment**
- 150) **Best Available Techniques (BAT) Reference Document** for the Management of Waste from Extractive Industries
- 151) Regulation 2019/826 on assessments of the potential for efficient **heating and cooling**
- 152) Regulation 2019/1021 on **persistent organic pollutants**
- 153) Regulation 2019/943 on the **internal market for electricity**
- 154) Directive 2019/944 on common rules for the **internal market for electricity**
- 155) Decision 2019/61 on the sectoral reference document on best environmental management practices, sector environmental performance indicators for the **public administration sector**
- 156) Decision 2019/62 reference document on best environmental manage-

ment practices, performance indicators for the **car manufacturing sector**

157) Decision 2019/63 reference document on best environmental management practices, performance indicators for **electronic equipment manufacturing**

158) Decision 2019/708 on determination of sectors deemed at **risk of carbon leakage** for 2021-2030

159) Decision 2019/1616 on the harmonised standards for **pressure equipment**

160) Regulation 2020/741 on minimum requirements for **water reuse**

161) Directive 2020/2184 on the quality of **water for human consumption**

162) Decision 2020/248 on technical guidelines for **inspections of extractive waste management facilities**

163) Regulation 2021/241 establishing the **Recovery and Resilience Facility**

164) Regulation 2021/821 setting up a Union regime for the control of exports, brokering, technical assistance, transit and transfer of **dual-use items**

165) Regulation 2021/1153 establishing the **Connecting Europe Facility**

166) Regulation 2021/1060 on the European **Regional Development Fund**, the European Social Fund Plus, the Cohesion Fund, the Just Transition Fund ...

167) Regulation 2021/2106 on the Recovery and Resilience Facility by setting common indicators and detailed elements of the recovery and **resilience scoreboard**

168) Regulation 2021/2139 on technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to **climate change mitigation**

169) Decision 2021/157 as regards industrial valves, welding procedures, equipment for refrigerating systems and **heat pumps**, shell boilers, metallic industrial piping, copper and copper alloys, LPG equipment and accessories and safety devices for protection against excessive pressure

170) Decision 2021/476 establishing the EU Ecolabel criteria for **hard covering products**

171) Decision 2021/2053 reference document on best environmental management practices, performance indicators and benchmarks of excellence for the fabricated **metal products manufacturing sector**

172) Decision 2021/2054 reference document on best environmental management practices, performance indicators for **information and communication technologies (ICT) services sector**

173) Regulation 2022/132 on **energy statistics**, as regards the implementation of updates for the annual, monthly and short-term monthly energy statistics

174) Regulation 2022/759 on a methodology for **calculating the amount of renewable energy used for cooling and district cooling**

175) Regulation 2022/869 on guidelines for trans-European **energy infrastructure**

176) Regulation 2022/1214 on public disclosures for **economic activities** in

certain energy sectors

177) Regulation 2022/2299 on rules as regards format, technical details and process for the integrated **national energy and climate progress reports**

178) Regulation 2022/2577 on a framework to accelerate the **deployment of renewable energy**

179) Decision 2022/1004 authorizing Finland to apply a **reduced rate of taxation** to electricity supplied to certain **heat pumps**, electric boilers and recirculating water pumps