Interreg
North-West Europe
DGE-ROLLOUT

Examination of the German regulatory framework and financial risk management of DGE

A recommendation approach

Deliverable T1.3.3

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August 2021

Disclaimer

The purpose of the following report is to give a short overview of active legal framework and financial support of DGE projects in Germany. It should provide general information to local, regional, and national public authorities, project developers, politicians and enterprises with heat demand. However, this report does not replace the own independent research on this topic. Appropriate legal advice should be obtained in actual situations.

The recommendations given herein are the authors subjective opinion based on the research which has been done for this report. It does not rely on actual experience during drilling or seismic exploration in the field. It mainly sums up the opinion of experienced project partners and today's goals in contributing as much as possible to stop climate change.

We cannot guarantee the accuracy, reliability, correctness or completeness of the information and materials given in this report and accept no legal responsibility. For further reading, more information and the accuracy of the here mentioned legal framework and financing methods, please refer to the literature mentioned herein.

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1 Introduction

One of today's main challenges is the unpredictable threat the human-made climate change bears for the environment and of course for the future life on earth. Scientists all over the world are warning against the rapid increase of temperature due to high emissions of greenhouse gases (GHG) into the atmosphere. More than ever, an energy transition is inevitable as a first step to reduce GHG emissions. Especially in Germany, renewable energy expansion has a long tradition, but mainly to cover the electricity demand. Heat is still being generated conventionally. Only 15.2% (BMWi, 2021) of the overall heat demand is covered by renewable energy sources such as biomass, solar and geothermal energy. The latter, especially in greater depth, has a high potential of being a cost-effective and baseload energy source not only to produce heat but also to generate electricity. Despite the many advantages of deep geothermal energy (DGE), to date it has received less attention. In Germany, there are only a few plants in operation leading to an overall thermal capacity of nearly 350 MW (BVG, 2021). The main hurdle curbing the expansion of DGE is the high economic risk factor, owing to the uncertain reservoir viability due to poor knowledge of the deep subsurface. Therefore, the initial stages of a DGE project (amounting up to 30% of overall capital cost, mostly equity), including the first exploration drilling, usually determines the success or failure of the project (Dumas & Angelino, 2015). Thus, insurance schemes, equity support and financial incentives are essential to cover the financial risk and enable a secure investment environment for DGE.

The aim of this report is to point out missing links in state support which are essential to actively foster heat transition. An improvement of the current support approaches can also decrease financial risk leading to a more secure investment environment, not only for public authorities but also for private investors. This report should also provide input for project developers and policy makers regarding risk mitigation of permits and other administrative processes for seismic acquisition and exploration.

The first part of this report deals with the thermal capacity of DGE currently installed in Germany and what measures are being taken to expand the implementation of new DGE plants. Subsequently, active legislations and how administrative processes are handled regarding exploration and operation are described. After that, some recommendations are given.

The next part of the report shortly describes the risk factors of DGE and the support schemes in Germany. Next, an analysis and improvements of the current state support incentives are presented. In the conclusion, all results of this report are summarised in a table.

2 Deep geothermal energy deployment in Germany

In Germany, the development of renewable energy has a long tradition with the implementation of supportive legislations in the beginning of the 90s. It was one of the first countries that adapted renewable energy (RE) into a feed-in tariff scheme. In 2000, the first legislation EEG 2000 was developed to foster innovative and renewable energy solutions. Since then, Germany is a world leader when it comes to renewable energy investments meeting national and European GHG emission targets to mitigate climate warming, and protecting the environment as part of the "*Energiewende"* and "*Wärmewende".* Especially in the development of deep geothermal energy, Germany plays a key role in Europe. Despite its small amount of installed thermal capacity (349.71 MW; BVG, 2021), Germany is among the most advanced markets in terms of TRL (Technological readiness level), being one of the first countries developing EGS projects (ETIP-DG, 2019). One of the key support schemes in Germany is the Renewable Energy Sources Act (EEG) which was extended by the Renewable Energies Heat Act (EEWärmeG) to reinforce the decarbonisation of the heating sector. Looking at today's heating market, biomass is the most prominent heating source together with solar and near-surface geothermal energy. Although the geothermal potential in Germany is high, especially in regions such as the Molasse Basin, Northern German Basin, the Upper Rhine Graben, and the South German Scarplands, DGE is a technology that still lives a shadowy existence among other RE solutions. The main reasons for this are unknown subsurface conditions and high investments costs. The latter is closely linked to the high risk of not finding an economically viable reservoir. In addition, occurrences such as the Staufen misfortune in 2007 are major hurdles for the social acceptance of DGE in Germany and therefore need to be addressed (Sass & Burbaum, 2010). Thus, not only the implementation of support approaches is important but also the social factor plays a major role in future project development for an expansion of DGE.

3 Active legislations on DGE and permitting processes

In the following, the different active legislations on DGE will be presented and discussed in terms of their advantages and disadvantages. Most of them also target the exploration of near-surface geothermal energy. The next part of this chapter deals with the permitting processes for the exploration and operational stages of a project.

Table 1: Active legislations on DGE (Holroyd & Dagg, 2011; Gec-co, 2019; BVG, 2020; Rumor & Schäfer, 2020; Rumor & Schäfer 2020a; van Malderen, 2020;)

Legislations	Short description	Advantage	Disadvantage
Federal Mining Act (BBergG) *Bundesberggesetz*	Federal act for the regulation of the several active mining laws. The aim of this act is to harmonise the current legal framework and function as a facilitator for the different mining authorities. The sustained supply of natural resources will be secured by this law. It can be subdivided into 12 different legal parts extending from initial exploration, via production and processing, to mining damage. According to the BBergG, Geothermal Energy is a federal resource which can only be exploited with an exploration and production license. The granting of a permit is related to a main operational plan (§§52 ff. BBergG). The results of the exploration must be provided to the responsible mining authority. After obtaining the exploration permit, the project developer needs to apply for an extraction permit to use the thermal energy.	• Harmonisation of legal framework on a federal level	• Especially the mining law (Bergrecht) offers a very large scope of interpretation, therefore it differs per federal state
Geological Data Act (GeoIDG) *Geologiedatengesetz*	Regulation of geological exploration, transmission and allocation of data to the public, to ensure a sustainable reservoir/subsurface usage/exploitation/utilisation. It replaces the old repository law (Lagerstättengesetz) with the obligation to affirm a transmission of geological data to the appropriate authority. **Within the framework of this law, a borehole shall be announced to the responsible state geological survey in accordance with §8 GeoIDG** and §127 BBergG (Bohranzeige).	• Transparency • Higher guarantee for sustainable exploration and exploitation • Mitigation of geological risk (more data = better knowledge)	• Additional work time for non-state-owned companies or private customers
Repository Site Selection Act (StandAG) *Standortauswahlgesetz*	Legal regulation for the search and selection of a site for the final disposal of nuclear waste. In pursuance of §21 StandAG, every drilling has to be initially authorised by the BASE (Federal Office for the Safety of Nuclear Waste Management) and BGE (Federal subsidiary for final disposal). For this, prior knowledge of the subsurface and its structures is not required. Every drilling is put through a validation procedure. If the drilling is not expected to hit a formation targeted for disposal of nuclear waste, it will be approved.	• Search and selection of a final disposal site is simplified by checking drillings • Safety requirements for the formations are high	• Approval procedure is too long; no official deadlines exist
Factory Act (ArbSchG) *Arbeitsschutzgesetz*	This is the regulation on industrial safety that employers must comply with.		
Water Resources Act (WHG) *Wasserhaushaltsgesetz*	A legal framework regulating the exploitation of water, its protection and the sustainable usage of ground- and surface water. The WHG covers the main part of the water law. Harmful	• Legal certainty for the public	• The usage of thermal water can be limited in time • Later changes in restrictions can lead to more

	contamination of these waters during drilling activities need to be prevented. Temperature changes of the ground water are regularly checked. The WHG is also applied to drillings deeper than 100 m (since deep waters are also defined as ground water) and regulates the use of thermal water by geothermal plants to a considerable extent (§3 sect. 1 WHG). Granting of the permit for DGE is decided by the mining authorities in agreement with the water authority (Lower Water Authority). For conventional fracking, the WHG includes intensified provision in pursuance of the amendment of the WHG (2017).	• High legal obligation especially in protected areas (*Wasserschutzzone*)	protection conditions for the developer
State Water Act (LWG) *Landeswassergesetz*	Regulation for the administrative procedures and selection of the responsible authorities. Approval agencies are generally the upper and lower water authorities. By now, only Baden-Württemberg and North Rhine Westphalia included specific regulations in the LWG for the construction of a geothermal plant. Protection of the ground water for the public and environment is also regulated by the LWG.	• §44 LWG: for geothermal plants with a capacity of less than 50 kW, agreement is mainly guaranteed	• Environmental associations are criticising the amendment of the LWG in NRW: lower restrictions for protected areas
State Act for Deep Drillings (BVOT, BVT) *Tiefbohrverordnung der Länder*	The BVOT generally affects the borehole mining and underground storage and regulates the construction of drilling sites with regard to high safety standards for the exploration and protection of the ground water. It includes e.g., the installation of a standpipe, cementation to prevent contamination, a guaranteed stability of the borehole etc. It is part of the main operational plan (BBergG).	• Amendment in 2006: harmonisation of the BVOT in many federal states	

3.1 Exploration

Generally, two types of exploration methods for DGE can be distinguished: drilling and seismic acquisitions. In this chapter the different permits for both of the exploration methods will be described and assigned to the related method. For both of them, press release and approval of the public and the nearby authorities and commission offices are required before the actual start of the exploration. If a close exchange of information about the exploration is neglected, the public can, for example, revoke the Environmental Impact Assessment permit (Gec-co, 2019).

3.1.1 Drilling

Table 2: Required permits during exploration: Drilling (from Rumohr & Schäfer, 2020 and van Malderen, 2020).

Name of permit	Short description
Mining permit *Aufsuchungsgenehmigung*	For exploration, exploitation, operation and completion of operations a mining permit is required which is provided by the mining authority. It can be subdivided into four different licenses: an exploration license, a main operational plan (Aufsuchung: bergrechtliche Erlaubnis, §7 BBergG), an exploration permit and an exploitation plan (Gewinnung: bergrechtliche Bewilligung, §8 BBergG). For approval, an operational plan needs to be prepared. Since water is the carrier medium for the extracted geothermal energy, it is also necessary to provide the WHG, which is granted by the lower water authority. An exploration permit is limited to five years and can be extended for 3 additional years, while an exploitation approval is set to 20-50 years.
Operational plan *Betriebsplan*	Pursuant to the BBergG, an operational plan for exploration and exploitation is mandatory for the corresponding approval (granted by the mining authority). With such a plan, the mining authority regulates a sustainable usage of the project site and its recultivation after the license expires. It also includes, for example, the above-ground heat exchanger, the pumps, pipes and fittings of the injection wells. If the mining authority grants approval for exploitation (§51 BBergG), only private appropriation and activity rights are justified. An operational plan is restricted to two years and can be extended by a general operational plan (Rahmenbetriebsplan; no written limitation of the duration). The latter is mandatory by law if the project requires an environmental impact assessment (UVP). This includes a planning approval and a planning approval decision. Additionally, the mining authority can request separate operational plans for specific operations on the site.
Environmental Impact Assessment (EIA/UVP) *Umweltverträglichkeitsprüfung*	The UVP examines operations, which could have a harmful impact on the environment and on any other legally protected good. A UVP is mandatory especially for EGS techniques, since a stimulation is generally associated with acids or other chemicals which could harm the ground water. The UVP pre-examination is undertaken by the responsible mining authority for every exploration/exploitation of natural resources deeper than 1,000 m. If it concludes an impact, a general operational plan as well as a planning approval are required. If the approach passes the UVP, only a main operational plan needs to be set up. However, the public can refute the pre-examination, which can ultimately lead to delay of the approval procedure.
Regional Planning Act (ROG) *Raumverordnungsgesetz*	The ROG is closely related to the afore mentioned UVP and needs to be fulfilled in terms of the selection of a geothermal site which is of supra-local importance and special significance (Raumbedeutsam). Although it does not share any legal effect, it needs to be considered in

	the approval procedure. Geothermal power plants locally take over the decentralised energy supply, therefore the prerequisites for a regional planning procedure are not fulfilled unless the legislator decides otherwise in the future.
Federal Soil Protection Law (BbodSchG) Bodenschutzgesetz	The BbodSchG ensures a sustainable soil function or the restoration thereof. It is regulated by the WHG and can also be included in the building law.
Planning approval *Planfeststellungsverfahren*	The planning approval is part of the BBergG (§§ 57a and 57b BBergG) and needs to be approved if a UVP is essential. During a planning approval procedure, the public is closely incorporated. A detailed report about the possible impact of the project and which measures are taken to prevent problematic approaches is set up by the project developer. This report is then submitted to the mining authority.
Water Resources Act (WHG) *Wasserhaushaltsgesetz*	As already mentioned in Chapter 3, the lower water authority needs to approve the exploration and the exploitation of geothermal heat. Its aim is to guarantee a sustainable usage of water and to both protect and restore the natural functions of surface waters, ground water and soil (see Table 1).
Emission Control Law (BImSchG) *Immissionsschutzgesetz*	The emission control law regulates the noise and the emission of pollutants during a DGE drilling. Approval is granted by the mining authority and the lower water authority. Even if the emission control does not require an authorisation it is still included in the main operational plan, since a noise annoyance can allow the public to stop the drilling process.
Nature Protection (BNatSchG) *Naturschutzgesetz*	Before being approved, a DGE project needs to be checked for compliance with the conservation objects of a fauna/flora habitat or nature conservation area or a European bird sanctuary, in accordance with § 34 BNatSchG and the corresponding state law.
Nuclear Waste Management	The StandAG (see Table 1) regulates the search and selection of a site for a repository for nuclear waste. Since every drilling can encounter a rock formation which could be suitable for the final disposal of nuclear waste, an approval of the StandAG is required.

3.1.2 Seismic acquisition

Pre-permit

As opposed to drilling, a seismic acquisition mainly requires an approbation of the public as well as of different commission offices such as e.g., the State Office for Nature and Environment, the forestry office and the mining authority. In addition, a species conservation examination needs to be set up and fulfilled to prevent any harm of the natural habitat. Once the seismic line is spatially defined, communication with the administrative district and the municipalities about the project is essential. These points are included in the pre-permit stage of a seismic acquisition. The vibro truck route also needs to be checked for old bombs and cables by an explosive ordnance disposal office and a spatial plan, respectively. In addition, an assessment of the water authority, the nature conservation authority, and the monument protection is needed.

Surveillance of measurement works

After obtaining approval by the different offices and state authorities, the permitting during the acquisition is initiated. During the permit on line, the convoy is supported and a supervisor checks the route and observance of agreements and prohibitions. If any inconveniences are noted, the supervisor

immediately checks possible (crop) damages and examines the compensations which are reimbursed immediately.

3.2 Operation

Table 3: Required permits during the operational phase of a DGE project (see van Malderen, 2020 for references).

Name of permit	Short description
Exploitation license *Abbaugenehmigung*	After finding an economically viable reservoir, an exploitation license is required to extract the geothermal energy of the deeper subsurface waters (§ 8 BBergG, bergrechtliche Bewilligung) with a production well. The permit is granted by the responsible mining authorities. The license guarantees a usage of the reservoir for up to 20-50 years.
Main operational plan *Hauptbetriebsplan*	For the construction and operation of a geothermal plant, a main operational plan is required. It describes the planned work and the used substances in detail. It is valid for two years. To extend the validation time, a general operational plan can be set up as part of the UVP.
Waste Management Act (KrWG) *Kreislaufwirtschaftsgesetz*	The aim of this regulation is to foster the recycling management, to save natural resources as well as to protect the environment during the production and regulation of waste. In the case of DGE, there are different sources of waste e.g., filtration residue, scaling, or drilling mud. Therefore, the conditions of the KrWG is not only considered during the operational phase, but also during the exploration.
Building License (BauGB) *Baugenehmigung*	A building permit is needed before the construction of the plant begins. It is normally related to the above-mentioned ROG and is granted by a building control authority.
Monumental Protection Law (DSchG) *Denkmalschutzgesetz*	The DSchG Law is a legislation related to spatial planning and included in the Building Code (Baugesetzbuch – BbauG). Its aim is to protect monuments, especially during the remediation of buildings and the transition of energy carrier.
Regional Planning Act (ROG) *Raumverordnungsgesetz*	The ROG is included during the construction of a geothermal plant (see Table 2). However, the spatial distribution has to be clarified during the drilling process, since the first well equals the production well.

4 Improvement of current regulations

For the implementation of a DGE project and before the initiation of the first exploration operation, different approvals are required and need to be considered during project development. While most of them, such as the mining permit or the approval of the lower water authorities, are essential, others are time consuming in terms of no defined approval durations (StandAG) which can lead to an extension of the project itself. In this chapter, the legal frameworks described will be discuss, especially with regard to how they can be improved to guarantee a safer project procedure not only for the developer but also for the investor.

Table 4: Recommended improvements of the legal framework.

Name of legislation/permit	Urgency for improvement				Improvement approaches
	High	Important	Less important	Not necessary	
Main operational plan			x		Since permissions are temporary, they could be extended by one more year. A fast start of the project bears a lot of risk and pausing it is only granted during the permission time.
Federal mining act		x			After several amendments of the BBergG, it still leaves a large scope of interpretation leading to the act being handled differently in different federal states. The language of the law needs to be reworked and a legal definition of geothermal energy as a regenerative heat source needs to be included.
Repository Site Selection Act (StandAG)		x			For the StandAG, testing intervals are necessary to overcome long permitting durations; especially for DGE projects a time limit should be included in the regulatory framework.
Water Resources Act (WHG)				x	During the approval procedure, new restrictions can extend the beginning of the exploration; could be neglected.

Despite all the mentioned improvement approaches (Table 4), the main reason for long approval procedures is related to analogue data transmission. It is strongly recommended that the permit process from submission to the actual approval is digitised. This would not only simplify the process itself, but also make the status of the procedure transparent. In addition, a fair system for licensing exploration is necessary, e.g., by forming corporations.

However, one also need to keep in mind that it can take several years until changes in legal framework are legally approved. Therefore, it is also important to target financial support schemes for a short-term improvement.

5 Common risk factors of DGE

Among other renewable energy technologies, DGE is by far the most expensive one, especially during the initial stages of project development. This is related to the high uncertainty of subsurface conditions before the first drilling operation, e.g., DGE projects require high upfront investments during the riskiest stage of project development. Especially in juvenile markets, state support for technologies with a high-risk profile are needed (Tasdemir & Arndt, 2020). This state support can lower the overall risk by investing into innovation, experience and knowledge. Future projects are then able to learn from best practise examples nearby. At the stage of high market maturity, private banks will be able

to grant loans for DGE projects and even cover particular risks through revolving funds. However, to reach this level of a safe investment environment and competitiveness, the state support is indispensable as a first step. In the case of DGE projects, a repayment of the loan will not start before the operation of the plant begins which can differ from project to project.

In this chapter, all common risks of DGE projects are summarised (Table 5) including their risk level, the project stage at which they occur, the market maturity level they affect the most, and how these risks can be mitigated.

Table 5: Possible risk factors of DGE and how to mitigate them (see Tasdemir & Arndt, 2020 and van Melle *et al.*, 2021).

Name of risk	Description of risk	Level of risk	Project stage	Affected market maturity	Mitigation scheme
Geological risk (Resource risk)	Short-term risk: No economically viable reservoir in the subsurface; target formation is missing (unexpected geology) Temperature (T) or flow rate (Q) too low or quick degradation Insufficient hydraulic connectivity Fluid chemistry is critical for wells	Very High	Exploration phase	Juvenile, Medium	Data acquisition (3D-modelling) Intense mapping and exploration of subsurface: - seismic acquisition - drillings - uncertainty modelling
	Long-term risk: Degradation of the reservoir over time; excessive corrosion and scaling in geothermal loop	Medium	Operational phase	All	Annual maintenance and cleaning of equipment; renewal of well leverage
Environmental risk	Induced seismicity: Change in stress field; can lead to house damage or earthquakes: reputational damage for DGE A change in T through injection can lead to stress and pressure changes	High	Exploration and operational phase	All	Comprehensive investigations of the deep subsurface and installments of a seismic monitoring network
	Pollution: Contamination of ground water with drilling muds	Low	Exploration phase	Juvenile	Existing artesian aquifers need to be identified before drilling and drilling equipment must be

	Working fluids and gases used in the plants can lead to contamination of the environment				checked to prevent leakage
Technical/Drilling risks	<u>Blowouts:</u> Contamination of environment through uncontrolled discharge of gas or drilling mud <u>Drilling:</u> Difficulties during drilling, e.g. damage of the reservoir, wellbore instability, loss of equipment, delays during drilling <u>Equipment:</u> Pump breakdowns	High	Exploration phase	All	Blowout preventer must be used during drilling
		High	Exploration phase	All	Experienced drilling company
		Medium	Operational phase	All	Regular maintenance of equipment
Offtake risk	Loss of customers	Medium	Operational phase	Juvenile	Binding through long-term contracts
Regulatory risk	Changes in legal framework before DGE project has started	High	Operational phase	Juvenile, Medium	Changes should suit the technological maturity level of each RE technology
Economical risk	<u>Energy pricing:</u> Changes in spot market prices can affect revenues <u>Bankruptcy risk:</u> Plant is not economically viable after a few years <u>Credit risk:</u> Can lead to bankruptcy if client is not able to pay bills; lack of long-term revenues	Low	Operational phase	Juvenile	State support incentives such as FIT; pricing set in PPAs (Power Purchase Agreement)
		High	All stages	All	Mainly depends on location of the plant; State support needed
		Medium	Operational phase	Juvenile	Exclusion of liability in the PPA contraction
Permitting risk	Delays in project start due to long approval procedures Negative if investments are time-bound	Medium	Development phase	Juvenile, Medium	Improvement of permitting procedures

Investment risk	Financing risk: Lack of financing for the next phases; no long-term investments possible or unexpected delays during project development Interest rate risk: Fluctuations in interest rates and increase of interest rates during refinancing Long-term uptake: Investors can back out; no long-term financing Operation delays: Different factors can lead to delays in operation of a plant	Low	Exploration phase	Juvenile	Experience in handling DGE projects is an advantage; more funding schemes necessary
		High	Operational phase	All	Contractually fixed interest rates; refinancing through PPAs
		Medium	Development phase	Juvenile	More state incentives needed
		High	Operational phase	All	Management and financing options are necessary
Social acceptance	Low acceptance of industrial projects can inhibit development (formation of citizens' initiatives)	High	Development phase	Juvenile, Medium	Comprehensive science communication with citizens

6 Summary of risk mitigation schemes

Since Germany is investing millions of euros in the expansion of renewable energy, incentives are offered by the state (Table 6). For a better comparability, especially in terms of recommendations for improvement, the advantages and disadvantages of the schemes are summarised. Also, the risk factors of the previous chapter are compared with the mitigation schemes in relation to their coverage. Since private financing is highly dependent on the financing institute and the contract, this financing scheme is neglected here.

Table 6: Advantages and disadvantages of the German support schemes for DGE (see Tasdemir & Arndt, 2020 for references).

State support scheme	Name of state aid	Description	Risk factors									Advantage	Disadvantage
			Geological	Environmental	Technical/Drilling	Offtake	Regulatory	Economical	Permitting	Investment	Social acceptance		
Policy EEG 2021 *Renewable Energy Sources Act*	Feed-in tariff (FIT)	A fixed feed-in tariff for energy supply For DGE the FIT is at 25,20 ct/kWh (§48 EEG); degression will start from 2024 with an annual decrease of 0,5%	-	-	-	+	+	+/-	-	-	+/-	• Independent from retail price of electricity • Guaranteed power offtake • Duration: 15-25 years	• Subsidy during operational phase • Only covers electricity demand • Can lead to uncontrolled implementation of RE, if schemes do not fit the market maturity level • Declination is too early, no clear explanation for decrease
	Market premium	Premium will be set through an auction and is fixed for 20 years For now, this is just an option for larger installations and mature RE technologies	-	-	-	-	+/-	-	-	-	+/-	• Fostering the demand-driven supply • Higher revenue range than with a fixed FIT	• Subsidy during operational phase • Limited chance for high subsidy • Only covers electricity demand • No guaranteed uptake for independent promoting of power • Not suitable for every technological maturity level
Policy EEWärmeG: MAP *Market Incentive Program*	BAFA investment grants	Direct grants provided by the BAFA for private home owners to change their conventional heater: near surface geothermal heating Thermal energy storage is also eligible for funding by the BAFA Since the 02.01.2021 individual measures will be accepted in the frame of the BEG EM (Federal Funding for Efficient Buildings)	-	-	-	-	-	-	-	+	+/-	• Online application for funding • Different bonuses depending on the annual working time of the heat pump • Up to 45% of eligible costs are covered • Revenue when feeding energy into grid • Upgrades of heat pumps are also eligible	• Funding is only eligible, if it is requested prior to the assignment to a company • No upfront subsidy; granting after usage reference (by no later than 6 months after utilisation) • Not for larger projects; for home owners only: for refurbishment • Funding depends on the building's efficiency level • For replacement obligations according to the §10 (EnEV), there is no funding granted

	KfW-Program – Renewable Energy Premium DGE	Subsidised loans with repayment grants provided by the German Federal Bank for Reconstruction (KfW) Funding for: DGE plants, production and injections wells Repayment grants of up to 50% of eligible costs Requirements: reservoir temperature at least 20°C, heat capacity at least 0.3 MWth	+/-	-	+	-	-	+/-	-	+	+/-	• Funding also combined for energy and heat • Low interest rates for small companies • Up to 3 years interest-only • Combination with other KfW programs possible; should not exceed 80% (≥20% risk capital) • First drilling operation can be covered	• House bank acts as a facilitator and covers risk • Uncertainty of interest rate prior to loan promise • Plant must be in operation for at least 7 years, even in case of disposition and decrease of thermal output
Policy	RED II – Renewable Energy Directive 2018/2001	Amount of RE in the energy and heating sector should be extended until 2030 (EU Directive) To meet these goals, financing incentives will be provided	-	-	-	+	+	+	-	+	+	• Directive on EU level • Member states have to follow the directive • More financial options will be generated and policies	• Does not include the improvement of active legislations in terms of higher financing options • District heating is put on the same level as local heating
RD&I fund	7th Energy Research Program of the Federal Government (FuE Funding)	Direct funding provided by federal budget, Energy and Climate Fund For demonstration and development projects (Research): €1.3 Bill will be provided annually Eligible parties: companies, research institutes	+	+	+	-	-	-	+	+/-	+	• Funding of innovations, pilot projects, international projects, energy supplier, and municipal utilities • Promotes projects targeting the SET implementation plan (see Tasdemir & Arndt, 2020)	• Purpose is the development of innovational technology rather than a quick implementation of geothermal energy in Germany
Risk Insurance	KfW – Fündigkeitsrisiko Tiefengeothermie	Subsidised loans provided by the KfW, initiated by the BMWi and Munich Re	+/-	-	+	-	-	-	-	-	-	• Covers the first drilling operation • Bank debt with a compensation clause for the developer • 80% of eligible costs covered	• House bank has primary liability (except for the short-term risk) • Debtor pays a risk premium on top of the interest rate until short-term risk is over • High initial costs
Other support measures provided by law: *Energieeinsparverordnung* (EnEV) – Energy Saving Ordinance → *GebäudeEnergieGesetz* (GEG 2020) – Building Energy Act, *Kraft-Wärme-Kopplungsgesetz* (KWKG) – Power Heat Coupling Law, *Konjunkturprogramm* - Conjuncture program													

7 Discussion and recommendation on financial support

Since Germany has a juvenile market maturity in terms of DGE technology, the EEG amendment in 2021 has improved the support and reduced the annual degradation rate of the feed-in tariff, which was adopted in the EEG 2017 and then aroused criticism from the economic sector. For other RE technologies, a market premium was invented to stop the uncontrolled implementation of RE and rather initiate a competitive atmosphere for these technologies. The guaranteed offtake also ceases with the market premium approach, leading to a self-promotion of the energy at the spot market. All these mentioned points are a progressive step towards a more market-oriented economy. In Germany a market premium for RE, such as wind and solar, thus suits the technological market maturity level the most. Therefore, this approach should also be targeted for geothermal energy, which is now the case with the 2021 amendment of the EEG.

A feed-in tariff is still more suitable for DGE in Germany than a market premium model, which, at this point, could only be implemented in Munich (medium maturity level) (see Figure 1). However, this

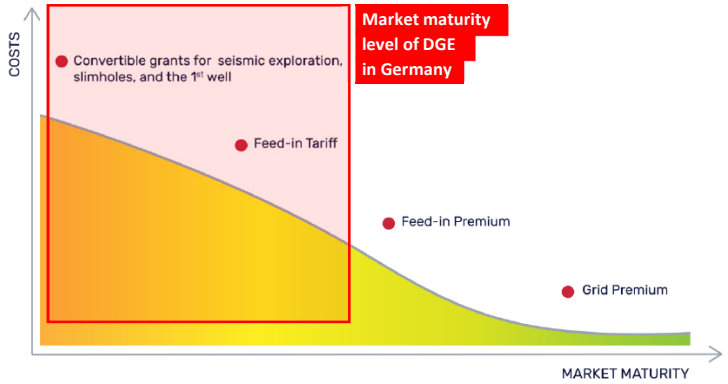

Figure 1: Technological market maturity level plotted against costs (modified after EGEC, 2016). With rising maturity of the market, the costs are decreasing.

should only be considered for heat and not for electricity. Also, a guaranteed offtake for heat that is produced by a geothermal plant is needed. By now, this is only the case for geothermal electricity. The heating market is completely excluded from a feed-in tariff model, which needs to be changed. Even if a feed-in tariff is a revenue subsidy, it is an effective measure to foster the offtake of renewable heat. This should not only be considered for geothermal energy but also for biomass. A degression of the feed-in tariff must then depend on the installed capacity, i.e. if a particular capacity is reached (at least 100 MW) a market-driven degression is initiated depending on the region, size, performance and technology. For the amendment of 2012 for electricity, an annual decrease of 5% was recommended for 15 years of revenue support. Such a high decrease would lead to a total degression of 75%, implying

that 5% are chosen rather randomly and do not depend on the development of the level of competitiveness geothermal energy within these 15 years. This calendar-driven degression needs to be prevented for heat. However, the first step would be to implement a feed-in tariff for geothermal energy and provide a guaranteed offtake of heat, e.g., through a compulsory connection and use obligation as a commitment to achieve Germany's climate protection goals. Since Europe is seeking to become the world's first climate neutral continent, more subsidies for innovative technologies are essential. Neighbouring countries such as the Netherlands already show how effective a feed-in tariff for heat supply can be (ETIP-DG, 2019).

The constant renewal of the EEG hinders the expansion of DGE, since the project development period can take up to 7 years. Therefore, a fixed feed-in tariff is essential for a secure planning and should be set at the time of permit (Hauptbetriebsplan), leading to a mitigation of the overall risk capital (equity). Anyway, the chosen support schemes have to suit the technological maturity level and therefore a market premium for heat from renewable sources could also be considered as a possible alternative to the conventional feed-in tariff. While this means that both support schemes should be offered to the supplier, in both cases the state is the responsible party for funding DGE projects until a certain maturity is reached where the public can be incorporated into investment decisions. To be able to fund this new renewable heat subsidy, the conventional heat and energy suppliers should pay a higher EEG levy to cover a large amount of the fund.

Since geothermal energy bears high upfront investments during the riskiest stage of the project, these investments need to be secured by the state through e.g., a revolving fund. This fund could serve as a kind of insurance for the first drilling phase. Such a drilling insurance was already implemented for DGE in Germany. To overcome outage of the fund in terms of a high probability of risk occurrence, the application requirements for developers were severe and expensive. For the comprehensive application stage, examination fees (up to 65,000 €), commitment fees (45,000 €), a high interest rate, debt discount, and provision commission had to be considered for each drilling project.

The "Fündigkeitsrisiko Tiefengeothermie (228)" by the KfW provided an insurance for the production drilling, but was soon terminated due to the mentioned comprehensive application procedure mainly because of the not existing indemnification for private banks. The actual debt contraction was made between the developer and the house bank. Soon, no bank was willing to provide a debt for the drilling phase due to missing support from the KfW. To prevent such a loss of confidence, the insurance scheme must include an indemnification clause for the private bank and the developer - in the event that no economically viable reservoir is found- which would guarantee a repayment of the debt to the bank by the state.

As already mentioned, the technological maturity level of deep geothermal energy technologies is juvenile; therefore, grants are needed for the initial project development stages. Looking at the existing support incentives for heat, there are only two options provided by the EEWärmeG: (1) Grants by the BAFA for private homeowners and (2) subsidized loans by the KfW for near-surface geothermal plants and DGE. The latter could be improved in terms of the interest-only years, which inevitably increase the redemption period, i.e., one year of interest-only increases the actual repayment of the debt to +5 years. This leads to a total increase from max. 3 years of interest-only to 20 years of repayment with additional interest rates. Such an approach is profitable for the KfW but not for the developer. Therefore, a grant would be more suitable as an equity support instead of interest-only years at the beginning of the project. Also, a flexibility grant[1] that already exists for biomass (stopped with the EEG 2017) could be adapted for DGE. It is an incentive to implement larger plants and guarantee a higher installment of heat capacity.

7.1 An alternative approach: the geothermal resource certificate

The idea of the Geothermal Resource Certificate (GeoRC) starts exactly where the exploration risk must be completely taken away from the operator/investor: It is simple, understandable and transparent, and also fair, despite major differences in the individual countries of the EU - in addition it can be introduced and implemented quickly, as no federal and/or provincial laws have to be changed or amended.

The new GeoRC is an official certification that a geothermal resource (with a certain temperature and permeability range) in principle exists at a certain location in the deep subsurface. This certificate is issued by the State Geological Survey or another competent authority. Through the certificate, the investor receives a subsidy in the amount of the discovery insurance (approx. 1 million € per site) as a funding commitment. The most important aspects are summarised below.

- It is a certificate confirming the existence of a geothermal resource in the subsurface of the site (according to the current state of knowledge).
- The geological authority issues the certificate if geological and geophysical data allow an assessment according to the state of the art. If the data situation is too poor, the authority must

[1] A flexibility premium is an addition to a market premium, i.e. when the energy supplier is placing its own energy on the spot market. The flexibility premium aims to increase the flexibility of energy usage by producing energy during a high demand period. With the amendment of the EEG in 2014 the flexibility premium will be replaced by the flexibility grant to foster a demand-based production. To date, this grant is only provided to energy production by biomass (annual grant of 65€/kW installed capacity for 20 years) (Next-Kraftwerke, 2021).

initiate exploratory measures for geothermal-geological mapping so that an assessment is possible.

- Any investor (e.g., city, district, municipality or private investor) can apply for a GeoRC if a previous application for a geothermal licence was successful. Requests will be processed according to the date of receipt.
- The GeoRC is comparable to a voucher for the subsidy in the amount of the costs of the exploration insurance (risk coverage of the initial drilling). This means that the state insures 100% of the exploration risk and investors of heating plants do not have to consider this risk in their investment calculation.
- If the authority determines that there are no geothermal resources in the subsurface, no resource certificate is issued. Potential investors then have to take the risk entirely on their own, because presumably no insurance will cover this case.
- The EU subsidises the countries' funding by up to 70% in order to achieve a fast start-up effect. The rest needs to be covered by every country as risk capital.
- On EU level, each country is responsible for how quickly it will implement deep geothermal energy. To do so, it is sufficient to determine the amount of funding per year. A country or federal state, for example, can get 10 deep geothermal projects underway with approximately 10 million euros of funding per year.

7.1.1 Advantages

- The same investment conditions are created for geothermal heat plants as for conventional lignite-fired plants.
- The funding instrument is simple, understandable and comprehensible.
- It can be used immediately, as no changes to the law are required.
- The countries regulate how quickly they want to promote the "geothermalisation" of the heat supply in their country through the annual subsidy amount.
- The EU regulates the expansion of deep geothermal energy in the EU through a subsidy. The amount of it is on a percentual basis.
- All other regulations in the individual EU countries remain unaffected.

8 Conclusion

To change the reputation of DGE in Germany and to foster its expansion as a climate-friendly energy source, various improvement measures need to be considered. Since changes to the legal framework are a time-consuming issue, the main target of improvement should be the several investment aids. On the other side, a large improvement is needed in terms of digitisation of the application processes for the permits. This step would not only simplify the whole process but would also lead to a better exchange of information.

The next table (Table 7) briefly summarises the different improvement steps recommended within this report.

Table 7: Summary of the recommendations of legal framework and risk management.

	Type of support	Relevant for			Level of improvement urgency	Recommendation for improvement	Effect on DGE
		Developer	Investor	Operator			
Legal framework	Digitisation of the permitting process	x	x		High	The whole permitting process from submission to approval needs to be fully digitised.	Simplification of permitting process and also shortening of the handling time.
Financial risk management	Feed-in tariff for heat	x		x	Medium	A feed-in tariff should also be implemented for heat production with renewable energy (same as in the Netherlands). Degression of the EEG for DGE should start not before a particular capacity is installed (at least 100 MW should be installed to start a degression; should rather be market-driven than calendar-driven degression)	Guaranteed offtake of heat from renewable energy sources.
	Market premium for heat	x		x	Medium	Federal states with a more mature technological market maturity should be able to get a market premium for individual selling approaches (same as in the Netherlands). But the application procedure should not depend on an auction as it is the case for solar and wind.	Individual promotion of heat on the spot market: more revenue.
	Grants rather than subsidised loans	x	x		Medium	Grants are more suitable for juvenile market structures. They also offer an equity support in the beginning of the project. A subsidised loan is not very profitable for the developer but for the provider of the credit. Especially in Germany, the concept includes an interest-only year with an increase of repayment years.	More projects would be implemented with a higher risk capital. Better change for private debt.

	Insurance for drilling	x	x		Very High	A risk mitigation scheme such as a subsidy loan needs to be implemented with a clear indemnification clause for the private bank and the developer in the event that no economically viable reservoir is found (80% of eligible costs covered by the State)	Secure investment atmosphere: investors would be more willing to invest into DGE
	Implementation of a flexibility grant for DGE	x	x	x	Medium	Flexibility grant (existed for biomass; stopped with the EEG 2017) could be adapted for DGE: incentive to implement larger plants and guarantee a higher thermal capacity	Developers would be more prone to build larger plants
	Equity support	x	x		Medium	Equity support could be provided through grants by the State (fund) or through private banks together with a loan (recommended for more mature technological maturity levels)	Support at the beginning of the project: higher risk capital
	Geothermal resource certificate	x	x		High	Similar to a risk insurance fund, but fully covered by the state (responsible actor).	High security of investments

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