SAPHEA
INTEGRATING GEOTHERMAL HEATING AND COOLING NETWORKS IN EUROPE

Financing Geothermal District Heating and Cooling: A Strategic Guide

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Executive Summary

This report presents a comprehensive overview of the current financing landscape for **geothermal district heating and cooling (GeoDHC)** in Europe and it offers strategic guidance on how to accelerate its large-scale deployment to support the shift toward a climate-neutral Europe by 2050, where clean, local, and secure heating and cooling solutions become the standard, not the exception.

Geothermal energy has a significant potential to **decarbonise Europe's heating and cooling (H&C) sector**, still accounting for nearly half of the total final energy consumption. Yet, GeoDHC remains significantly underexploited despite its advantages: reliable, local, competitive, fully operable, compatible with urban H&C infrastructure, offering stable heat prices and reducing energy imports. This is due not only to technical or geological challenges, but more critically, to high upfront capital requirements, fragmented financing frameworks, and a persistent perception of risk among investors, also for those lower-risk technologies (shallow geothermal, closed loop, ESG, repurposed old O&G wells), because the image of geothermal energy in the wider audience is tied to the traditional open-loop deep geothermal duplet.

The report maps a range of **available sources of capital and providers, with their strengths and weaknesses**. It presents the **types of risks affecting GeoDHC projects**, highlights why **de-risking mechanisms** are pivotal to unlocking massive deployment of geothermal energy, and gives an overview of existing risk-mitigation tools and their effectiveness. Key insights include:

- The importance of **risk mitigation tools** across the project lifecycle, particularly for early-stage geological risk, which is a major bottleneck for investor confidence.
- The need to **strengthen the bankability of project developers**, especially municipal and mid-sized actors, who often lack the credit profile to access traditional capital.
- The role of **public-private investment vehicles**, guarantees, and revenue-backed contracts in improving financial viability and de-risking investment environments.
- The emergence of **new business models**, such as **Heat Purchase Agreements** and **Heat-as-a-Service**, which can attract third-party capital and lower entry barriers.

The report then proposes a series of **financing blueprints** and **strategic recommendations**, to catalyse extensive deployment of geothermal energy, including the deployment of de-risking schemes at scale, possibly through the creation of a **European Risk-mitigation Insurance** as a stand-alone instrument or as part of a wider programme, such as a **European Geothermal Fund** or a **European Geothermal Bank**, issuing a variety of financial instruments.

The findings are intended to support policymakers, developers, financiers, and local authorities in designing tailored financial strategies that accelerate the uptake of geothermal heating and cooling, making it a mainstream solution in Europe's clean energy transition.

A Complex and Fragmented Financial Landscape

The SAPHEA status report **mapping existing financing instruments for GeoDHC** (Conforto, 2024)and exploring their effectiveness, accessibility, and gaps, has revealed a wide but fragmented landscape. Equity, debt, grants, subsidies, concessional finance, and revenue support all play important roles, but they are often applied inconsistently across countries, and too few are tailored to the unique characteristics and risk profile of GeoDHC. Developers often struggle to combine these instruments, particularly in early-stage projects with uncertain geological outcomes and long payback periods. The result is a **market restrained by complexity, caution, and under-investment in GeoDHC**.

Sources of Capital: The Need for Coordination

While equity and debt remain foundational, they require strong public support to catalyse initial investment. Public incentives, such as grants, investment subsidies, and concessional loans, can significantly improve project economics and reduce the burden on developers. At the same time, also operating subsidies and feed-in tariffs help stabilise cash flows and reduce long-term revenue risk.

Crucially, the report also highlights the importance of **developer bankability**. Regardless of the structure of financial instruments available, access to capital ultimately depends on the creditworthiness and capacity of the project developer. This remains a barrier, especially for municipalities, SMEs, and new market entrants, and underscores the need for technical assistance, aggregation platforms, and capacity-building alongside financial innovation.

Risk: The Defining Challenge of GeoDHC

The assessment of risks in GeoDHC projects highlights how **geological risk**, especially in the early development phase, is the single greatest hurdle to investment. This section outlines also the other risks that play a role in GeoDHC projects and their financial consequences.

De-risking: From Tools to Strategy

This report reviews a range of de-risking instruments, from short-term tools like pre-drilling insurances and exploration guarantees to long-term mechanisms such as revenue stabilization grants and credit guarantees. It also shows how **non-dedicated instruments**, such as investment grants, operating subsidies, and public-private partnerships, can indirectly de-risk projects by improving financial viability.

- ➢ What emerges is that financing must not be seen as an isolated intervention. It is a **systemic strategy**, where instruments are combined, sequenced, and matched to the risk profile of each phase of a GeoDHC project.

Blueprints for the Future: Towards Strategic Investment Frameworks

To operationalise these insights, the report proposes concrete **financing blueprints**, offering risk-pooling benefits, long-term visibility, and the ability to bundle projects across multiple jurisdictions and geologies. Some of these blueprints could even be combined in a wide-ranging programme. Thus, the concept of a **European Geothermal Bank or Fund** emerges as a compelling next step: a centralised mechanism, either through InvestEU or a specialised EIB window, that could coordinate risk mitigation, capital mobilisation, and project selection across the continent. Such an institution could overcome the fragmentation that currently hinders scale and coherence. Whether deployed as a single centralised entity or through national agencies operating under a harmonised EU framework, it would provide the standardisation, risk management, and strategic alignment needed to make GeoDHC finance-ready and investment-attractive.

The report then proposes a series of **financing blueprints** and **strategic recommendations**, to catalyse the extensive deployment of geothermal energy, such as deploying de-risking schemes at scale, supporting greater uptake of Heat Purchase Agreements (HPAs) and bundling them with policy guarantees, scaling investment grants and operating subsidies, mainstreaming concessional finance, as well as embedding risk Assessments and Market Facilitation Tools in Planning.

In particular, the creation of a **European Risk-mitigation Insurance** is long needed, as advocated by EGEC and other stakeholders for decades now. This could be created as a single instrument, financed via EU funding or catalysing national funding from various member states, or it could be set up as part of a wider programme, such as a **European Geothermal Fund** or **Facility**, which could be the first step towards a more stable **European Geothermal Bank**, issuing a variety of financial instruments.

Strategic Guidance

Finally, the recommendations chapter lays out the core enabling conditions to unlock the potential of geothermal district heating and cooling:

- Expand and standardise de-risking instruments for geothermal energy at the national and EU level: to reduce perceived investment risk and improve bankability, attracting private capital.
- Promote innovative business models that remove upfront barriers for end-users, such as lowering upfront costs for users (e.g., via ESCOs, leasing), making projects more financeable and attractive to investors.
- Harmonise regulatory frameworks and simplify permitting processes, with the aim to cut delays and uncertainty, reducing soft costs and improving project timelines, key to investor confidence.
- Integrate geothermal systematically into local and regional energy planning, thus enhancing visibility, political support, and alignment with public funding priorities, unlocking eligibility for grants and co-financing, enabling aggregation and scaling, as well as improving risk-assessment, because of the public engagement, and encouraging cross-sector synergies.
- Support skills development and professionalisation of the geothermal workforce, to advance the development of the whole geothermal value-chain, and reduce technical risk, making investments more secure and attractive.
- Elevate geothermal in EU energy policy and funding frameworks, to ensure access to dedicated funding and level the playing field with other renewables, boosting financial flows to the sector.

Final Reflection

GeoDHC is uniquely positioned to deliver clean, reliable, locally sourced and fully operable heating and cooling. It offers base-load capacity, aligns with circular and climate-resilient cities, and complements electrification efforts without exacerbating power grid constraints. However, the risks will likely leave the potential for GeoDHC largely untapped without bold and coordinated action to align **capital, risk, and policy**.

This report offers a roadmap to make that alignment possible. The tools exist. The capital exists. What is now required is a step-change in commitment, coordination, and ambition.

Call to Action

A clear and urgent imperative emerges: if Europe is serious about decarbonising its heating and cooling sector, then scaling up geothermal must become a central strategic priority. To do so, we must transform how geothermal projects are financed, how their risks are managed, and how their deployment is integrated into the broader energy and urban planning ecosystem. While a lot of attention keeps going to sources that are not yet commercially available, such as hydrogen, or imply long development times, such as nuclear, geothermal is already a viable, clean and secure solution. Let this be the decade where geothermal heating and cooling moves from marginal to mainstream, powered by smart finance, systemic de-risking, and strategic vision.

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CAPEX	Capital Expenditure
CDD	Cooling Degree Days
CHP	Combined Heat and Power
DHC	District Heating and Cooling
EED	Energy Efficiency Directive
EGS	Enhanced Geothermal Systems
EIB	European Investment Bank
EIF	European Investment Fund
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
ESCO	Energy Service Company
EU	European Union
FEC	Final Energy Consumption
FiT	Feed-in Tariffs
GeoDHC	Geothermal District Heating and Cooling Network
GDP	Gross Domestic Product
GFA	Gross Floor Area
HDD	Heating Degree Days
H&C	Heating and Cooling
HPA	Heat Purchase Agreement
IEA	International Energy Agency
LTRS	Long-Term Renovation Strategy
NECP	National Energy and Climate Plan
NEEAP	National Energy Efficiency Action Plan
NPV	Net Present Value
O&M	Operation & Maintenance
OPEX	Operational Expenditure
ORC	Organic Rankine Cycle
PPS	Power Purchasing Standard
RES	Renewable Energy Sources
RRP	Recovery and Resilience Plan

1. Introduction

As well known, to achieve the EU's climate goals, it is crucial to decarbonise the heating and cooling (H&C) sector, which accounts for nearly half of the EU's total energy demand and emissions. Geothermal energy, with its capacity to provide abundant, clean, reliable and operable heat, offers a huge potential to transform the H&C landscape, especially when combined with district heating and cooling (DHC) networks. Being a stable and renewable source, geothermal energy can provide heating, cooling, and electricity sustainably, suitable for baseload, enhancing energy security.

From a technical point of view, many barriers are being lowered. Traditional deep geothermal can easily supply DHC networks and significantly reduce dependence on fossil fuels, and shallow geothermal and networked heat pumps achieve high efficiencies while allowing the integration of other renewable energy sources (RES) like solar and biomass in a multivalent system. Geothermal can supply heating, cooling, and work as H&C storage, notable given the growing needs for space cooling, as well as flexibility in systems that integrate growing shares of renewables. The latest technological advancements now allow access to geothermal resources that so far lay vastly unexploited: novel drilling technologies, new exploration methods, closed loops, smart systems and 3D models, underground thermal energy storage, and ultra-deep, advanced, enhanced and supercritical systems.

Regarding policy, the EU has repeatedly emphasised the need to decarbonise the building sector and the huge potential of geothermal energy, via the Renewable Energy Directive (EU/2023/2413)(EU Parliament, 2023a), the Fit for 55 package(European Council, 2023), and the EU Parliament resolution on geothermal energy 2023/2111(INI) (EU Parliament, 2023b), just to name a few. The Council of the EU calls for faster deployment of geothermal energy (European Council, 2024), as affordable, stable, secure and local RES able to provide H&C and electricity. The IEA stated in a recent report on the future of geothermal energy that it is "a promising and versatile renewable energy resource with vast untapped potential for electricity generation, heating and cooling" (IEA, 2024). Also, it has been announced that an EU Geothermal Action Plan will be published in Q1 2026 (EU Parliament, 2025).

However, despite all this progress, geothermal energy still faces a series of challenges hindering its market uptake, especially in DHC systems: significant upfront investment costs associated with geological and technical risks, fragmented regulatory frameworks, and limited social acceptance. Financing, a critical enabling factor, often becomes a bottleneck where all these underlying barriers converge.

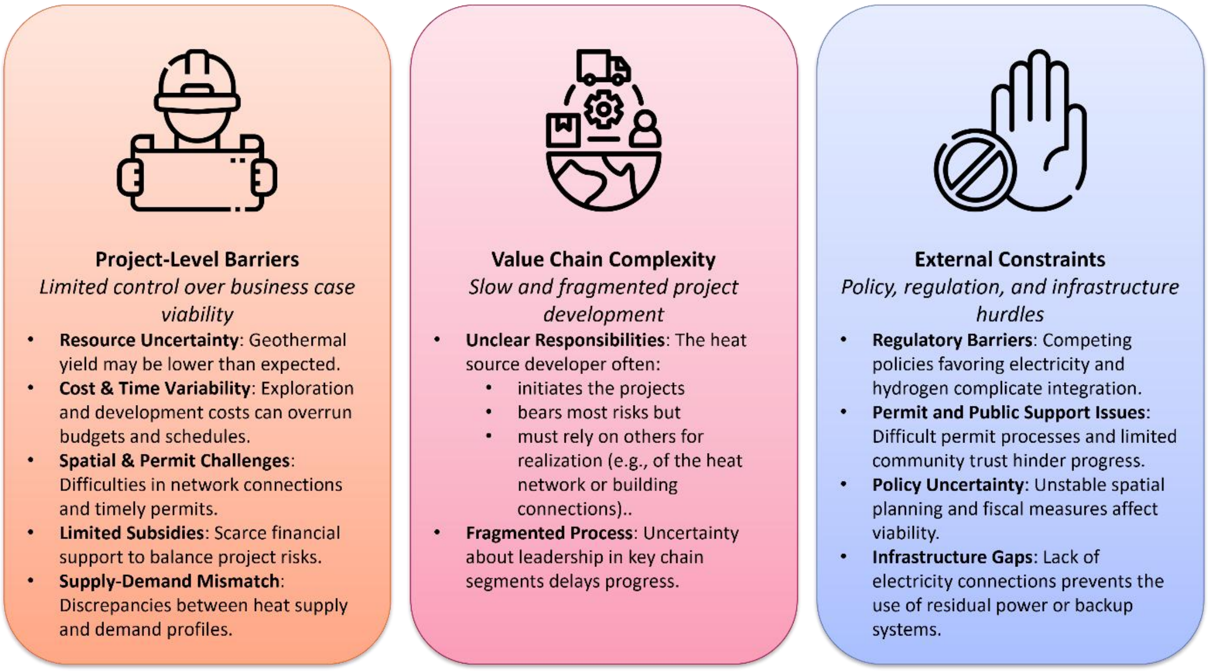

Figure 1: GeoDHC Projects Barriers

Hence, SAPHEA created a Market Uptake Hub[1], including tools, reports, data and methodologies addressing persistent challenges in the effort to facilitate early-stage decision-making and support increasing adoption of GeoDHC systems.

Concerning the financing of geothermal DHC systems, SAPHEA has already published status reports mapping the most common business models (Dumas, 2024) and financing instruments (Conforto, 2024) currently offered and employed in geothermal projects. Building on this foundation, the present report takes a deeper dive, identifying what financing instruments present the largest potential to support the vast and persistent market uptake of geothermal DHC systems.

The report proposes a series of Innovative Financing Blueprints, emphasizing the most promising instruments already in use and recommending new or underutilized instruments to accelerate market adoption, especially enabling smaller developers and municipalities to access financing. In addition, it provides strategic guidance for change, outlining how financing can be integrated into broader policy and market transformation strategies to foster an enabling environment for geothermal energy.

The findings presented in this report underscore the critical role of tailored financing solutions in overcoming systemic barriers and unlocking the full potential of geothermal DHC networks. By bridging the gaps in financing, the SAPHEA project aims to catalyse the widespread adoption of geothermal energy, advancing decarbonization, energy resilience, and social acceptance in Europe.

[1] https://www.saphea.eu/

2. Key Findings of the SAPHEA Status Report Mapping Financing Instruments for GeoDHC

The SAPHEA status report on financing instruments for GeoDHC assessed the European financial landscape in 2024, building on an EU-27 comprehensive country mapping of public and private financing schemes for decarbonizing buildings and H&C.

Mapping Results

An overall mapping identified 597 schemes, of which 317 (53%) are relevant to GeoDHC. These are predominantly public (79%), highlighting strong public support but also some investor reluctance, with geothermal and, more broadly, renewable energy projects still perceived as more risky and less profitable than traditional alternatives. The highest number of schemes was found at the EU level and in countries like France, Germany, Austria, and Poland, where DHC is a well-established or considered a promising technology.

Instruments

Despite the vast variety of financing instruments identified in the literature, most schemes involve traditional instruments: grants/subsidies and soft loans for the public offer, and green loans and bonds for the private one. In fact, while innovative instruments offer several advantages, mostly trying to overcome the shortcomings of traditional instruments, their potential to attract capital remains limited compared to traditional instruments that are easier to implement and communicate.

European Public Financing includes programs like Horizon Europe, LIFE, and the Innovation Fund, providing grants for R&D, demonstration, and scaling of geothermal projects.

In many EU member states, national programs offer incentives for renewable H&C systems, including ground source heat pumps, which are particularly effective when networked, and DHC integration.

Private Financing includes mostly green loans for small investments, such as ground source heat pumps, as well as a few green bonds, equity and project finance options. However, banks and institutional investors remain risk-averse. Hence, risk mitigation is crucial to support the development of geothermal energy. When the national risk-mitigation guarantee scheme was launched in France for instance, a clear correlation with the number of geothermal projects emerged (Schmidlé - Bloch, 2024). A European Geothermal Risk Mitigation mechanism would greatly help at the continental level, but it is still missing.

Besides, the combination of multiple instruments can be beneficial in supporting more geothermal projects, such as concessional loans combined with grants. Similarly to how blended finance has proved exceptionally successful in supporting the uptake of solar panels, a small amount of public funding combined with larger private loans at market rates, could place most risks on the public partner and attract private capital.

Sector Coverage

While most instruments target energy efficiency, broader renewable energy integration, or overall building thermal upgrades, only a minority of schemes specifically target GeoDHC, mostly aimed at businesses and non-residential settings. As DHC projects are large and long-term investments, it makes only sense that the number of schemes supporting them is much more limited compared to the schemes incentivizing the upgrade of individual H&C solutions targeting a multitude of individual households and businesses.

Correlations and Trends

The analysis revealed strong positive correlations between public energy efficiency spending, population size, and the number of financing schemes. However, economic maturity and high GeoDHC adoption did not directly influence financing availability. Cold climates, marked by higher heating demand, showed greater DHC adoption but not necessarily stronger GeoDHC financing support.

Sector Barriers and Solutions

High upfront costs, regulatory uncertainty, and limited financial sector expertise in assessing geothermal projects are reported as some of the main barriers to financing GeoDHC, both in the literature and in a series of expert interviews. On the other hand, public support, energy cost reductions, and policies promoting renewables are drivers to mitigate these challenges.

To enhance GeoDHC financing, the report identified among other strategies:

- Increasing investor confidence by documenting successful projects.
- Facilitating access to finance through standardized processes, open data, and technical assistance.
- Enhancing profitability by leveraging efficient designs, long lifespans, and reliable subsurface data.
- Promoting uptake through de-risking mechanisms, pilot projects, and streamlined permitting processes.

Challenges and Recommendations

The mapping process highlighted significant challenges, including limited transparency in budget allocation and the dynamic nature of funding schemes. While numerous schemes exist, their effectiveness remains unclear without historical data and data on their actual utilization. Given the persistent investment gap for decarbonization, it seems that financing instruments must be coupled with regulatory mandates and long-term policy commitments. Reducing energy demand through building efficiency should be prioritized before seeking to integrate low-carbon sources. Strong political commitment and coordinated efforts are essential for increasing the uptake of GeoDHC networks.

Efforts should focus on creating centralized, user-friendly platforms offering detailed financing information, as well as fostering public-private partnerships and innovative financing solutions. As part of the SAPHEA project, the full mapping is accessible through the Market Uptake Hub[2], providing stakeholders with valuable resources to navigate the financing landscape and accelerate GeoDHC adoption.

[2] https://www.saphea.eu/data-viewers/

3. Sources of Capital

Own capital is commonly the first source of investment in geothermal district heating and cooling (GeoDHC) projects, but it can rarely cover the full investment and may place a significant burden on the balance sheet. Public financing schemes also provide a foundational layer but are also insufficient on their own. Therefore, GeoDHC projects are usually financed through a combination of multiple sources. This chapter presents an overview of these sources of capital, with their strengths and weaknesses, and how they can be effectively leveraged.

3.1 Equity

Equity financing refers to raising capital in exchange for ownership. It plays a critical role in GeoDHC projects, particularly in the early stages (from pre-feasibility to post-drilling), when risk is high and access to debt is limited. Equity typically enters the project via two channels: **corporate finance** and **project finance.**

Corporate Finance

In this case, equity is raised at the company level, based on the overall financial strength of the firm. This model is common for utilities, Energy Service Companies (ESCOs), and startups that are scaling innovative GeoDHC business models. Typical sources are:

- **Own Capital**: Project developers (municipalities, utilities, technology providers) finance early stages internally, when it is still too risky or costly to bring in external investors.
- **Venture Capital (VC)**: Targets scalable solutions, such as platform providers or technology aggregators. Can be distinguished in various series depending on the maturity of the project. Pre-seed and Seed Capital include founders, business angel investors, or innovation funds that cover early development. Series A/B/C can scale operations or expand into new markets after initial validation, once resource risk decreases.

Strengths

- Faster decision-making and lower transaction costs than SPV-based models (see next paragraph 'Project Finance').
- Easier to reinvest across multiple projects or scale activities.

Weaknesses

- Investors take on broader company risk, which may limit their risk appetite.
- Less suitable for capital-intensive, single-asset projects like deep geothermal wells.

*Note: **Blended equity models** (e.g., public-private partnerships) are increasingly used, especially when cities aim to retain partial ownership while leveraging private capital and expertise. Given the reluctance of local bodies to take over the project risks, this can work best in well-developed reservoirs or after a successful well is proven.*

Project Finance

This structure is more typical in geothermal energy due to its high upfront costs and subsurface risk. Here, investment is channelled into a **Special Purpose Vehicle (SPV)** dedicated to the project, with returns tied to the project's cash flows. Typical sources are:

- **Development Finance Institutions**: Provide early-stage equity or quasi-equity to de-risk projects and crowd in private investors.
- **Strategic Investors**: Utilities, EPC contractors, or equipment manufacturers investing where they have commercial interests.
- **Private Equity, Infrastructure and Pension Funds**: Focused on stable, long-term returns, usually entering in post-drilling or construction phases in well-developed markets. Given the long

technical lifetime of newer systems, such as 5GDHC grids, they can become a high-return asset for decades after full economic depreciation.

Strengths

- Limits investor exposure to the SPV and not the broader corporate balance sheet.
- Attracts investors with long-term investment horizons and sustainability mandates.
- Facilitates blending with public finance or concessional instruments.

Weaknesses

- Requires strong revenue frameworks (e.g., Heat Purchase Agreements (HPAs), connection guarantees).
- Structuring can be complex and costly, with extensive due diligence.
- Equity investors may delay entry until resource risks sink (post-drilling).

*Note: **Revenue certainty tools,** such as risk mitigation mechanisms, HPAs, public guarantees, or anchor-load contracts, are essential to attract equity investors.*

3.2 Debt

Debt financing allows project developers to access capital with the commitment to repay it over time, typically with interest. Interests are risk-based; hence debt financing becomes more accessible once early-stage risks (subsurface) are reduced, and revenue streams are secured (e.g., Heat Purchase Agreements). Debt can be used to finance the construction and operational phases of GeoDHC projects, as it can significantly scale up investments, but commercial lenders generally require stable revenue contracts and risk-sharing arrangements. Typical sources are:

- **Commercial Bank Loans**: Conventional loans from private banks, usually secured against project assets or future cash flows.
- **Credit Lines**: Flexible borrowing mechanisms to cover working capital or unexpected costs during implementation.
- **Green and Climate Bonds**: Debt instruments issued to finance sustainable infrastructure, often structured around SPVs with secured revenue streams.
- **Infrastructure Funds and Institutional Lenders**: Some infrastructure funds extend debt financing alongside equity, preferably in later project stages with lower risk.

Strengths

- Enables large-scale capital mobilisation without diluting ownership.
- Lowers the weighted average cost of capital (WACC) compared to equity.
- Lenders with sustainability mandates are increasingly targeting low-carbon infrastructure.

Weaknesses

- Commercial loans are rarely accessible in early project stages due to exploration risk.
- Requires proven bankability: robust revenue models (e.g., HPAs), clear permitting, and experienced project developers.
- Interest and repayment schedules can stress project cash flows if not properly aligned with operational ramp-up.

Note: In many GeoDHC projects, debt becomes viable only after drilling success and signing of HPAs or anchor customer agreements.

3.3 Public Capital Support: Grants & Subsidies

Public incentives, such as grants and subsidies, play a pivotal role in making GeoDHC projects financially viable, especially in the early phases and young markets, by reducing upfront costs, and improving the overall return profile, thus helping to attract private equity and debt. The main sources are:

- **Direct Grants:** Non-repayable funds provided for early-stage activities such as pre-feasibility studies, resource assessment, and exploration drilling.
- **Investment Subsidies:** Public contributions covering part of the capital expenditure (CAPEX), typically disbursed during construction or commissioning phases, are designed to close viability gaps and improve affordability.
- **State Aid & Public Incentives**: These can include cost-based compensation, feed-in premiums for renewable heat, or fiscal incentives (e.g., accelerated depreciation, VAT exemptions) depending on national frameworks.

Strengths

- Reduce the capital burden on developers and lower project-level risk.
- Improve bankability by catalysing private capital and unlocking blended finance.
- Often include technical support or facilitation services (e.g., permitting, stakeholder engagement).

Weaknesses

- Depend on public budgets and shifting policy priorities.
- Competitive application processes and limited funding envelopes.
- Potential delays in disbursement, especially for performance-based subsidies.

Note: ***Grants are most effective when strategically combined with equity and concessional finance,*** *forming the "first layer" of capital to de-risk GeoDHC investments.*

3.4 Public Revenue Support: Tax Incentives, Feed-in Tariffs & Operating Subsidies

While grants and subsidies reduce upfront capital needs, revenue-side support mechanisms are also crucial to ensure the long-term financial viability of GeoDHC projects. These tools provide income stability, improve cash flow predictability, and increase the attractiveness of projects to equity and debt investors. Main Instruments are:

- **Tax Incentives**: Fiscal measures such as reduced corporate income tax rates, VAT exemptions, or accelerated depreciation for capital investments directly improve project profitability and internal rates of return.
- **Feed-in Tariffs (FiTs)**: Guaranteed or sustained heat purchase prices over a fixed period reduce market risk and provide revenue certainty, particularly important in new or less competitive district heating markets.
- **Operating Subsidies:** Output-based payments linked to actual heat generation, often calibrated to reflect avoided emissions or renewable content. These ensure public support goes to productive assets and can be more adaptive than fixed tariffs.

Strengths

- Improve bankability by stabilising future revenue streams.
- Encourage efficient operation and maintenance, especially with output-based models.
- Can be tailored to policy goals (e.g., emissions reduction, fuel switching, local sourcing).

Weaknesses

- Require long-term regulatory stability and clear implementation frameworks.
- Risk of over-subsidisation or underutilisation if poorly designed.
- May be phased out or capped as markets mature.

Note: When combined with upfront support (grants, investment subsidies), revenue-side incentives provide a full lifecycle financial architecture to de-risk and scale up GeoDHC deployment.

3.5 Concessional Finance

Concessional finance refers to loans or credit provided at below-market terms, e.g., lower interest rates, longer repayment periods, or grace periods. It plays a catalytic role in GeoDHC by improving affordability and de-risking early phases of development. Main Instruments are:

- **Low-interest or Soft Loans:** Offered by public banks, multilateral development banks (MDBs), or dedicated energy transition facilities (e.g., EIB's InnovFin(EIB and EIF, 2018), InvestEU(InvestEU, 2025)).
- **First-loss Tranches:** Public lenders take the riskiest debt layer to crowd in commercial co-financiers.
- **Hybrid Instruments:** Combining elements of loans and grants, such as results-based financing or repayable advances.

Strengths

- Improves cash flow during critical early phases.
- Reduces weighted average cost of capital (WACC).
- Often paired with technical assistance or capacity building.

Weaknesses

- Complex application and compliance requirements.
- May require sovereign or public guarantees.
- Limited availability, typically project-specific or competitive.

Note: Often most effective when combined with commercial loans and private equity in blended finance structures.

3.6 Risk Mitigation Instruments, Guarantees & Insurances

GeoDHC projects, particularly involving deep geothermal, are exposed to a range of risks. Thus, risk mitigation instruments are essential to enhance bankability, attract private capital, and ensure long-term financial viability. These tools reduce the risk exposure of investors and lenders, especially in early stages or in untested markets. Key Instruments are:

- **Geological Risk Insurance**: Covers part of the costs if geothermal drilling fails to yield the expected resource. Often backed by public schemes or multilateral funds.
- **Guarantees & Credit Enhancements**: Issued by public financial institutions to improve a project's credit profile (e.g., by guaranteeing payments from public off-takers, co-financing early stages, can cover all or part of a lender's losses in the event of project failure, particularly effective in attracting commercial bank debt).
- **Revenue-Backed Contracts**:
  - **Heat Purchase Agreements (HPAs) and Anchor Load Agreements**: Long-term contracts guaranteeing the sale of heat at an agreed price and volume. Signed with anchor customers (e.g., municipalities, hospitals, industry), they provide predictable cash flows and are a critical enabler for both equity and debt financing.
  - **Take-or-Pay Clauses**: Commit the buyer to pay for a minimum volume of heat regardless of actual consumption, further reducing demand-side risk.

Strengths

- Directly reduce perceived and actual project risk.
- Improve access to commercial capital by enhancing project creditworthiness.
- Can unlock financing even in early-stage or first-of-a-kind projects.

Weaknesses

- Often require strong public sector involvement or guarantees.
- Insurance and guarantee application processes can be lengthy and administratively demanding.
- HPAs require well-structured demand aggregation and reliable counterparts, which may not be available in all markets.

Note: These instruments are often most effective when combined with concessional finance or grants, creating a layered risk-return profile that accommodates both public and private investors.

3.7 Innovative Business Models

New business models, while not being strictly a source of capital, are another way to bridge financing gaps and accelerate GeoDHC deployment by redefining how services are delivered, risks are shared, and revenues are generated. Emerging approaches are:

- **Energy-as-a-Service (EaaS):** Customers pay for delivered heat instead of owning infrastructure, enabling third-party ownership (e.g., ESCOs, investment platforms).
- **Public-Private Partnerships (PPPs):** Municipalities co-invest with private actors, combining public oversight with private capital and technical expertise.
- **Cooperative & Community Models:** Local stakeholders co-own the system, aligning financing with local benefits.

Strengths

- Unlock new funding sources (e.g., infrastructure funds, impact investors).
- Increase flexibility and scalability of projects.

Weaknesses

- Requires new legal and regulatory frameworks.
- Coordination complexity among actors.
- Revenue models must be robust and clearly communicated.
- EaaS requires complex and highly competent organizations to deliver the full value proposition to both investors and customers.

*Innovative business models work best in enabling policy environments, where long-term planning, procurement flexibility, and utility regulation support systemic change. For a deeper understanding of innovative business models for GeoDHC, please refer to SAPHEA D4.3 "**Blueprints for Business Models"**(Cittadini and Dumas, 2024)**.***

3.8 Overall Note: Developer Bankability and Creditworthiness

Across all financing sources and instruments, the **bankability and credit profile of the project developer** play a decisive role. Lenders and investors will assess not only the technical feasibility and cash flow projections of a GeoDHC project, but also the **track record, financial health, and institutional capacity** of the entity developing it.

Larger corporations, public authorities, municipal utilities, and experienced ESCOs may benefit from stronger creditworthiness and easier access to finance, compared to new market entrants. **Credit enhancements, guarantees, and strong off-take agreements** can partially offset weaker credit ratings but do not replace the need for a capable, reliable, and professionally managed developer.

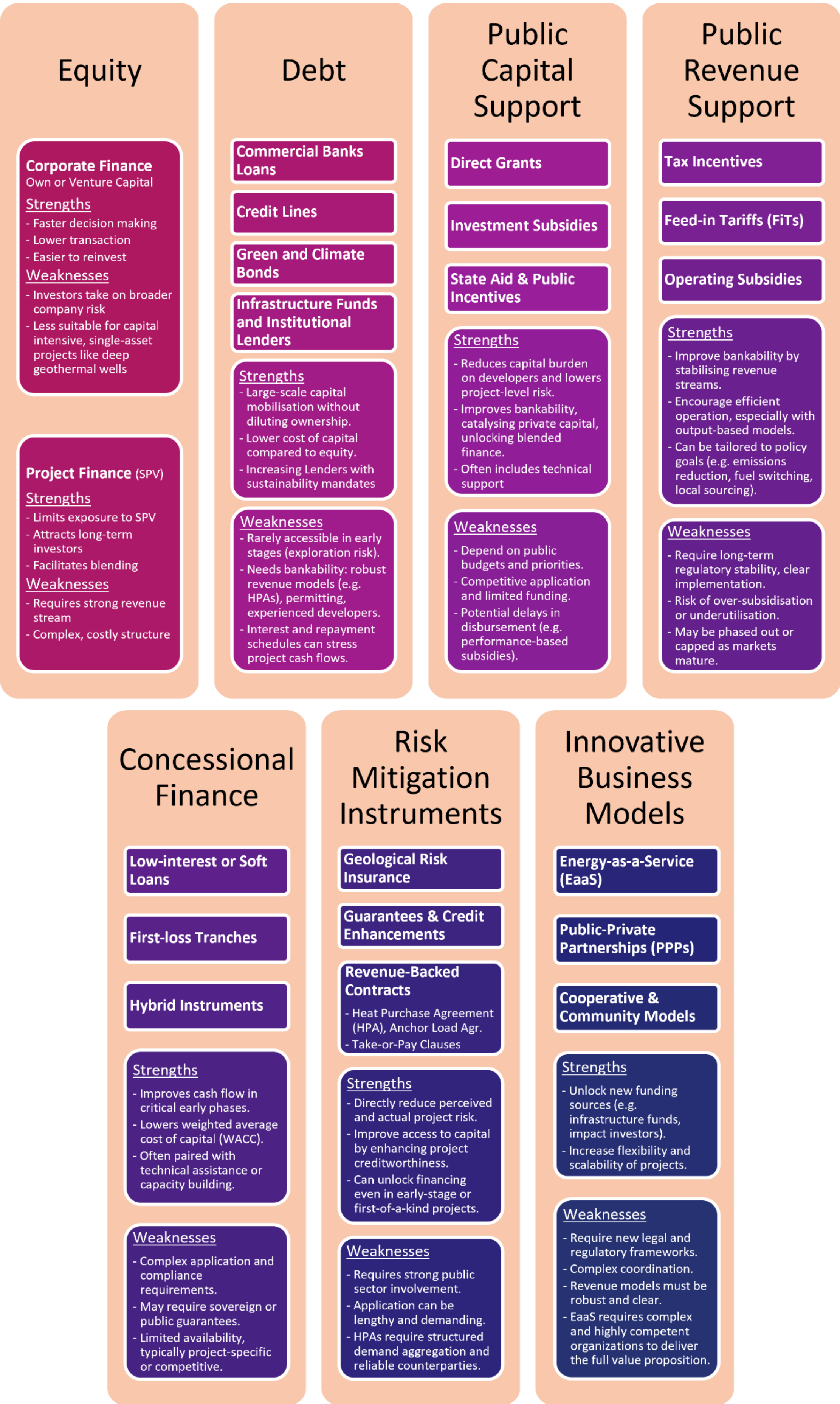

Figure 2: Overview of Financing Instruments for GeoDHC

4. Risks in GeoDHC Projects

Developing and operating GeoDHC systems involves navigating a complex landscape of risks that can affect project viability at every stage. Of course, the complexity changes if there is an existing DH grid or not. Risks range from the well-known geological uncertainties of subsurface exploration to technical, regulatory, financial, commercial, and social challenges. Identifying, categorising, and addressing these risks is essential to attract investment, ensure long-term performance, and deliver on the promise of low-carbon, renewable heat. This chapter provides an overview of the key risk categories in GeoDHC projects, laying the groundwork for targeted de-risking strategies discussed in the following section.

4.1 Geological Risks

These are unique to geothermal and typically the most significant in early phases:

- **Resource Risk**: Uncertainty about the presence, temperature, permeability, or sustainability of the geothermal resource.
    - **Exploration Risk**: Possibility that exploratory drilling does not find a viable resource (short-term).
    - **Reservoir Risk**: Risk that the reservoir is not large or productive enough to support the system over time (long-term).
- **Seismic Risk**: Potential for induced seismicity, mostly in Enhanced Geothermal Systems (EGS).

It is worth making a distinction here between deep and shallow geothermal. Deep geothermal carries intrinsic risks that are often difficult or costly to mitigate. Shallow geothermal, by contrast, involves minimal geological risk but delivers lower-temperature heat, which limits its potential for heating, while it can offer high efficiency for cooling.

4.2 Technical and Engineering Risks

These occur throughout project development and operation:

- **Drilling Failures**: Equipment breakdowns, blowouts, or borehole collapse.
- **Technological Limitations**: Failure or underperformance of heat exchangers, pumps, or Organic Rankine Cycle (ORC) systems.
- **Integration Risk**: Difficulties connecting geothermal heat into existing or new DHC networks.
- **Corrosion and Scaling**: Chemical issues leading to damage or inefficiencies in the infrastructure.

Again, while all these risks are a concern for deep geothermal, shallow geothermal experience minimal drilling risks and much simpler integration risks. Technical limitations depend on the technical elements used in the system. Corrosion and scaling occur only in open-loop systems, while closed-loop systems have minimal exposure.

4.3 Regulatory and Permitting Risks

These refer to delays or changes in legal frameworks that can jeopardize the project:

- **Permitting Delays**: Lengthy or unclear processes for exploration, drilling, construction, or environmental approvals. Permitting processes can be simpler and shorter for shallow geothermal in some countries within a certain depth.
- **Land Access**: Legal or administrative issues for securing access to land or sub-surface rights.
- **Policy Instability**: Shifting priorities or withdrawal of public support (e.g., subsidies, FiTs).

- **Cross-sectoral Coordination**: Misalignment between energy, environment, and urban planning regulations.

4.4 Financial Risks

These affect both CAPEX-intensive early stages and OPEX over time:

- **Capital Availability**: Difficulty in securing sufficient upfront financing.
- **High Upfront Costs**: Especially for drilling and infrastructure.
- **Cost Overruns**: Construction or drilling costs exceeding budget.
- **Uncertain Operation & Maintenance (O&M) Costs**: Difficulty predicting long-term operation and maintenance expenses.
- **Currency Risk**: Especially in international projects with foreign loans or equipment imports.

4.5 Market and Commercial Risks

These relate to the actual operation of the DHC system and securing clients:

- **Offtake Risk**: Failure to attract enough consumers to the DHC system.
- **Pricing Risk**: Heat or cooling prices being too high (non-competitive) or too low (not cost-covering).
- **Revenue Stability**: Linked to variability in demand or dependence on operating subsidies/FiTs.
- **Competition**: From other heat sources (e.g., biomass, heat pumps, waste heat).

4.6 Organisational and Stakeholder Risks

These include issues within the consortium and with local communities:

- **Consortium Risk**: Misalignment between partners, unclear responsibilities, weak governance.
- **Skill and Capacity Gaps**: Lack of technical or financial expertise in project teams or partners.
- **Community Opposition**: Public resistance due to perceived environmental or noise risks, especially in urban or protected areas.
- **Labour Issues**: Shortage of skilled workers or disputes.

4.7 Environmental and Climate Risks

These affect the sustainability and acceptability of the project:

- **Environmental Impact**: Risks of groundwater contamination, land subsidence, or induced seismicity.
- **Climate Variability**: Impacts on surface systems, cooling demands, or heat load profiles.

4.8 Political and Macroeconomic Risks

These are particularly relevant in regions with weak or unstable governance:

- **Political Instability**: Risk of nationalization, policy reversal, or governance collapse.
- **Inflation and Interest Rates**: Affect the cost of capital and project returns.
- **Public Budget Constraints**: Delays or withdrawal of promised grants or subsidies.

Figure 3: Risks potentially affecting GeoDHC projects

5. De-risking Measures

De-risking is pivotal in securing capital for GeoDHC projects. Given the high up-front costs and geological risk, especially in deep geothermal applications, de-risking mechanisms are essential to attract private investment and ensure project viability. However, such mechanisms remain fragmented across Europe, with varying levels of implementation and support. This chapter summarizes existing de-risking schemes, evaluates their strengths and weaknesses, and highlights those that have demonstrated significant impact in facilitating GeoDHC project financing.

Geological risk is one of the most defining challenges in deep geothermal developments the drilling phase involves significant uncertainty, which is significantly lowered in shallow geothermal and closed-loop systems. The feasibility, capacity, and efficiency of a geothermal system depend heavily on the actual subsurface conditions encountered, including temperature, permeability, fluid chemistry, and pressure, which are only partially understood before exploration and drilling.

This makes the early project phases (exploration, test drilling, and initial production drilling) both capital-intensive and risk-heavy, with a real possibility that the resource proves insufficient or uneconomical. Such outcomes can lead to partial or total project failure and sunk costs. As a result, **geological risk often becomes a key barrier to investment**, particularly for private and commercial finance providers who are reluctant to enter projects without risk-sharing mechanisms in place.

To overcome this barrier and improve bankability, a range of risk mitigation instruments have been developed. These can be broadly grouped into **short-term** and **long-term** mechanisms depending on the project phase and the type of coverage offered.

5.1 Short-Term Geological Risk Mitigation Instruments

These mechanisms are designed to absorb or reduce the financial impact of early-stage exploration and drilling failure. They are typically applied before or during the test drilling phase.

Risk Insurance Schemes: Private and public insurance schemes (e.g., Munich-RE Commercial Insurance and Munich Re-KfW Geothermal Insurance (Munich Re, 2024)), Marsh's early mitigation products(Marsh, 2025)) cover a portion of exploration or drilling costs in case of unproductive wells. Often structured with premium payments and bonus payout conditions based on predefined failure criteria.

With the intervention of public funding, a useful improvement in this type of insurances would be to offer reduced upfront premiums jointly with the payment of royalties in case of successful drillings.

Geothermal Guarantee Funds: Publicly backed schemes such as the **French SAF-Environment** and **AQUAPAC** (Geothermies, 2025), Dutch Geothermal Guarantee Scheme **RNES** (NLOG, 2025), the Hungarian Fund, GRMF East Africa (Stollenwerk, 2025), and GDF Latin America (GDF, 2025)offer partial cost recovery for dry and failed wells, reducing the financial downside for developers.

Cost-Share Grants: Instruments like German, Austrian and Dutch public funds (**Leitfaden Tiefengeothermie** (Altmann, 2024; klima und energiefonds, 2024)**; SDE++**(EGEN Green, n.d.)) that provide non-repayable contributions for early drilling, or the Turkish Risk Sharing Mechanism (**RSM**), a hybrid grant-insurance with partial reimbursement if the resource is not viable, no upfront premium, but a success-fee payment (RPM jeoturkiye, 2025).

Exploration Risk Mitigation Programs: Past initiatives like **EBRD's PLUTO** in Turkey (EBRD, 2016), Chile Geothermal Risk Mitigation Program (**MiRiG**) (IEA, 2013) or the proposed but not yet launched **European Geothermal Risk Insurance Fund (EGRIF)** combine technical assistance with phased funding, allowing projects to reduce risk exposure gradually as geological confidence increases.

5.2 Long-Term Geological Risk Mitigation Instruments

Once drilling is complete and production begins, new risks emerge around reservoir sustainability and long-term performance.

Sustainable Performance Guarantees: These instruments (e.g., some modules under the **Swiss 2008/2018 frameworks**, the **long-term risk mitigation** under the **French SAF Enviornment** (Geothermies, 2025), the **Danish Heat Supply Act** (GeoEnergy and Cariaga, 2023) provides municipal-backed loan guarantees and low-interest financing to public non-profit DH companies) offer coverage for production shortfalls or pressure declines over time, helping developers and financiers manage long-term delivery risk.

Alternative Risk Transfer (ART) Instruments: Still emerging, ART models seek to bundle risk through capital market instruments or reinsurance, allowing broader sharing of long-term geological uncertainties.

In sum, addressing geological risk is essential to unlock geothermal potential. While no mechanism can fully eliminate subsurface uncertainty, a well-designed combination of **short-term insurance or guarantees** and **long-term performance coverage or revenue tools** can significantly reduce perceived risk and attract both equity and debt financing into GeoDHC projects.

5.3 Other Financing Instruments Indirectly Mitigating Risks in GeoDHC Projects

While dedicated geological risk mitigation tools are crucial, many **financial instruments and support schemes primarily designed to improve project economics or attract investment also perform a vital risk reduction function**. These instruments help manage broader financial, operational, and market-related uncertainties, thus enhancing the overall bankability and creditworthiness of GeoDHC projects. Below are key examples.

Investment Grants cover part of the CAPEX, reducing up-front financing needs, thus reducing **capital availability risk** (directly) and also **revenue risk** (indirectly) as projects can operate with lower cost recovery thresholds, reducing pressure on tariffs or heat sales volume. They also provide an **early signal of public support**, improving investor confidence.

Operating Subsidies & Feed-in Tariffs provide a stable revenue stream based on heat output or guaranteed pricing, thus reducing **offtake risk**, and **pricing risk**, by decoupling revenues from volatile heat markets, and stabilizing **revenue risk**, by improving long-term financial predictability and facilitating debt service coverage.

Guarantees make credit more accessible (e.g., loan repayments, equity protection, off-taker default), thus reducing **capital availability risk**, and partially also **credit risk** (on off-takers or public counterparts), and increasing the **credit rating** of the project SPV, hence lowering financing costs.

Public-Private Funding Structures blend public and private capital in a coordinated project vehicle or funding pipeline, thus reducing the perception of **institutional and political risks**, enhancing confidence in **regulatory stability**, and are often linked to **longer investment horizons**, which better match geothermal payback timelines.

Revenue-backed Contracts (e.g., HPAs, LTAs) for heat purchase or leasing of geothermal capacity minimize **revenue risk** as well as **market and pricing risks**, especially when indexed to inflation or cost benchmarks, while improving project **cash flow predictability**, critical to secure long-term debt.

Standardized Risk Assessment Tools can facilitate decision-making, funding allocation, and due diligence. Tools like the **GeoRISK Tool** for risk assessment tool of deep geothermal projects (GEORISK Project, 2021) or the "Decision Support Tool for Social Engagement, Alternative Financing and Risk Mitigation of Geothermal Energy Projects (Ioannou et al., 2023) aim to provide a structured evaluation of subsurface and financial risks, reducing **information asymmetry** between developers and investors and enabling more transparent and comparable risk profiling, improving access to financing.

Concessional Finance offers below-market loans or patient capital, thus reducing **financing risk** by improving project affordability, potentially offsetting higher risk premiums associated with early-phase development and reducing pressure during uncertain ramp-up phases, if **grace periods** are included.

To sum up, while not risk mitigation tools per se, these instruments play a **complementary and often critical role in reducing financial, operational, and market risks** across the GeoDHC value chain. A well-designed financing strategy integrates both targeted and auxiliary risk mitigation components to build investor confidence and accelerate project deployment.

5.4 A Low-Risk Development Opportunity: Reusing old Oil and Gas Wells

Repurposing abandoned oil and gas (O&G) wells for geothermal energy offers a unique opportunity to **significantly lower exploration risks and development costs**, addressing two of the main barriers to geothermal deployment.

By reopening closed O&G wells, the exploration risk is drastically reduced, as the **subsurface conditions are already known** (logs, pressure data, temperature gradients, and geological models). This eliminates the uncertainty typically associated with identifying viable geothermal reservoirs and estimating resource quality.

Drilling is one of the most expensive and risky components of deep geothermal projects. Reusing existing wells avoids this cost (CAPEX) and the associated permitting delays. Besides, infrastructure such as access roads, pads, and casing may already be in place, reducing both investment and environmental impact.

Extends the life and usefulness of existing wells that would otherwise be environmental liabilities or financial burdens (decommissioning costs) increases the **sustainability and circular use of infrastructure**, while supporting the **just transition** in fossil fuel regions by offering new clean energy jobs and development without the need for greenfield drilling. Reusing abandoned O&G wells aligns with the EU objectives of **repurposing fossil fuel infrastructure** and ensuring cost-effective deployment of renewable heating and cooling.

Repurposed O&G wells can be adapted for **closed-loop geothermal systems** (e.g., Advanced Geothermal Systems), **Enhanced geothermal systems (EGS)** if reservoir stimulation is needed, as well as **co-production of heat and fluids** from marginal oil wells in some cases. This could be a key component of **low-risk portfolios** eligible for public guarantees, risk mitigation instruments, or green bonds.

However, it must be considered that most O&G wells are most often suitable for **H&C production** but are **far away from urban areas**, where a DHC system can be most viable, and piping can be very expensive (~1 million euros per km). Their **compatibility with power generation** must be verified case by case. Besides, if the wells have been abandoned for a long time, both the well and the surface infrastructure might require **maintenance** which would impose additional costs.

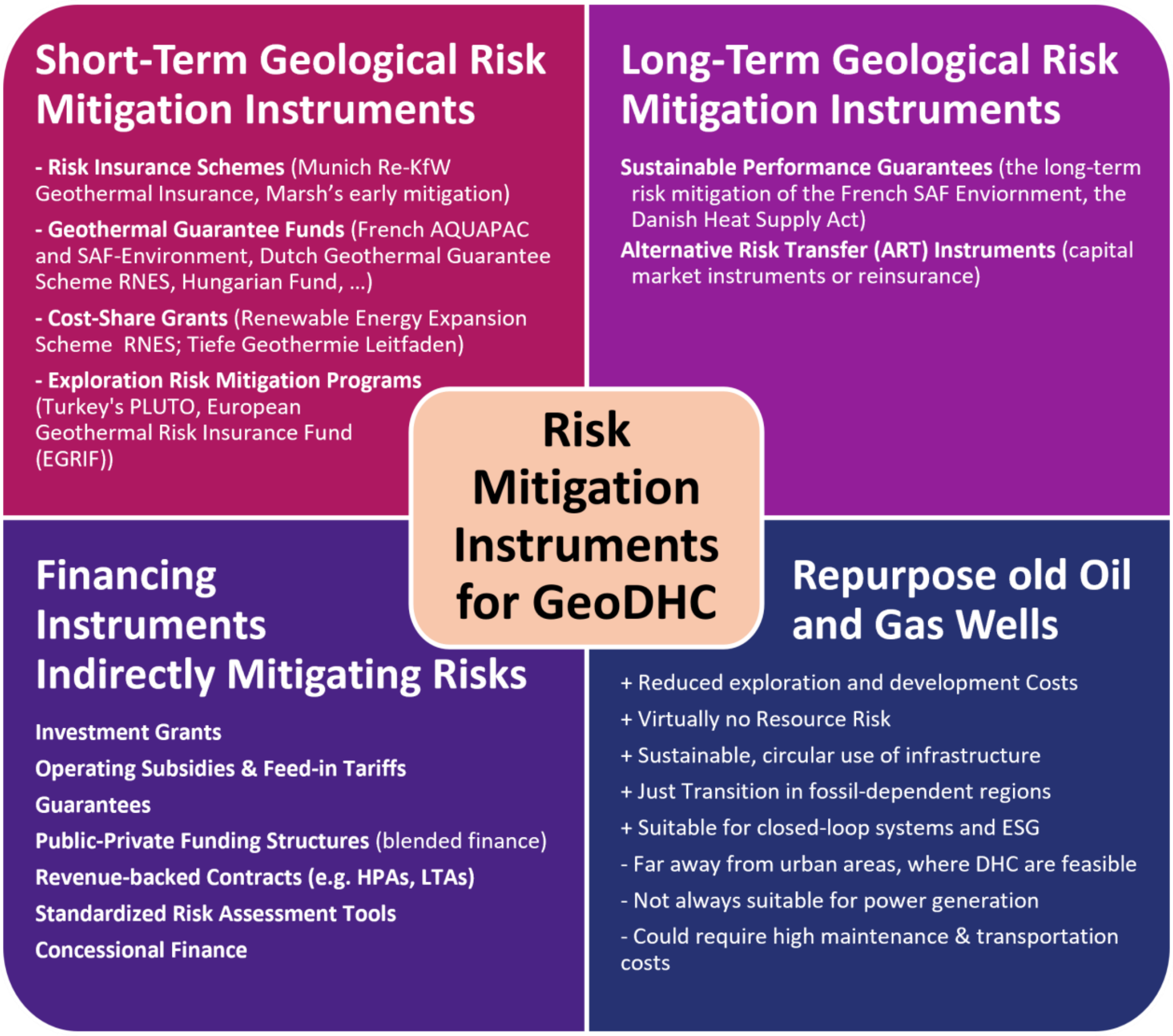

Figure 4: Risk-Mitigation Instruments for GeoDHC

6. Financing Blueprints

Despite their high decarbonisation potential, GeoDHC systems remain underutilised due to complex risks, long payback periods, and fragmented financing. A transformation in GeoDHC deployment requires **coordinated action across financing, regulation, and project development**. No single instrument will unlock the market, rather, success depends on **smart combinations** tailored to the project's stage, risk profile, and actor landscape. Based on the analysis of capital sources, financial instruments, and risk mitigation mechanisms, a step change in market uptake requires **integrated financing blueprints** that simultaneously de-risk, mobilise capital, and build investor confidence. Below, we outline a set of financing blueprints designed to pave the way for a more widespread and sustainable deployment of GeoDHC.

6.1 Deploy De-Risking Schemes at Scale

Geological uncertainty remains the key bottleneck for shallow geothermal and casts a shadow on the less known shallow geothermal. The absence of widely available insurance schemes discourages early-phase investment.

This blueprint proposes to scale up and replicate **risk-sharing mechanisms** (e.g., **French SAF-Environment** and **AQUAPAC** (Geothermies, 2025), Dutch Geothermal Guarantee Scheme **RNES** (NLOG, 2025)) at the EU level, by establishing a **central EU Geothermal Insurance**, with reinsurance backing and a claims history database. This could be combined with a **first-loss public guarantee layer** and premium rebates based on exploration success. Insurance premiums and bonuses are recommended to be asset-based, especially in the event of a partially successful well, which can still produce, but less than expected. Over time, with market development, it would be beneficial to explore options for a reinsurance market.

This blueprint is the key to unlocking geothermal deployment.

6.2 Bundle Heat Purchase Agreements (HPAs) with Policy Guarantees

Long-term revenue certainty is essential for debt financing.

This blueprint proposes to standardise and promote **HPAs**, ideally with municipal off-takers, introducing **contract-based price floors**, indexation, and off-take guarantees backed by public agencies, especially where there are no regulated tariffs. HPAs could be potentially coupled with **feed-in tariffs or per-MWh operating premiums** that kick in during demand shortfalls.

Innargi's contract in Aarhus offers a strong example. To boost investor confidence, the Danish government granted geothermal projects an exemption from the "substitution price" rule applied to district heating in Denmark. This rule normally prevents DH companies from switching to a cheaper energy source during the heat purchase agreement period, an exemption that proved crucial for securing investment.

6.3 Scale Investment Grants and Operating Subsidies

Capital-intensive infrastructure needs upfront support and long-term viability incentives.

This blueprint proposes to replicate and expand national investment grant schemes (**Leitfaden Tiefengeothermie** (Altmann, 2024; klima und energiefonds, 2024)**; SDE++**(EGEN Green, n.d.)), Turkish Risk Sharing Mechanism (**RSM**), etc.) with EU support and introducing **performance-based operating subsidies** (€/MWh of heat delivered), de-linked from fossil benchmarks. Eligibility for **accelerated depreciation**, VAT exemptions, and tax credits for geothermal systems could be expanded across EU tax codes. In addition, **multi-annual budgetary commitments** would help enhance predictability for investors.

6.4 Mainstream Concessional Finance

GeoDHC systems involving dep geothermal face high financing costs due to their peculiar risk profile and long payback period, but when successful, they can deliver a positive Net Present Value (NPV), indicating a long-term value creation and making them financially attractive in the long run.

This blueprint proposes to scale access to **concessional debt instruments** via EIB, national green banks, and international funds. Concessional terms could be tied to projects that meet specific technical and environmental criteria (e.g., energy efficiency thresholds, low-carbon sourcing).

6.5 Embed Risk Assessments and Market Facilitation Tools in Planning

Decision-makers lack transparent, standardised tools to evaluate and compare GeoDHC investments.

This blueprint proposes to institutionalise the use of tools like the **SAPHEA Toolbox** and **Falcone Risk Tool** (Ioannou et al., 2023) in local and regional planning. This could include developing a **pre-screening and scoring system** for GeoDHC projects to prioritise funding and linking risk scores to **financial instrument eligibility**, similar to credit scoring.

Additionally, developing **EU guidelines for geothermal project bankability** would be beneficial, covering risk allocation, SPV structuring, and credit enhancement strategies, encouraging the adoption of **voluntary disclosure standards** on geological data, business models, and off-take arrangements, for example in Denmark.

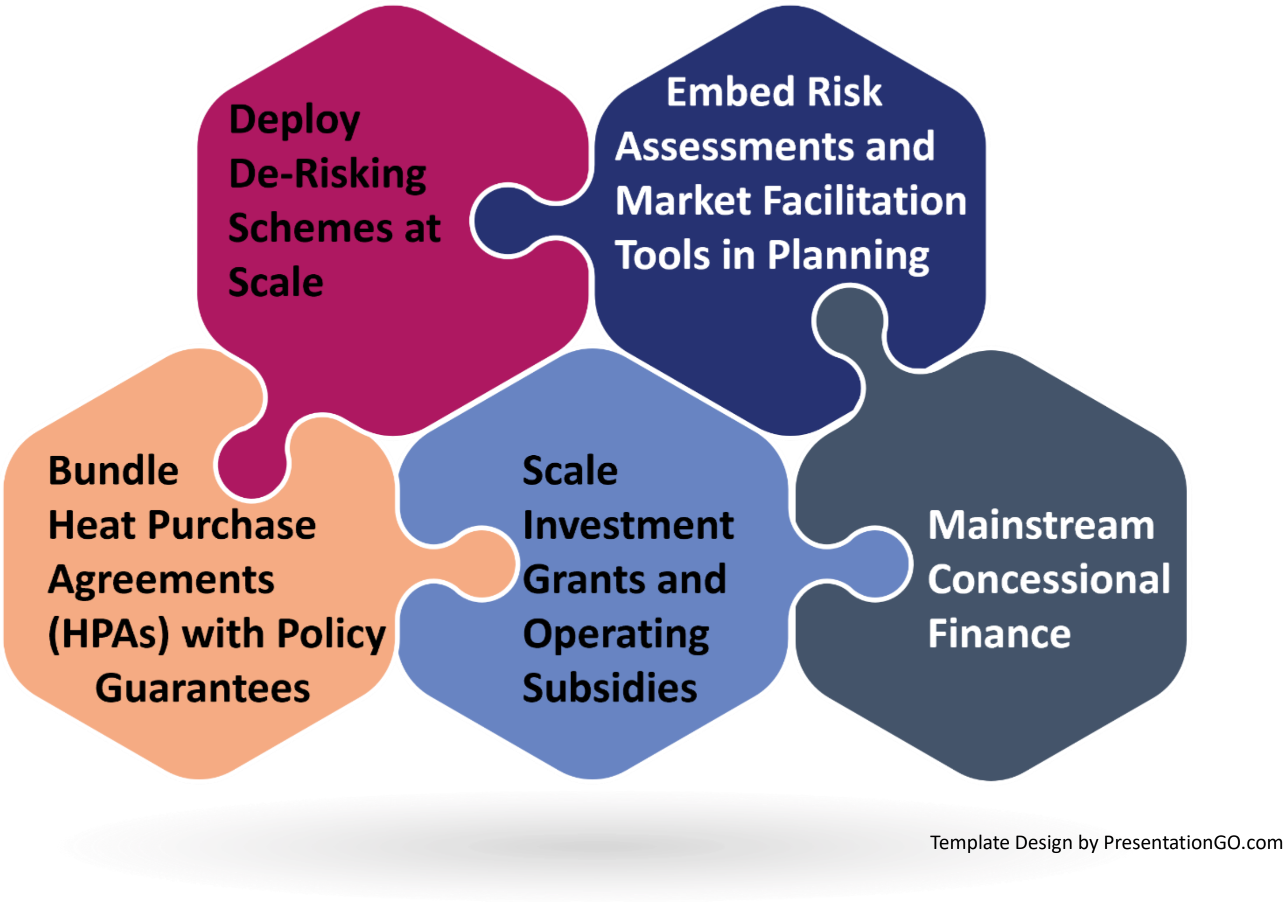

Figure 5: Financing Blueprints for GeoDHC Market Uptake

7. A European Geothermal Bank: A Central Pillar for De-risking and Scaling Investments

A key limitation in the current landscape is the **market fragmentation.** Project developers do not reach the size needed to be able to adopt a portfolio management of risks, as usual in the oil and gas sector which manages it easily while facing much higher subsurface and exploration risks. At the same time, **risk mitigation instruments** are scattered, depending on national programs, and mostly underdeveloped. The lack of an **integrated, EU-wide approach to supporting geothermal market uptake** undermines the creation of a stable EU-wide investment environment, despite successful models exist (e.g., **French SAF-Environment** and **AQUAPAC** (Geothermies, 2025), Dutch Geothermal Guarantee Scheme **RNES** (NLOG, 2025); **Leitfaden Tiefengeothermie** (Altmann, 2024; klima und energiefonds, 2024)**; SDE++**(EGEN Green, n.d.)**,** the Turkish Risk Sharing Mechanism **RPM** (RPM jeoturkiye, 2025); the **Danish Heat Supply Act** (GeoEnergy and Cariaga, 2023)).

To address this gap, a **Geothermal Risk Mitigation scheme** available across the whole EU-27 is paramount, as steadily advocated by EGEC and many other stakeholders (S Fraser et al., 2013; Spyridon et al., 2021; Garabetian et al., 2021).

Option 1 – A decentralized **European Geothermal Fund** could be a dedicated pool of financial resources set up for the specific purpose of managing geothermal geological risks. This could see the EU setting the framework and national authorities managing the actual implementation in each member state (shared management). Funding could come from the EU budget with national co-funding, with a medium lifespan. Successful examples of similar entities are the European Regional Development Fund (ERDF), and the Innovation Fund.

Option 2 – A **European Geothermal Programme** would be the simplest centralized option, but also the most transient one, with a medium-short lifespan, suitable to issue just one risk mitigation instrument, most likely a performance guarantee, or an insurance or cost-share grant.

Option 3 – A **European Geothermal Facility**: establishing a mechanism within an existing EU Institution would offer a more stable setup. The facility could be governed jointly by the Financial Facility and the EU, with an open-end time span, financed by a mix of EU budget, institutional capital, and private investment. This setup could have more capabilities compared to a single programme (guarantees, risk-sharing instruments, revolving capital, autonomy in project selection, etc.) while streamlining access to capital, fostering cross-border replication of best practices, and enhancing coordination and risk pooling across Member States. Successful examples are the Modernisation Fund (via EIB) and Invest EU, which could be the right institution capable of housing such a Facility.

However, drilling failure rates, and thus the risk of net losses for insurers remain a hurdle. According to the most recent data, in Germany, where Munich Re and KfW have recently launched geothermal risk-mitigation insurance, 16% of wells had partial losses, and 11% resulted in complete loss. **Data availability of the subsurface conditions** is what determines the possibility of issuing commercial insurance, in very well-developed basins where risk is reasonably measurable (e.g., Munich RE in the Bavarian Molasse), or a state-backed insurance or guarantee, in less developed regions with higher uncertainty (e.g., Munich RE-KfW programme in the North Rhine Basin). For the time being, geothermal risk mitigation insurances are only financially self-sustaining in few well-developed areas, requiring public support elsewhere. However, over time, the development of currently less-known basins with more data, better technology, and wider development of the geothermal value chain could make many more areas suitable for commercial insurance.

If we are serious about boosting the geothermal deployment, options 1 to 3 are still too limited.

Option 4 – A centralized **European Geothermal Fund**, managed by or operating through entities with the appropriate license, it could be a dedicated pool of capital to support geothermal deployment. Capital injection could be time-bound, and focused on de-risking instruments (grants, first-loss guarantees, insurance premiums, etc.). A centralized European Geothermal Fund could be a more stable set-up than a simple facility, but still easier to create than a bank, managed by existing bodies (for instance EIB/EIF, co-financed by private actors such as investment funds) who would issue and administer all instruments. This third-party administration would be the major limitation of such a fund, which would depend on external capital injections, but it would greatly help support early-stage project phases and demonstrate scalability to unlock mainstream financing. Creating a European Geothermal Fund would convey the message that Geothermal needs targeted, flexible financial support to overcome specific market barriers and de-risk investments.

Option 5 – A **European Geothermal Bank:** a fully institutionalised financial entity with a banking license or equivalent, able to issue a multi-prong offer of loans, guarantees, bonds, etc. Assuming that the EU Geothermal Risk Mitigation scheme might not be fully financially sustainable, depending on projects selection, and it could incur some net losses, a strategic choice would be to diversify the financial offer including revenue-generating instruments to refinance the risk mitigation insurance, while supporting the whole geothermal sector development. Only a more structured institution, such as a bank, could offer the required variety. It could be funded by the EU budget, with national co-funding, but it could very well attract private capital, especially from insurance companies, and participation from national development banks, until becoming financially independent. This way it could also leverage the expertise of private insurance companies and public development financial institutions.

The choice between establishing a Fund or a Bank would ultimately depend on the interested investors and financial institutions, their interest in developing one or the other format, and the public support their initiative might encounter. Independently from the set-up, all options 3, 4 and 5: the Facility, Fund and Bank could to various extents offer a combination of the following revenue-generating and revenue neutral or negative instruments.

The **revenue-generating instruments** could be:

- **Concessional Loans**: loans granted below market interest, repayable upon success, potentially issued through a revolving mechanism, so that as soon as a loan has been partially repaid, the beneficiary can reuse it for further projects. This would be ideal for lower-risk projects, such as those located in well-characterised basins, shallow geothermal or closed-loop.
- **Geothermal Green Bonds**: asset-based bonds, backed by revenue-generating projects, with bond interests paid by projects' cash flow, part of the proceeding paid to investors and part refinancing the risk-mitigation insurance. In the case of a Fund, not a bank, these bonds could be issued by a third entity, (e.g., by the EIB).
- **Insurance Premiums**: insurance charging differentiated premiums based on geological risk, project size, development phase etc. Premiums would partially refinance the insurance.
- **Success Fee**: a success fee would be claimed in projects that have benefitted from grants, insurance or guarantees. The payment of the fee could be administered as a small equity stake, or as monthly royalties, putting less pressure on project cashflow, or as future offtake revenue or capacity-based payments (e.g., heat sales).

The **revenue-neutral (or negative) instruments** could be:

- A **European Geothermal Risk Mitigation Insurance** to cover both **short-term and long-term risk** (taking inspiration from both the Munch-RE/KfW model and the French SAF-Environment). This could be financed by public and private funding in a **Blended Finance** approach (in variable rates, e.g., 30/70). Public funds could come from the EU budget or from national development banks. Parties could spread risk equally, in proportion to their contribution, or agree on junior and senior debt taken on respectively by the public and private partners. The offer could include both insurance (repaying directly the project developer of their loss) and guarantees (paying a loan from a third-party bank, when that has become impossible to reimburse). Unsuccessful projects would be repaid of their loss (unrealized revenue), in proportion to the percentage of unsuccess compared to the project expectations (validated by the fund experts when issuing the insurance). Successful projects would conversely pay a success fee (royalty once in operation or small equity stake to back the geothermal green bonds). This would help keep premiums at a minimum while refinancing the insurance capital pool. Larger developers could access this product in the form of a credit line, continuing to benefit from the same insurance to develop additional wells, assuming that their risk profile has been approved, reducing transactional costs.

- **Blended Finance** to support low-risk small projects, but with high CAPEX, such as networked shallow heat pumps/5G-DHC ideally coordinated and financed centrally, but managed locally through national promotional institutions that could act as catalysers.
- **Standardised Project Templates**: a structured toolkit of ready-to-use documents and methodologies to support early-stage geothermal project development.
    - **Risk assessment frameworks** (technical, geological and financial)
    - **Due diligence checklist** and templates
    - **Business models blueprints** (DHC, CHP, industrial self-consumption)
    - **Contract Templates** (HPAs, EPC, O&M, risk sharing, consortium agreements, etc.)
    - **Compliance Mapping** (alignment with EU taxonomy, ESG, national permitting).
- **Technical Assistance**: on-demand advisory services supporting project developers in selecting and implementing the most suitable business model for their context.

The incomparable advantage of centralizing such a diversified financial offer is that a **European Geothermal Bank/Fund** could reach the size suitable to adopt a **portfolio risk management**, which individual project developers and national entities cannot do. This would imply **Diversification** (not betting one well, but exploring multiple sites), **Risk Quantification** (via probabilistic models e.g., Monte Carlo simulations, to estimate the chance of success/failure and potential returns for each project), **Resource Allocation** (dynamic capital allocation across projects based on regularly updated expected value, risk, and technical potential), **Real Options** (deciding at each stage whether to proceed or abandon based on new data), **Portfolio Optimization** (balanced to maximize expected return) and **Risk Spillover** (a successful test drill reducing uncertainty not just for that well but for the surrounding area, as geological conditions tend to be similar within a certain radius).

Centralizing project assessment would thus allow for prioritizing lower-risk projects, optimizing the use of public disbursement and reducing overall losses for unsuccessful projects. In this regard, geological risks can be much **better assessed by regional basins**, as resource potentials do not align with national borders, requiring a transnational lens for risk assessment and data sharing. **EU-wide oversight** could support cross-border research and ensure a **level playing field**, so that each Member State could benefit from high-quality instruments and methodologies tested elsewhere (e.g., KfW in Germany, ADEME in France). A centralized entity would also overcome the barrier that **many countries lack mature support schemes**, especially in Central and Eastern Europe, where the national capacity to structure and finance early-stage exploration is limited.

Establishing a **European Geothermal Bank** would send a strong signal, that geothermal is mature and strategic enough to justify a permanent, specialized financial institution while fostering a just development of the sector. Leading to increased exploration in less-developed regions, especially in **lower-income countries**, greater data sharing, and improved data availability, would all help advance the sector development and keep insurance premiums low. From a communication point of view, branding such a broad offer as a **European Geothermal Bank** would reflect both strong policy support at the EU level and the diversity of financial products offered. At the same time, it would help communicate a complex support package in simple terms, and the creation of a permanent institution would convey the EU's stable and long-term commitment to geothermal energy, raising awareness and visibility.

One potential shortcoming that should be considered though, is that while a **European Geothermal Bank** could centralize funding, permitting processes and reporting requirements would remain managed at the national level, with remarkable differences. In this sense, a policy harmonization would be most desirable and beneficial for the development of the geothermal sector.

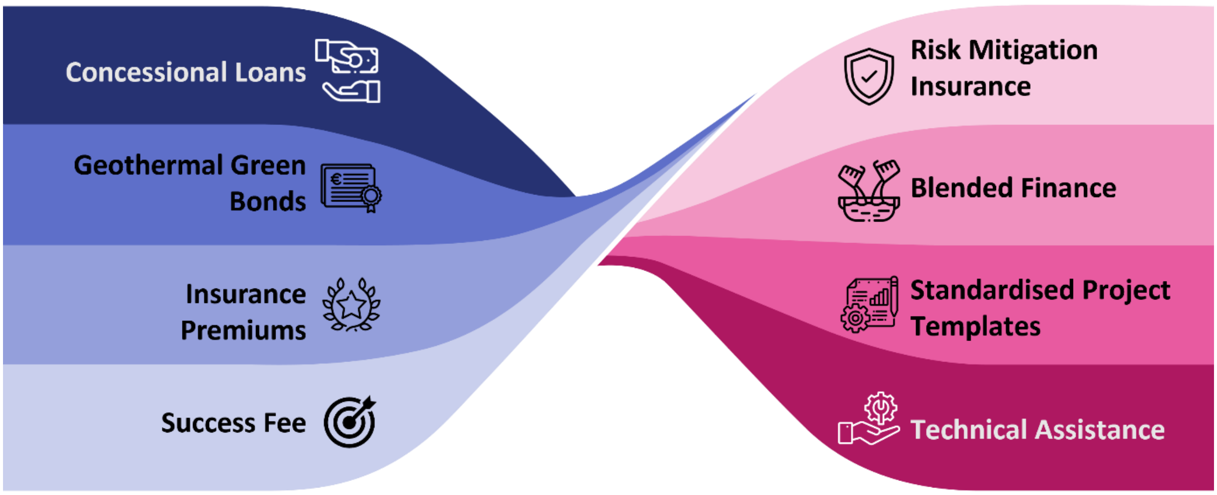

Figure 6: A European Geothermal Bank

8. Recommendations and Strategic Guidance to Change

Despite its strong potential to decarbonise Europe's heating and cooling sector, geothermal energy, particularly in GeoDHC applications, remains significantly underutilised. This is not due to technological immaturity, but rather due to structural barriers in finance, policy, and project development ecosystems. This chapter provides strategic guidance for policymakers to overcome these challenges, drawing on comprehensive analysis of financing instruments, risk mitigation strategies, and emerging best practices.

Address Perceived and Actual Risks Through Systemic De-risking

Challenge: Investors, especially institutional or commercial lenders, often perceive geothermal energy as high risk, primarily due to geological uncertainty, long development timelines, and underdeveloped secondary markets.

Recommendations:
- Expand and scale geological risk mitigation tools such as guarantees, premium-refund schemes, and multi-phase insurances at both national and EU levels.
- Create multi-country de-risking platforms that allow risk pooling and regional-level subsurface assessments.
- Institutionalise the use of revenue-backed contracts (e.g., Heat Purchase Agreements) and portfolio-based guarantees to stabilise long-term revenues and reduce investor exposure.

Mobilise More Capital Through Blended Finance and Strategic Public Support

Challenge: The high upfront costs and capital intensity of geothermal projects, especially drilling, create access barriers for municipalities, SMEs, and smaller energy service companies.

Recommendations:
- Promote concessional finance windows within InvestEU or the EIB tailored to GeoDHC, with interest buy-downs and extended tenors.
- Enable public-private investment vehicles that allow utilities, pension funds, and cities to co-invest under pre-defined risk-sharing rules.
- Provide tiered investment grants that are performance-based (e.g., exploration success, capacity achieved) and tied to clear carbon and security-of-supply objectives.

Create a European-Level Geothermal Finance Platform

Challenge: The fragmentation of support mechanisms across the EU makes it difficult for developers to navigate the financing landscape and scale projects beyond national boundaries.

Recommendations:
- Establish a European Geothermal Fund or Facility under InvestEU or as an EIB window, offering a centralised portfolio-based financing and risk management mechanism.
- Standardise templates for risk assessments, contracts, and financial models to lower transaction costs.
- Promote EU-wide green bond or blended finance mechanisms to pool projects, enable refinancing, and de-risk private capital mobilisation.

Promote Innovative Business Models to Increase Market Adoption

Challenge: Traditional project finance models place the investment and performance risk solely on the developer, limiting the uptake of geothermal solutions by users with constrained capital.

Recommendations:

- Encourage Heat-as-a-Service or energy service contract models where third-party operators build, own, and operate systems in exchange for predictable fees.
- Support community-based and cooperative models in areas with social ownership traditions or small local utilities.
- Incentivise integrated value chain actors (e.g., utilities, aggregators, housing providers) to bundle drilling, network, and building retrofitting services.

Harmonise Regulatory Frameworks and Improve Permitting Efficiency

Challenge: Permitting delays, inconsistent procedures, and a lack of administrative capacity hinder project deployment timelines and increase costs.

Recommendations:

- Promote one-stop-shop authorities for GeoDHC permitting, building on best practices from countries like the Netherlands, France and Hungary.
- Standardise environmental impact assessments and geothermal classification systems across Member States.
- Streamline licensing of resource access rights and subsurface mapping data for early-stage developers.

Embed GeoDHC in Local Energy and Urban Planning

Challenge: Many municipalities do not yet integrate geothermal into their long-term energy planning or heating transition strategies.

Recommendations:

- Mandate the inclusion of geothermal potential assessments in Sustainable Energy and Climate Action Plans (SECAPs) and local heating and cooling strategies.
- Support GIS-based planning tools and technical assistance to help cities identify and prioritise geothermal options.
- Incentivise zoning regulations and pre-feasibility studies at the regional level to identify heat clusters and connect anchor consumers.

Increase Public Awareness and Professional Training

Challenge: Public acceptance, lack of skilled labour, and limited understanding of geothermal benefits continue to slow down project approvals and adoption.

Recommendations:

- Launch public information campaigns on GeoDHC's benefits, safety, and role in energy independence.
- Support vocational training programmes for drillers, planners, and municipal energy managers.
- Build EU-wide skills platforms aligned with the Net-Zero Industry Act and European Year of Skills to address workforce gaps in the geothermal value chain.

9. Conclusion: Laying the Financial Foundations for a GeoDHC Breakthrough in Europe

GeoDHC holds immense promise as a secure, renewable, and local energy solution, capable of contributing significantly to Europe's climate, energy security, and affordability goals. Yet despite its technical readiness and long-term benefits, GeoDHC remains largely untapped across many Member States.

This report has mapped the current landscape of capital sources, financing instruments, and risk mitigation mechanisms for GeoDHC projects. It has highlighted both the strengths of available tools and the persistent gaps, especially during early-stage development and drilling, where risks are highest and support is most critical.

A key finding is the need to **treat GeoDHC as an infrastructure priority**, not just an energy technology. Like other networks, such as railways, broadband, and electricity, GeoDHC requires long-term vision, cross-sectoral planning, and a strong public backbone to crowd in private investment.

Risk must be reduced and shared, not offloaded entirely onto developers. To do so:

- Europe needs **coordinated financial instruments** that combine guarantees, grants, concessional loans, and insurance.
- Public institutions at all levels must play a stronger role in de-risking, aggregation, and project development support.
- A **European Geothermal Bank** (or a **centralized European Geothermal Fund of Facility**), backed by EU institutions (EIB, InvestEU) and national development banks, could become the anchor of a consistent, accessible, and credible financing ecosystem for GeoDHC.

In parallel, we must expand the community of actors engaged in geothermal, from municipalities and utilities to industry champions and financial institutions, and **make GeoDHC bankable, investable, and scalable**.

The SAPHEA report serves as both a mapping exercise and a strategic guide. It calls on policymakers, financiers, and developers to act now, collectively and decisively, to unlock geothermal energy transformative potential. The time for pilots and fragmentation is over. The time for scale, speed, and system change has arrived.

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