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Public Finance and Private Exploration in Geothermal: Gümüşköy Case Study, Turkey

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The Role of Public Finance in Deploying Geothermal

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About the San Giorgio Group

The San Giorgio Group is a working group of key financial intermediaries and institutions engaged in green, low-emissions, and climate-resilient finance. established by Climate Policy Initiative in a collaboration with the World Bank Group, CLP (China Light & Power), and the OECD. San Giorgio Group case studies provide real-world examples of how public resources can spur low-carbon and climate-resilient growth, what approaches work, and which do not. Through these case studies, which share a systematic analytical framework, CPI describes and analyzes the types of mechanisms employed by the public sector to catalyze and incentivize private investment, deal with the risks and barriers that impede investment, establish supporting policy and institutional development, and address capacity constraints.

About CPI

Climate Policy Initiative is a team of analysts and advisors that works to improve the most important energy and land use policies around the world, with a particular focus on finance. An independent organization supported in part by a grant from the Open Society Foundations, CPI works in places that provide the most potential for policy impact including Brazil, China, Europe, India, Indonesia, and the United States.

Our work helps nations grow while addressing increasingly scarce resources and climate risk. This is a complex challenge in which policy plays a crucial role.

Executive Summary

Geothermal energy holds significant promise for the development of low-carbon energy systems. One of the lowest cost sources of renewable electricity, it also has the ability to meet baseload power demand and backstop fluctuating supply from other renewable sources. Geothermal could be a vital component of low carbon electricity systems – where resources allow.

In many countries, early stage exploration and development risks are the main barriers preventing geothermal energy from making a bigger contribution to meeting energy demand. Public finance can help to address these barriers.

Globally, the costs and risks associated with the exploration and development phases of geothermal projects make finding early-stages financing a challenge. Costs related to exploration can reach up to 15% of the overall capital cost of the project, success rates for wells drilled in this phase are estimated at 50-59% (IFC, 2013b), and it takes 2-3 years on average to confirm that a geothermal resource is suitable for generating electricity. Despite this concentration of risk in the exploration phase, 90% of multilateral public finance at the global level has focused on the later stages of the geothermal projects by offering concessional finance to build power plants once the major resource risks have been reduced. Public resources could be more effective when targeting support at geothermal's early-stage development risks and improving developers' access to finance.

Turkey is a major growth market for geothermal but could benefit from more private sector involvement in exploration to harness the technology's full potential.

In recent years, installed capacity of geothermal power plants grew faster in Turkey than anywhere else in the world. The sector went from 30MW in 2008 to 405MW at the end of 2014 – a compound annual growth rate of 54% compared to 4.5% globally - and is well on the way of fulfilling the Turkish government's deployment targets of 1GW by 2023.

Turkey's geothermal potential is far higher than its current policy target. Harnessing its full geothermal potential – an estimated 4.5GW of installed capacity – would allow the country to meet 8% of overall demand in 2030 rather than the 1.3% currently envisaged by the government.

Despite this growth, Turkey faces similar issues to other countries seeking to develop geothermal – specifically the ability of the private sector to take on the high risks associated with the exploration and development of geothermal resources. Until 2013, 11 out of the 12 projects developed in Turkey were on sites where the government had already demonstrated that the resource was suitable for generating electricity and then put it out for tender.

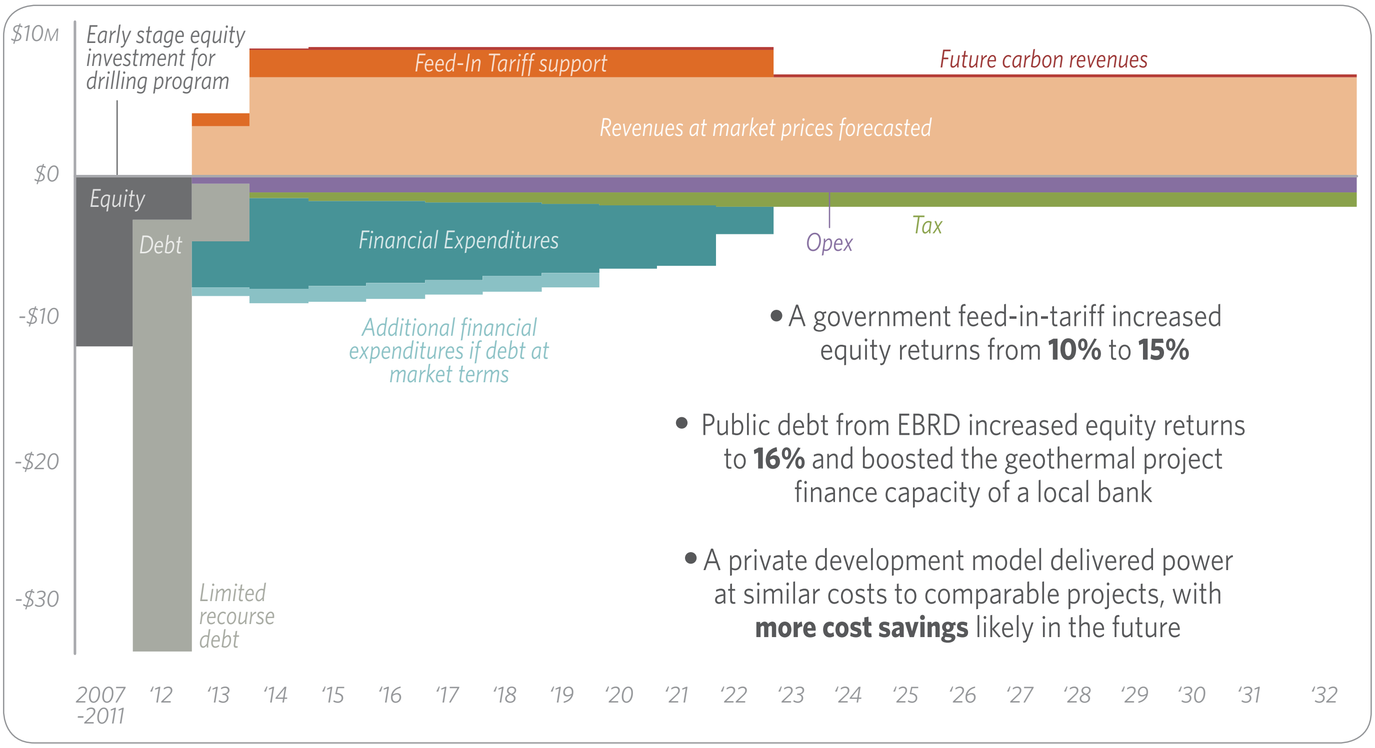
While this public-private development model has worked up to now, Turkey is now pushing for more private investment in the energy sector and the government has reduced drilling activity for geothermal exploration. More ambitious policy targets and a transition to a more private-sector led development model could help the sector realize its potential and would fit well with the country's current policy priorities.

Private sector exploration and public finance in the Gümüşköy Geothermal Power Plant

This case study analyses the Gümüsköy Geothermal Power Plant (GPP) to help policymakers and donors understand which financing instruments and public-private financing packages can enable fast and cost-effective deployment of geothermal energy. It is one of a series of studies carried out on behalf of the Climate Investment Funds (CIF) looking at the role of public finance in driving geothermal deployment.

The Gümüşköy GPP is the first case where the private sector financed exploration of an unproven field in Turkey. The 13.2MW project developed by BM Holding, a Turkish infrastructure company, was commissioned in 2013. The company demonstrated significant risk appetite in undertaking early-stage exploration. BM Holding invested up to USD 12m (24% of the total investment costs) in exploration and development prior to financial close, when debt financing of up to USD 34.5m (70% of the total costs) was secured from Yapikredi, a local commercial bank. Yapikredi sourced USD 24.9m of this debt from the Medium Size Sustainable Energy Finance Facility (MidSEFF), an on-lending facility managed by the European Bank for Reconstruction and Development (EBRD). The Government of Turkey's provision of a ten-year feed-in-tariff ensured the project was financially viable.

Figure ES 1: The role of public finance on cash flows of Gümüsköy GPP



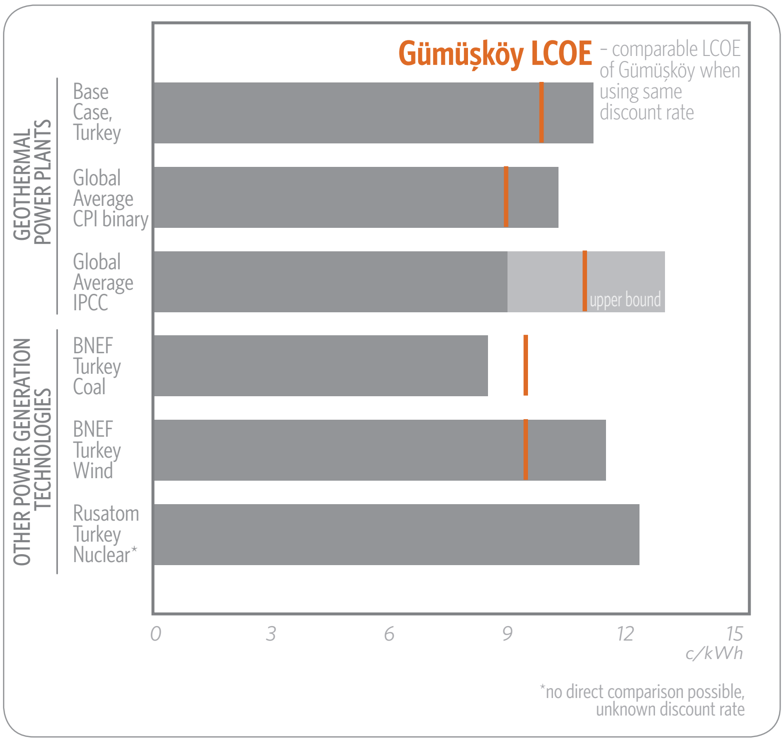
The above figure (Figure ES1) indicates how key stakeholders allowed the project to be successfully implemented.

Key findings for policymakers

The project provides insights for policy makers related to cost-effectiveness and providing an adequate enabling environment for the private sector.

- **The government feed-in tariff (FiT) ensured that the return expectations were met, even with the inclusion of exploration costs.** The 10.5 USD¢/kWh FiT provides certainty over a ten-year period that revenues will be 28% higher than current market rates and allows the project to achieve payback of all investment costs within eight years. Expected returns of 16% on the project equity and 12% on the project investment as a whole are similar to other geothermal projects in Turkey where returns range from 11-14%. Without the feed-in tariff, the internal rate of return (IRR) on equity would drop to 10%, which is very likely below the return expectations of the developer. The FiT in Turkey has a smart design: it is limited to 10 years and is denominated in USD, reducing currency risks for private investors and lenders.
- **This private-led project development model can deliver power at similar costs to public-private models in Turkey.** The costs of an exploration program – including surveying, tests and exploration drilling of an unproven field as well as the acquisition of new equipment and in-house knowledge capacity – compare well with the traditional development model of winning tender contracts for proven fields from the government. Gümüşköy GPP is 12-17% cheaper than comparable geothermal plants globally and other power projects in Turkey (see figure ES2). With loans at current market rates, the lifetime cost of power would be 10.6 USD¢ / kWh, close to the current FiT rate.
- **A private-led project development model is likely to deliver more cost savings in the future if accompanied by appropriate policy measures and development of industry capacity.** For now, coal power in Turkey remains 12% cheaper if the costs of emitting carbon and the health impacts are omitted. However, with experience gained in this project, the developer expects to halve the time and costs spent on exploration and drilling in the future. Through three subsidiaries, the developer has shared lessons and knowledge through the contracting of drilling equipment and consulting on 17 new projects in Turkey. A dedicated geothermal services market has begun to emerge. Policy measures to scale up the sector and reduce development costs further include improved data-sharing and centralized permitting procedures.

Figure ES2: Competitiveness of Gümüşköy LCOE to other LCOE's experienced in other regions and technologies (Black & Veatch 2012; Micale et al 2014; BNEF 2014; World Nuclear Association 2014)



Key findings for public finance providers

- **Access to long-term, low-cost debt through the EBRD-funded Mid-size Sustainable Energy Finance Facility (MidSEFF) facilitated the project by decreasing its financing costs.** Yapikredi was able to pass on the lower borrowing costs of the EBRD credit line to BM Holding boosting return (IRR) on equity from 15% to 16%. Receiving the finance at this point allowed the project developer to refinance the USD 12 million in equity it had invested, build the first 6MW power plant, and carry out drilling for the second 6MW plant while applying the lessons it had learnt.
- **Channeling long-term, low-cost debt through a local bank proved to be an effective way of building the capacity of a local private lender in geothermal project finance.** EBRD's provision of the credit line through the MidSEFF facility ensured the loan was economically attractive for Yapikredi and drove the Turkish bank to lend to a geothermal project for the first time. Participation in this and other projects is building the local bank's capacity to assess the environmental and technical risk of geothermal and other sustainable energy projects.
- **In markets where local banks already finance construction of geothermal power plants, public finance is more beneficial if it addresses early-stage risks.** Similarly to other projects in Turkey, Gümüşköy GPP was able to secure debt finance once the resource was proven as feasible for electricity generation. Early exploration and development depended on the project developer's ability and willingness to assume resource and drilling risks through a USD12m outlay. This private development model may not be replicable for many project developers as they may not have the resources and risk appetite to spend approximately 24% of total investment costs in equity financing in the exploration and development phases before reaching financial close. In countries like Turkey where local banks have signaled willingness to fund construction stages of geothermal power plants, public finance should target exploration and drilling stages directly to bridge these funding gaps. Multilateral Development Banks (MDBs) are exploring several models of providing contingent grants or soft loans for exploration costs, as well as insurance and guarantee mechanisms (EBRD 2014).

With the right tools, public finance providers and national policymakers can address the financing challenges of geothermal scale-up in Turkey but they also need to meet challenges of managing carbon emissions. Many of Turkey's existing geothermal plants are situated on reservoirs where the carbon content of non-condensable gases (NCGs) in the geothermal fluids are high. Without capture and sequestration, the potential greenhouse gas emissions impact of a scale up of the sector would be significant (Aksoy et al 2015). Public finance providers can help address this by mandating certain technology choices and facilitating development of offshoot markets for carbon as a byproduct. Through the use of heat exchangers, binary systems have the potential to re-inject geothermal fluids directly, thereby minimizing the possibility of carbon leakage. In addition, as in Gümüşköy GPP, carbon may be captured and produced as a byproduct for use in greenhouses and industrial sites. If these non-financial issues can be addressed, and policy and public finance support is appropriate, then the Turkish geothermal sector can reach its potential.

Contents

1. Introduction

Geothermal energy holds significant promise for the low carbon energy systems of developing countries. As a renewable electricity source with the ability to both meet baseload power demand and backstop fluctuating supply from other renewable sources, it can be a vital component of low carbon electricity systems – where resources allow.

Many developing countries in Southeast Asia, East Africa and Latin America are well endowed with geothermal resources, situated as they are, near geological fault lines (ESMAP 2012). But exploration and development risks are preventing geothermal energy making a bigger contribution to meeting these countries' energy demand. The average 2-3 year timeframe required to confirm that a geothermal resource is suitable for generating electricity, coupled with the investment costs associated with drilling, make early-stage financing of geothermal projects a challenge particularly for private developers. However, 90% of multilateral public finance predominantly focuses on the later stage of geothermal project development where resource risks are already known and managed (Audinet 2013).

This case study of the Gümüşköy Geothermal Power Plant (GPP) in Turkey is part of a research program carried out by Climate Policy Initiative on behalf of the Climate Investment Funds. The overall objective of the program is to help policymakers and donors understand which financing tools to use in order to enable fast and cost-effective deployment of geothermal energy. The research will draw on three in-depth case studies and dialogues with multilateral development agencies and the private finance community dedicated to scaling up deployment of geothermal electricity plants globally.

Gümüşköy is the first time the private sector financed exploration of an unproven geothermal field in Turkey. Furthermore, it shows how on-lending of debt can develop local financial institutions' technical capacity to lend to the sector

We study the financing and deployment of the Gümüşköy GPP for two key reasons. Firstly, it is the first time a private sector project developer has financed exploration of an unproven field in Turkey. Previously, the Turkish government agency responsible for mineral research and exploration had surveyed and drilled potential geothermal fields and auctioned off proven resources for power plant development (see Track 1 in Table 1). **Project developer BM Holding developed Gümüşköy on a discarded field, and represented a first medium-to-high-enthalpy discovery by the private sector in Turkey**.[1]

1 The Gümüşköy geothermal reservoir with its 182C temperature is close to the threshold between medium-enthalpy geothermal reservoirs (100-180C) and high-enthalpy fields of >180C that are most common with electricity generation. See: http://www.geoelec.eu/about-geothermal-electricity/

Table 1: Turkey's 2 track geothermal project development model adapted from ESMAP (2012)

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	
	PRELIMINARY SURVEY	EXPLORATION	TEST DRILLING	FIELD DEVELOPMENT	POWER PLANT CONSTRUCTION		OPERATION & MAINTENANCE
	EARLY STAGE			MIDDLE STAGE	LATE STAGE		
TRACK 1							
TRACK 2							

PUBLIC SECTOR
PRIVATE SECTOR

Secondly, the project represents an **interesting case of financial sector capacity development in geothermal project finance**.[2] The project was financed through a combination of early-stage equity capital from the developer and debt financing from both public and private sources. However, rather than public finance agencies providing debt directly, the debt finance was channeled through a local Turkish bank, Yapikredi, at competitive market rates.

This case study follows the methodology of the San Giorgio Group.[3] The analysis will feed into the following broader research questions:

- How can private sector and private finance participate more across the development of geothermal projects, particularly in the early exploration and development stages?
- How do public finance, policy and regulatory frameworks stimulate private sector activity?
- What are the risks, costs and benefits of different project development models?
- How does geothermal add value to the energy system, for example in terms of cost competitiveness and timely deployment?

Section 2 provides an overview of the electricity system and policy and regulatory framework in which the project developed. **Section 3** analyzes the project, its stakeholders, financial contributions, different cost components and the returns achieved. **Section 4** considers how risks were allocated and managed through the project development. **Section 5** reviews how the project finance and development model were effective and the lessons for replication in Turkey and beyond. **Section 6** concludes with key findings.

2 Yapikredi participates in the Turkish Mid-size Sustainability Energy Financing Facility (MidSEFF), a program implemented by the European Bank for Reconstruction & Development (EBRD) that provides a total of EUR 1 billion in loans to seven Turkish banks for on-lending to sustainable energy projects, including geothermal. See: www.midseff.com

3 The San Giorgio Group case study approach aims to systematically explore the role of project stakeholders, their investments and sources of return, the risks involved and arrangements to deal with them, and the lessons on how to replicate and scale-up best practices. It has been applied to a total of nine projects in solar, wind, energy efficiency, climate resilience, and forest conservation.

2. Context for the project

2.1 The Turkish Government is prioritizing more privatization in the energy sector

Since 2001, Turkey has liberalized its energy markets with a focus on increasing competition and private investment. By the end of 2013, the government had privatized the operators of distribution grids across the country and approximately 63% of electricity generation assets were run by private sector independent power producers (IPPs) (BNEF 2014).

The need for private investment in power has been underlined by how fast Turkey's economy has been growing. Over the past four years, electricity demand has grown by 25% on the back of 26% of economic growth (World Bank 2014). The government expects electricity demand to increase 85% by 2023, and 160% by 2030 (BNEF 2014).

Much of the new demand has been met by fossil fuels, in particular imported natural gas, and this has had a detrimental effect on the country's balance of payments. Energy imports took $56bn, the equivalent of 7% of Gross Domestic Product (GDP), out of Turkey's economy in 2013. This corresponded to 56% of the trade deficit in the same year (Turkstat 2014).

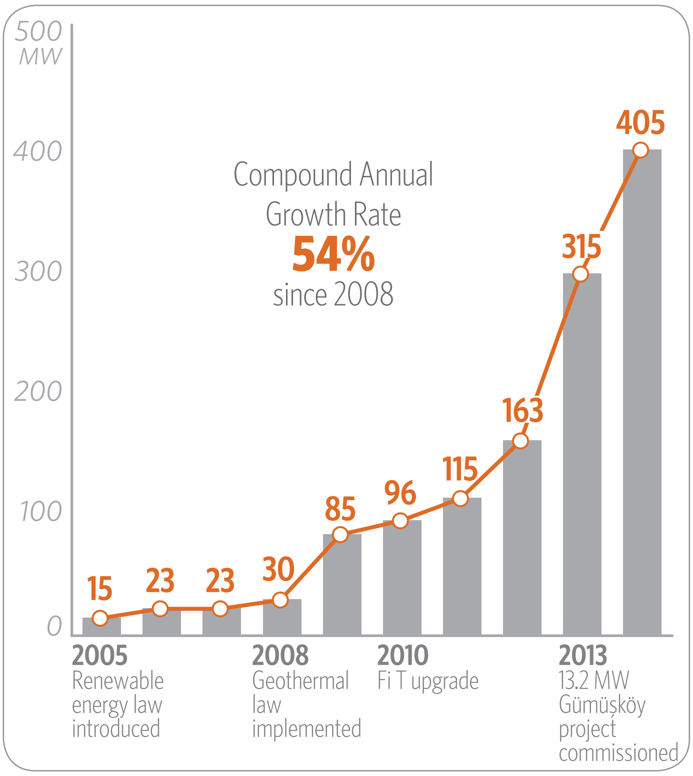
The government is prioritizing the development of indigenous energy resources to meet expected demand growth and to improve macro-economic performance. It plans to reduce the share of gas in the mix by 2023, replacing it with 12 GW of indigenous coal resources, 10 GW of nuclear, 14GW of hydro, and 17 GW of wind capacity (BNEF 2014). It has set a relatively small target of 1000MW geothermal capacity by 2023 (MENRa).

2.2 Turkey's regulatory framework has enabled significant growth in geothermal

In 2005, the government introduced a renewable energy law to provide a framework for the utilization of renewable energy resources with a common EUR-denominated feed-in tariff of 5.5 EUR cent (c) per kilowatt-hour (kWh). However it was not until 2010, when dedicated tariffs for each form of renewable energy were increased, that real development activity took off. Geothermal benefitted from a tariff increased to a USD-denominated 10.5c/kWh. The USD denomination of the tariff can provide substantial cost savings on hedging foreign exchange risks, if renewable energy projects are funded with debt in foreign currency.

Private sector development of geothermal fields had been enabled through the Law on Geothermal Resources and Natural Mineral Waters in 2007, the first Turkish law to specifically focus on geothermal. The law introduced regulated private ownership of and access to geothermal resources by licensing electricity generators to explore and operate resources. The licensing included a three-to-four year time limit on exploration to reduce hoarding by market operators. In addition, the law established reduced fees, a market for transferring licenses, and procedures for negotiation with real estate owners (Parlaktuna et al 2013).

Figure 1: Growth in Turkey geothermal sector (TEIAS 2015)



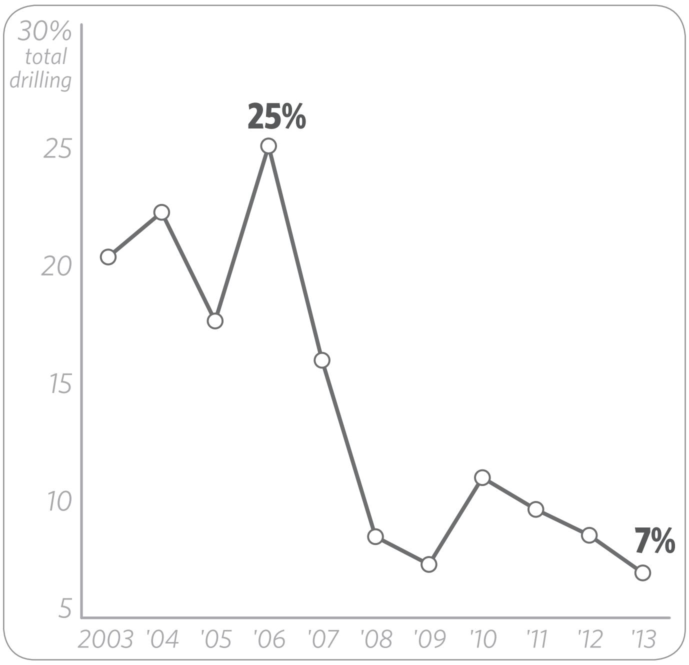
Note: CAGR = Compound Annual Growth Rate

In this context, geothermal electricity projects grew from 30MW in 2008 to 405MW in 2014 – a ten-fold increase in capacity and compound annual growth rate (CAGR) of 54%. This compares to a CAGR of 4.5% for geothermal sector globally over the same period (GEA 2014).

2.3 Turkey's development model for geothermal projects is in transition

Historically, the private sector rarely took on the risks for exploration on greenfield sites in Turkey. Exploration of geothermal potential in Turkey was primarily the responsibility of the General Directorate of Mineral Research & Exploration of Turkey (MTA), a government agency under the auspices of the Ministry for Energy and Natural Resources. Subsurface surveying and exploratory drilling has been conducted on potential sites since 1962 with the first plant commissioned at Denizli Kizildere in 1984 (Parlaktuna et al 2013).

Figure 2: Government geothermal drilling activity in Turkey relative to other sectors



Source: MTA Annual Reports 2010 – 2013

12 out of the 13 plants commissioned by the end of 2013 were developed on fields initially explored and drilled by MTA, and then sold through public tender for field development and construction (see Track 1 in Table 1 and Annex 1 for geothermal projects in Turkey commissioned by the end of 2013) (Black & Veatch 2012).

However, **it is likely that for geothermal to play a larger role in Turkey's energy mix, barriers to private exploration and risk taking need to be overcome.** Government exploration of geothermal resources is falling both in absolute terms and as a proportion of total drilling. MTA drilling in geothermal sites fell to 7% of their total drilling activity in 2013, a clear drop from a high of 25% in 2006. (Figure 2).

Drilling has also traditionally focused on Western Turkey while potential in central and eastern regions of the country remains undiscovered. All of the 20 fields the government has discovered to have the potential to generate electricity are located in Western Turkey (Yildizeli 2014) where the potential for high-enthalpy reservoirs (>180C) is greater. In all, 65% of MTA-drilled wells are in the Western provinces with 21% in central provinces and only 5% in the east (Yildizeli 2014).[4] All geothermal projects under development as of end of 2013 are located in Western Turkey (Mertoglu & Basarir 2013).

Shallow drilling in central and eastern areas of the country report lower temperatures than the West, though without extensive deep drilling the exact potential of the resource remains unknown (Black & Veatch 2012). MTA has increased drilling in these areas: in 2012 and 2013, 60% of drilling activity took place in central provinces although it is unclear whether the purpose was for geothermal direct use for heating or for electricity generation.

4 The remaining wells are located near the Black Sea and in the south-east Mediterranean coast.

3. Financing Gümüşköy GPP

3.1 Project background and main characteristics

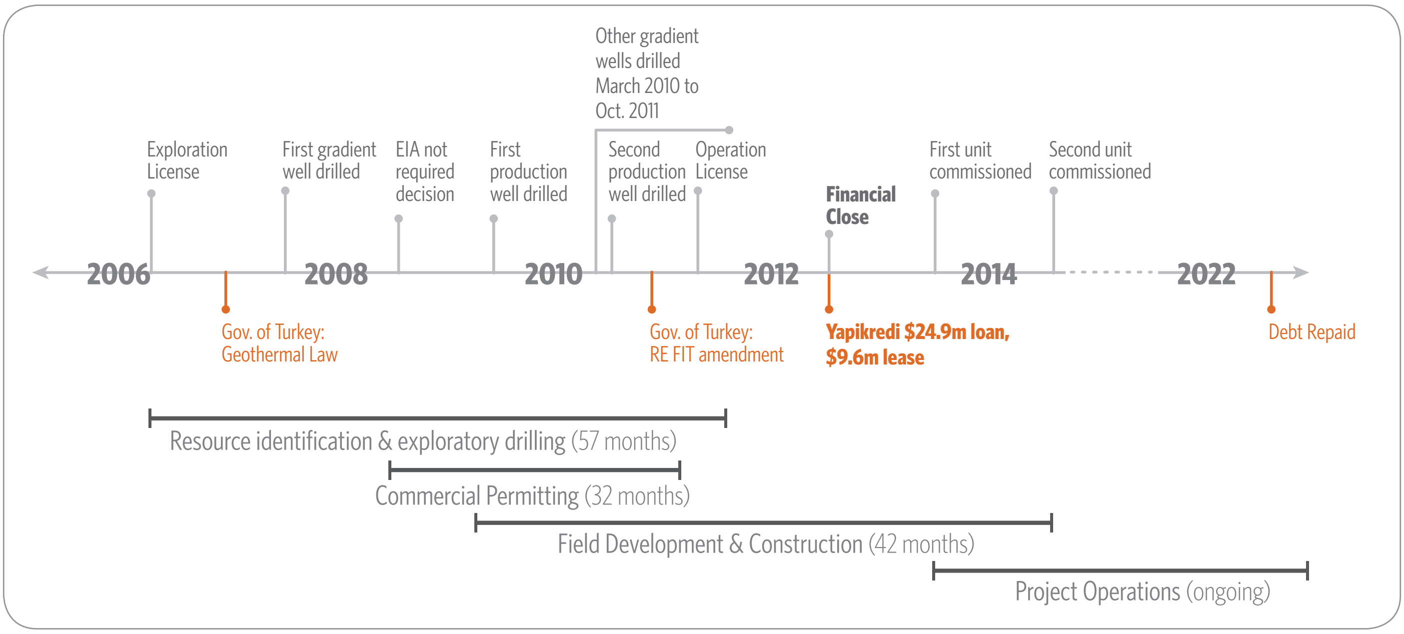
Gümüşköy GPP was developed by BM Holding (BM), a Turkish infrastructure development company. [5] The project is located in Aydin Province in the south-west of Turkey where the vast majority of confirmed geothermal resources are located. The exploration license was obtained in 2006. The first 6.6MW unit of Gümüşköy GPP was commissioned in November 2013 with a second 6.6MW unit following in early 2014. Both use a binary organic rankine cycle (ORC) turbine system.

Surveying and exploration drilling to confirm the resource was feasible for electricity production accounted for approximately half the project development time (Figure 3). This long lead time was largely due to skills acquisition and training needed for the company's first project, delays in contracting drilling rig equipment, and long permitting procedures. Once the first production well was drilled in June 2009, the project took a similar length of time to develop as other projects on proven fields in Turkey (see later section for

Table 2: Technical features of the Gümüşköy GPP (BM Holding 2014a, 2014b)

TECHNICAL FEATURES	
TECHNOLOGY	Binary ORC
DEPTH OF PRODUCTION WELLS	1250 - 2000m
TEMPERATURE	182°C (140-167°C at wellheads)
INSTALLED CAPACITY	13.286 MWe
POWER GENERATED	105 GWh (90% load)
POWER SOLD (NET)	77 GWh
CARBON PRODUCTION POTENTIAL	38kt CO2/yr
CARBON PRODUCTION (ACTUAL)	Approx. 8.5kt CO2/yr
NET CARBON AVOIDANCE	47 kt CO2/yr (if no leakage of carbon)

Figure 3: Project timeline and key milestones



5 Dates and figures presented in section 3 and 4 are CPI calculations and views based on information collected from interviews with and documents from the project developer and financiers.

comparative analysis). Financial close was achieved in April 2012 after completion of two production wells and a re-injection well utilized by the first unit.

A notable byproduct of geothermal resource extraction in Turkey is the release of non-condensable gases (NCGs) from the brine of fluid as it is utilized for electricity generation. Approximately 2% of the brine volume of Gümüşköy GPP is NCGs, predominantly carbon dioxide with a potential carbon production of 38kt CO_2/year (Table 2). The binary system re-injects the majority of the carbon dioxide gas produced along with the geothermal fluid, while approximately 8500 tonnes CO_2/year are captured for use in local greenhouses and, in the future, for selling to industrial gas consumers.

Box 1: CO2 emissions and geothermal in Turkey

Turkish geothermal resources have been characterized with high levels of non-condensable gases (NCGs) at 1.5%-2.3% of concentrations by weight. This is similar to other countries such as New Zealand and Costa Rica but over 10-15 times higher than reservoirs found in the US (Atkins 2014). Approximately 95-99% of NCGs in Turkish geothermal projects is CO_2 due to a combination of carbonate rocks such as marble and limestone degrading in reservoirs and temperatures are not high enough to separate the gases naturally (Aksoy 2015).

This makes the choice of geothermal technology crucial to ensuring that geothermal in Turkey offers low-carbon electricity. Binary systems offer a good solution. Through their use of heat exchangers, they can re-inject geothermal fluids directly in a closed system, thereby minimizing the possibility of carbon emissions. 10 out of 13 projects in Turkey use binary systems (see Annex 1). In addition, carbon may be captured and produced as a byproduct for use in greenhouses and industrial sites as in Gümüşköy GPP (see section 5).

3.2 Project stakeholders and financing

The project reached financial close in April 2012 when 70% of the total investment cost of the project was covered through debt finance provided by local bank, Yapikredi (see Table 3). Until that point, BM Holding had invested USD 12m of its own equity in developing the field and conducting its drilling program. It invested another USD 3m in equity at financial close (USD 15.1m equity in total).

50% of the project was financed through a USD25m 10-year, limited recourse loan provided by the EBRD MidSEFF facility via Yapikredi at a highly competitive market rate (see Box 2 for details on the MidSEFF facility).[6] The loan availed of a corporate guarantee by BM Holding to the project special purpose vehicle (SPV) during the construction phase of the project before reverting back to non-recourse debt solely backed by project cash flows during operation. Another USD 9.6m was provided in lease finance through a subsidiary of Yapikredi specializing in this form of debt at a shorter tenor and higher interest rate than the MidSEFF loan.

On the technical side, the developer used the project as a testing ground to develop in-house capacities for surveying, testing and drilling services for geothermal exploration. High-level survey maps from the government were complemented with detailed modeling tests and mapping. BM Holding purchased slim-hole mining drilling rigs in 2007 and modified them for geothermal exploration. The subsequent development of a slim-hole well exploration methodology reduced costs of exploratory drilling by 80% in comparison to drilling conventional wells.[7] BM Holding also developed expertise in undertaking flow tests and well compilation studies. BM Holding now has three subsidiary companies involved in providing consultancy, project management and drilling services to 17 clients in the geothermal sector.

US-based equipment supplier TAS Energy designed, manufactured and installed an organic rankine cycle (ORC) binary power plant, specifically adjusted to the project's brine characteristics (temperature, chemical content). The project was the first entry into the Turkish

6 The interest rate on the project is lower than would otherwise have been the case due to ability of local banks to channel EBRD funding with its relatively low capital costs to the projects loans.

7 The cost reductions apply to the exploratory phase and occur as no full-size wells have to be drilled. Cost reductions are smaller if the full drilling costs are considered, as conventional full-size wells can be used for production, while slim-hole wells have to be extended.

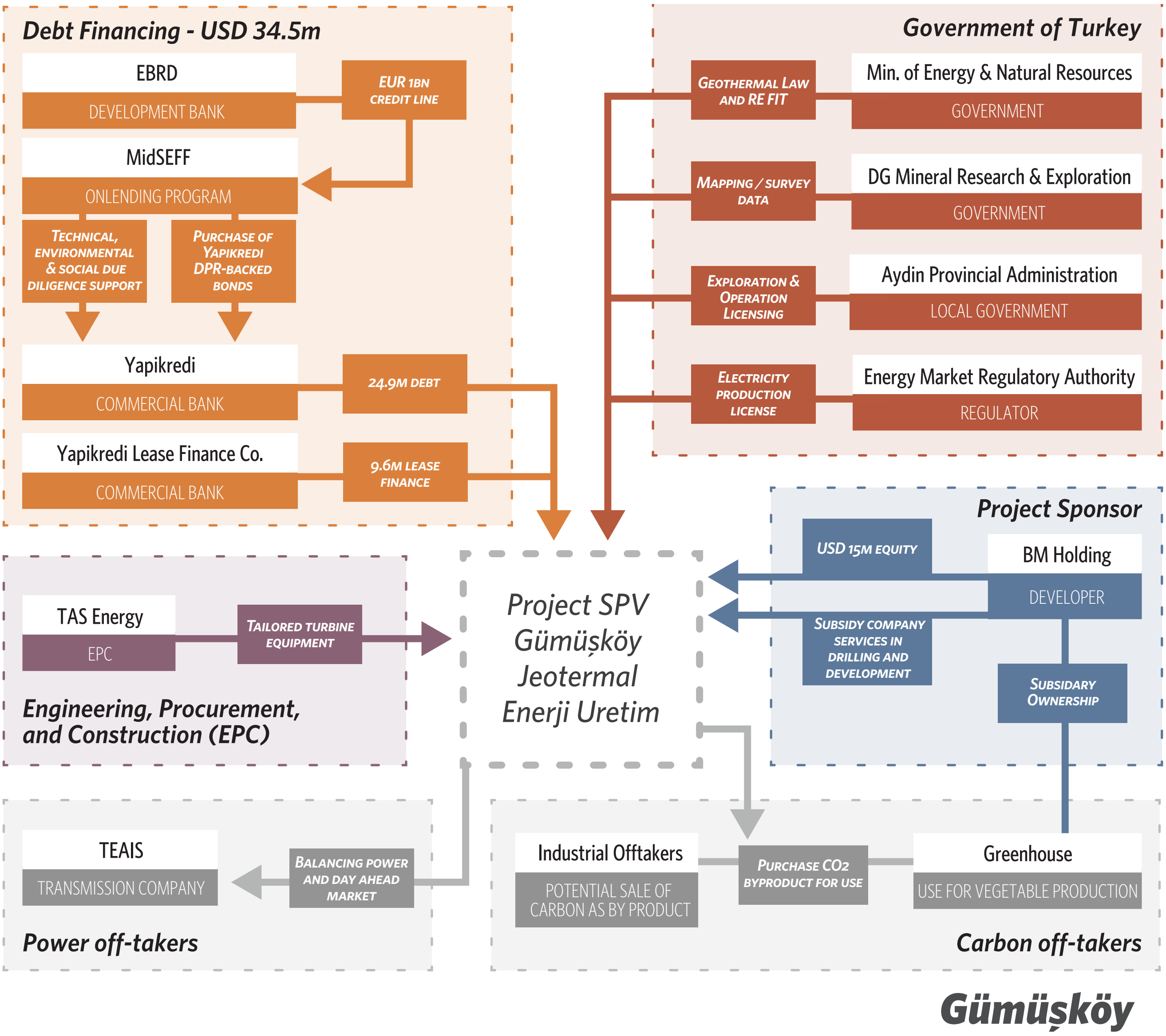
Table 3: Capital structure and financing sources of the Gümüşköy GPP (USD million)

DEBT				
EBRD MidSEFF via Yapikredi	LOAN	PUBLIC	**24.9**	50%
Yapikredi	LEASE FINANCE	PRIVATE	**9.6**	20%
EQUITY				
BM Holding	EQUITY	PRIVATE	**15.1**	30%
TOTAL PROJECT COST			**49.6**	**100%**

market for TAS Energy who had only provided one custom-made binary power plant for a geothermal project in the US market at that time.

Public sector stakeholders include the Ministry of Energy and Natural Resources (MNRE) overseeing the regulatory framework that provides the feed-in tariff for the project, the transmission grid off-taker Turkish Electricity Transmission Company (TEAIS), as well as the permitting authorities at national and provincial level, responsible for issuing exploration and drilling licenses on geothermal sites and electricity generation operation licenses to participate in the market. Finally, local greenhouses owned by BM Holding (and in the future, potential industrial users such as Linde, or Habas) have a stake in purchasing the carbon production as a byproduct of the facility.

Figure 4: Mapping Gümüşköy GPP stakeholders and their contributions to the project



Box 2: Overview of European Bank for Reconstruction and Development (EBRD) MidSEFF facility

The MidSEFF facility was launched by the (EBRD) in 2011 with support from the European Investment Bank (EIB) and European Commission. It will provide up to EUR 1 billion in loans to seven Turkish commercial banks for on-lending to private sector renewable energy, waste-to-energy and industrial energy efficiency projects. By mid-2014 EUR 550 million in loans had been disbursed, of which EUR 56 million went to geothermal projects (MidSEFF 2014).

The facility aims to demonstrate the attractiveness of new financial products for clean energy projects to commercial banks, ensure a diversity of different project types to finance, and develop local commercial banks' knowledge and skills in assessing environmental standards and risk in clean energy project finance.

The method of providing the credit line to the local banks allowed EBRD to channel competitive fund-raising costs through to the project loans and ensure that the lending is economically attractive for the banks. The MidSEFF credit line benefitted from an existing Diversified Payment Rights (DPR) program that Turkish banks use to raise funds at a lower cost than their own corporate unsecured funding or even that of the government (as DPRs are an offshore instrument). DPRs are rights to current and future cash flows that are denominated in a foreign currency such as USD or EUR through payment orders. Payment orders are created between investors that send funds to Turkey through the local bank to be received by resident Turkish entities or individuals.

In this case, EBRD bought amortizing senior investment grade rated debt via Yapikredi's existing DPR program, with the specific agreement that the bank lend the funds on to eligible MidSEFF projects. The collateral for the notes are the DPRs to the future payments in foreign currency (USD) being made to Yapikredi from Turkish entities. Yapikredi made the final decision on providing the loans to the project and was able to channel the rates of the EBRD financing through to the project loans.

3.3 Project costs and returns

We use a simulated discounted cash flow analysis of the project's financial profile to estimate the project's revenues, liabilities, and profitability and ultimately its levelized cost of electricity (LCOE).

Policy and public finance boosted the project's returns in two ways: the ten-year feed-in tariff increases revenues and will allow the project to pay off its debt sooner; and longer loans at a competitive market rate decreased costs.

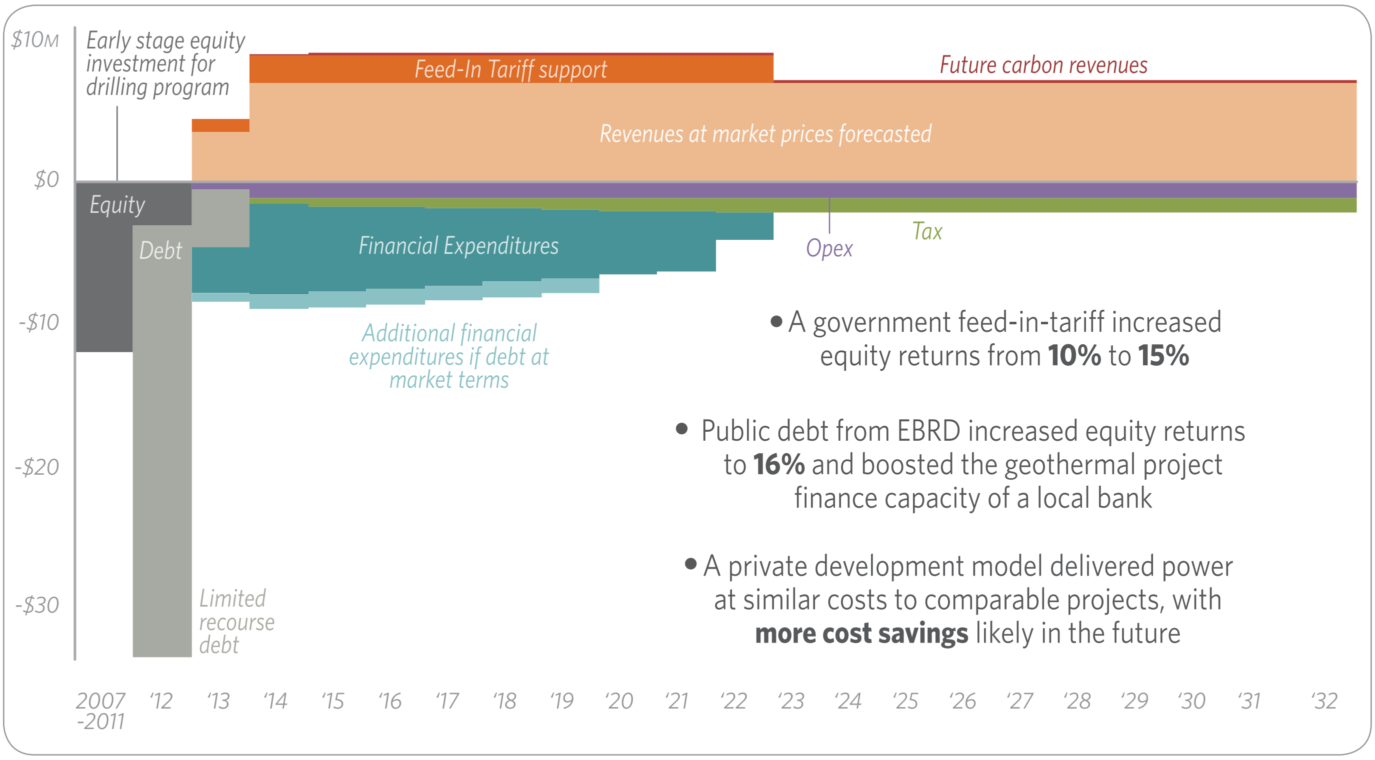
3.3.1 COSTS BREAKDOWN

The project's **capital expenditure (CAPEX)** amounted to USD 49.6 million or 71% of overall project costs (if discounted with equity IRR). Equity makes up USD 15 million or 30% of CAPEX, which is a typical equity share for geothermal project finance in Turkey (see Table 7). Per installed MW, CAPEX amount to USD 3.8 million, which is within the range (USD 2.4- 5.9 million/MWe) for other binary-cycle geothermal plants (IEA 2010). Approximately 8% of the project costs were **allocated in the exploration and test drilling phase**

The project's **operational expenditure (OPEX)** are mainly personnel expenses, chemicals and contingencies, and amount to USD 1.1 million per year or USD 22 million over 20 years,[8] which is 13% of total project costs discounted with equity IRR. This small share of operation costs in geothermal is particularly useful in reducing ongoing operational cost risks compared to fossil fuel power stations, which have due

8 20 years is the timeframe used in financial modelling. Due to discounting, operational costs beyond 20 years have no relevant impact on key indicators like rate of return or share of OPEX as % of overall costs.

Figure 5: Cash flows of the Gümüşköy Geothermal Power plant



Note: Simplified cash flow, not depicting VAT repayment and lower Fin Ex in case of market-term debt between 2021-2023 (due to shorter tenor).

to their ongoing fuel use a higher OPEX share of costs: 31-33% in case of coal and even 63-76% in case of gas (see Nelson and Shrimali, 2014).

Financial expenditure (FINEX) amount to USD 4.7 million (discounted with equity IRR) or 16% of project costs. FINEX is lower and occurs in a shorter term than is the case for comparable geothermal projects on the market (see Figure 5), as the EBRD loan channeled from MidSEFF via Yapikredi has a two-year longer tenor and cost an estimated 200 basis points less than what the market rate would have provided at that time.

3.3.2 SOURCES OF REVENUE

The main source of return for the project is the sale of power at the feed-in tariff (FiT) rate of 10.5 USD¢/kWh for the first ten years of the project's life. This provides certainty that revenues will be 28% higher than current market rates and allows the project to achieve payback of all investment costs within eight years. While the FiT is favorable compared to market rates, it is not as excessive as in other countries where FiT are often guaranteed for up to 20 years and substantially higher. Annual income from power sales increases from around USD 7 million at market prices to USD 9 million at FiT level (see Figure 5 and Table 4).

The sale of carbon dioxide gas for use in greenhouses and as dry ice in industrial sites provides a secondary source of revenues. The plant currently sells its limited CO_2 production to BM Holding's own greenhouses locally at a knockdown market rate. Because information on investment costs varies significantly according to the flow rates of CO_2 we have not estimated the production and sale of CO_2 in the financial model.

The third potential source of revenue is the sale of carbon credits estimated at USD 0.2 million per year, assuming carbon credit prices of USD 4-5 per tCO_2 reduced by displacing fossil fuel power production.[9] The project is registered as Voluntary Gold Standard project but to date no carbon credits from the project have been issued (Markit 2014).

9 This credit price is based on the average price for geothermal carbon offset credits in 2012, when the project reached financial closure (Ecosystem Market Place and BNEF, 2013). It is a conservative assumption, as voluntary offset credits from projects in Turkey even sold at an average price of around USD 5 per tCO2, and Voluntary Gold Standard credits at an average price of USD 10 per tCO2.

Table 4: Revenues, costs and return

GÜMÜŞKÖY GEOTHERMAL POWER PLANT	VALUE	UNIT	COMMENT
Annual Energy Generated, expected	85	GWh	Annual power generated estimated on the available capacity of 13.2 MW, a capacity utilization factor of 73% (estimation at time of investments). No annual degradation factor is taken into account. According to newest information, net electricity sold per year is only 77GWh (BM Holding 2014), which reduces the actual IRRs and increases the LCOE.
Annual Revenues first 10 years	9.1	USD mn	Annual revenues are almost entirely generated though the sale of power according to a guaranteed 0.105 USD/kWh (first 10 years) and projected flat market price of 0.082 USD/kWh (from year 11 on)
- Power sold through FIT	8.9	USD mn	
- Power if sold at market prices	7.0	USD mn	
- Sale of captured CO2	Not estimated		
- Sale of carbon credits	0.2	USD mn	
Investment Costs	50	USD mn	Investment costs are within the range of 2.4/MWe to USD 5.9/MWe for other binary-cycle geothermal plants (IEA. 2010)
	3.8	USD/MW	
Levelized Cost of Electricity (LCOE)	10.3	USD ¢/kWh	We calculated the LCOE using the equity IRR as the discount factor, returning a value very close to the tariff bid in the Phase 1 tender (USD 0.105/kWh). CAPEX is by far the largest component of the levelized costs
- CAPEX	71	%	
- OPEX	13	%	
- FINEX	16	%	
Project IRR (after tax), expected at financial closure	12	%	Project IRR expected at financial closure is similar to expected capital returns (11-14%) of other geothermal plants in Turkey see FutureCamp 2011, South Pole Carbon Asset Management 2011). Performance-adjusted IRR reflects lower electricity generation than expected (77 instead of 85 GWh, expected).
Project IRR (after tax), adjusted for actual performance	10	%	
Equity IRR (after tax), expected at financial closure	16	%	Equity IRR is higher than benchmark IRRs for solar PV (13%) and wind (11%) according to BNEF (2014), and equity IRRs of 6-14% achieved by wind and hydro power plants in Turkey in the years 2008-10 (Voluntary Gold Standard Project Design Documents). Performance-adjusted IRR reflects lower electricity generation than expected.
Equity IRR (after tax), adjusted for actual performance	12	%	

3.3.3 RETURNS AND COST OF ELECTRICITY PRODUCTION

Our cash flow model results in expected 16% Internal Rate of Return (IRR) on equity and expected 12% IRR on the project level, which is similar to other geothermal projects in Turkey that expected IRRs of 11-14% (FutureCamp 2011, South Pole Carbon Asset Management 2011). **Equity returns are considerably higher than without public support**, e.g. without EBRD/ MidSEFF debt (with its longer tenor and lower costs), equity IRR would only be 14.7% (see Table 5), and **without the feed-in tariff equity IRR would drop to 10%, which is very likely below the return expectations of the developer.**

As the electricity generation is only 77 GWh per year, so 8 GWh per year below expectations (see Table 4), we estimate that, after adjustment for lower performance, actual equity IRR is only 12% and project IRR only 10%.

Using the expected equity IRR for discounting cash flows and electricity production, we estimate Levelized Cost of Electricity (LCOE) in the project of 10.3 USD¢ / kWh, which is very close to the feed-in tariff. This LCOE does not include the cost to the public of providing debt at slightly preferential conditions. **Under market conditions (without public finance), LCOE would be higher at 10.6 USD¢ / kWh,** which is a good proxy for the actual economic LCOE under the project.[10] Costs of 10-11 USD¢ / kWh are not far from the current market price of electricity of around 8.4 USD¢ / kWh in Turkey(Platts 2014) and depending on the evolution of the electricity market and cost reduction in geothermal plants, projects similar to Gümüsköy could become cost-competitive in Turkey soon.

Without the feed-in tariff, equity IRR would drop from 16% to 10%, which is very likely below the return expectations of the developer.

Returns for project stakeholders go beyond pure financial benefits, as Table 6 shows – the project developer is learning and building in-house capacity, the private lenders improves its understanding of geother mal financing and EBRD is achieving both climate and private sector promotion goals.

Table 5: Impact of market rates for debt on equity IRR and LCOE

	EQUITY IRR (%)	COMPARED TO PROJECT	LCOE ($C/KWH)	COMPARED TO PROJECT
PROJECT (WITH EBRD DEBT)	15.9%		10.3	
MARKET-RATE COST OF DEBT (+ 200 BPS)	15.1%	- 5%	10.5	+ 2 %
MARKET-RATE TENOR OF DEBT (- 2 YEARS MATURITY)	15.2%	- 4%	10.5	+ 2 %
MARKET-RATE TENOR / COST (+200BPS, -2 YEARS)	14.7%	- 8%	10.6	+ 4 %

10 The 10.6 USD¢ / kWh are very close to 11.2 USD¢ / kWh, which Black & Veatch (2012) calculated for a 25 MW geothermal power plant in Turkey (base case, 12% project IRR).

Table 6: Summary of the costs and benefits to project stakeholders

STAKEHOLDER	INPUTS / COSTS	OUTPUTS / BENEFITS
PRIVATE DEVELOPER		
BM HOLDING	$15m in project equity	16% return on investment
	6.5 years development time	Significant learning and in-house capacity built, development of competitive drilling technology 2-3 years development time reduced 17 new clients for drilling technology and exploratory services
FINANCIERS		
YAPIKREDI	$9.6m lease finance $24.9m limited recourse loan at longer tenor and competitive market rate	$13m in interest payments (estimated)
	Due diligence for loan approval	Understanding of geothermal project financing
EBRD	Base funding for $24.9m loan decreasing project costs and providing access to finance	Support for IPP development of sustainable energy projects and carbon emission reductions
	Support on environmental and social assessments	Potential scalable solution for NCG emissions
GOVERNMENT		
MINISTRY OF ENERGY AND NATURAL RESOURCES; MTA; AYDIN PROVINCIAL ADMINISTRATION; ENERGY MARKET REGULATORY AUTHORITY	Revenue support mechanism of $10.5c/kWh increasing project revenues	Meeting geothermal deployment and carbon emission reductions targets
	Licensing and permitting regulatory framework	Private sector capacity development for geothermal exploration
	Value Added Tax (VAT) paid during construction can be deducted from VAT for electricity sales in first years of operation	Improves equity IRR by more than 300 basis points
	Initial high level surveying data	

4. Risk allocation in Gümüşköy GPP

The amount of time and level of investment required in geothermal projects to confirm the feasibility of the resource for electricity generation is widely identified as the key risk in project development (ESMAP 2012, Micale et al. 2014). However, other risks related to financing, policy, or technology performance may occur at later stages in the project.

4.1 Risk identification and assessment

In order to systematically identify all the material risks faced by different stakeholders participating in Gümüşköy GPP, we categorized risks according to the three stages of exploration, development, and operation. We then assessed their probability of occurrence (low/moderate/high) of each risk; and their impact on the project's financial and non-financial objectives (again from low/moderate/high). Below we identify the most material risks.

4.1.1 RISKS IN EXPLORATION

- **Lack of skills/knowledge – High Risk Event**: As the project was the first development undertaken by BM Holding, there was considerable risk that costly delays could occur.
- **Resource confirmation – High Risk Event:** The project was under development on a site that was discarded by the government as too small or of potentially too low temperature. Failure to confirm a temperature, depth and flow-rate that make electricity generation feasible was a significant risk at the project outset.
- **Resource estimation – High Risk Event:** Apart from confirming the presence of a medium to high temperature resource at a suitable depth, there was a significant risk that the estimate for electricity potential and reservoir management would be far below expectations.

4.1.2 RISKS IN DEVELOPMENT

With a legal framework in place for licensing and development of geothermal projects, regulatory and permitting risks were relatively low for the project. However, other risks related to the field development and construction were apparent.

- **Power plant construction – Moderate Risk Event:** As geothermal binary power plants are custom-made to suit the technical characteristics of that particular resource, it can be regarded that risks related to performance of the equipment would be low. But the nature of ordering custom-made equipment leads to over-reliance on certain manufacturers and costly contingency plans if there are delays in the delivery of the equipment and start-up of the project, as the supplier cannot easily be changed.
- **Earthquake risk – Moderate Risk Event**: The project is in an earthquake hazard zone and damage to equipment and delays in construction could occur.
- **Drilling risk for production – High Risk Event:** Even exploratory and test drilling does not totally remove the risks that a production well may not produce the required flow rate or temperature. Deep drilling rig equipment is expensive in Turkey, with daily rental rates applied, similar to New Zealand, Kenya and Indonesia, as opposed to charges according to drilling depth achieved as applied in Iceland. Total costs can range from $1.7 to 3.3m per well (Kaya 2012)[11]. The risk of higher costs due to blowouts and well losses during drilling could deter the successful testing of a reservoir.
- **Financing risk – High Risk Event:** Project finance for clean energy projects was relatively scarce at the time BM Holding was developing Gümüşköy GPP. Costs for field development incurred two to three years before the project reached financial close point to the difficulties the sector had in accessing finance.
- **Environmental and social risks – High Risk Event:** The presence of non-condensable gases in geothermal resources meant that the project could have failed to meet environmental and social standards of public sector financiers or achieve sustainability policy objectives of the government.

11 Depending on a depth of 1500, 2500 or 3200 meters

4.1.3 RISKS IN OPERATION

During project operation, the denomination of the FiT in USD as well as a mandatory requirement for off-taking renewable energy electricity supplied to the grid, meant that foreign exchange and off-taker risks are not applicable to this phase of the project. In addition, the length of the FiT at 10 years means price risks are non-existent, even beyond this period as all investment costs will have been repaid before that time. However significant technology, resource management and financing risks remained.

- **Technology risk – Moderate to High Risk Event:** In organic rankine cycle (ORC) binary plants, the choice of the organic boiling fluid that will best transfer heat from the resource is a key responsibility of the turbine provider. However different fluids have risks, including cost, efficiency and availability. These risks impact on the ability of the turbine to meet the required net output for feasibility. At the time of financial close, turbine provider TAS Energy had only one reference for a geothermal plant in the U.S. which had yet to be commissioned (BNEF, 2014).
- **Loan repayment – Moderate to High Risk Event:** Although the feasibility of the project was proven at the time of financial close, the debt during construction was placed on the parent company of the SPV, BM Holding. At that time, it had no independent audit report and showed losses over the previous three years, placing a moderate to high risk on loan repayment on the lenders.
- **Resource management – High Risk Event:** In addition to electricity generation from productive wells, BM Holding needs to sustainably manage and renew the heated fluid in the underground reservoir to ensure its productive life. Re-injection wells are drilled to facilitate the return of the fluid but there is a risk that these wells will lead to other reservoirs not within the license of the project developer and deplete BM Holdings' own resource more quickly. Even with potential mitigation of this risk by extensive modeling studies, reservoirs may end up having multiple license holders with rights to the same resource. This can introduce complications with regard to resource management for project viability. For medium temperature resources in particular, wells can become blocked at re-injection due to a high content of amorphous silica and carbonate in the water and the much lower temperature of the fluid after heat transfer, leading to long down-times.

4.2 Risk analysis, allocation and mitigation

In the dynamic risk matrix in Figure 6, we illustrate the bearer of risks across the project stakeholders and map how key risks were transferred through different approaches.

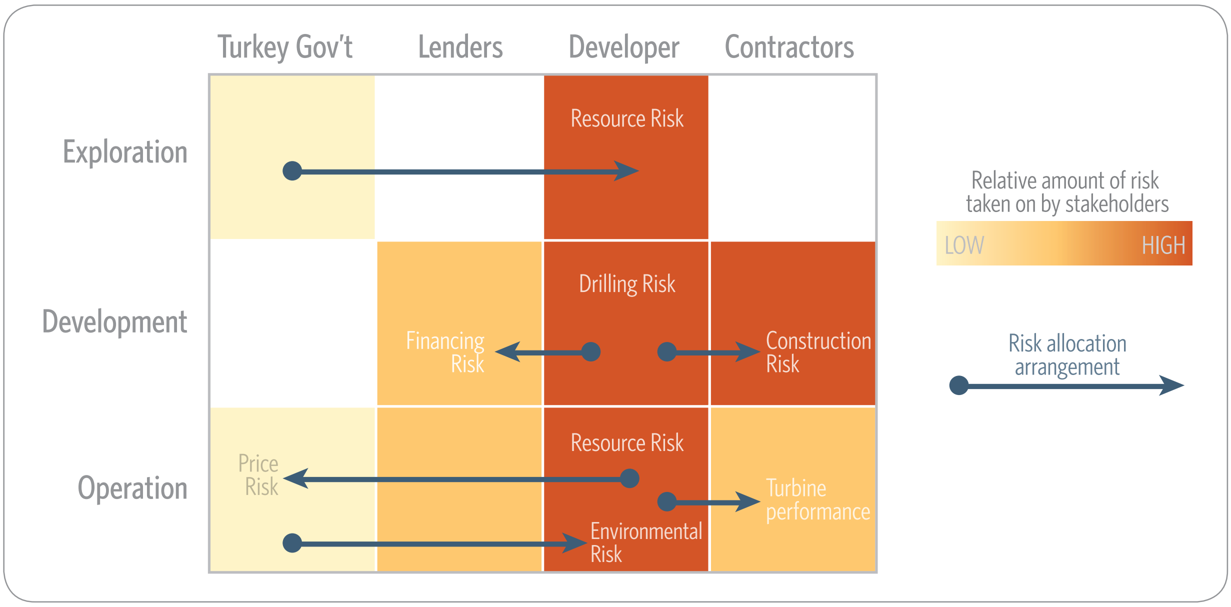
4.2.1 RISK ALLOCATION TO THE DEVELOPER

In exploration, the development model employed in the Gümüşköy GPP meant that previous resource confirmation risks usually borne by the government agency MTA, were taken on by the project developer. BM Holding mitigated this risk by recruiting engineers, drilling equipment and expertise with the requisite knowledge and experience to undertake the exploration. However, these acquisitions and recruitment meant that the risk of failure at this stage of the project remained with the project developer rather than being transferred to an external contractor. Numerous delays in this phase were due to the modification of newly purchased equipment and the training of staff.

The Gümüşköy GPP project is distinguished by the project developer's willingness to take on resource and drilling risks at each stage of the project.

Risks in production drilling and resource management continued to be borne solely by the developer in the following stages of the project. Difficulties in procuring a drilling contractor meant that the completion of the first production well was delayed by one year to June 2009 once BM Holding had acquired the necessary equipment and expertise through acquisition. The risk of scaling in wells, whereby a well may be blocked due to deposition of calcium carbonate scales from the geothermal fluid, was managed through engaging an external consultant to examine the severity of the issue at re-injection in a geochemical study. Equipment

Figure 6: Risk allocation among stakeholders in Gümüşköy GPP



to inject chemicals into the fluid at re-injection was installed to manage the scaling risk. A tracer study for the re-injection well was undertaken to ensure the fluid would be returning to the reservoir licensed to BM Holding rather than to other reservoirs and projects in the area. As the re-injection well had to be located at a higher altitude, the energy required for the fluid re-injection and pumping system resulted in a lower net electricity production for power sales of up to 2MW. However it did mitigate the risk that the resource would be exhausted prematurely.

Risks that were transferred to the developer from other stakeholders included:

- **Environmental and social risks from the government and lenders:** The developer's design and use of CO_2 byproduct from the geothermal wells allowed government and public lenders to justify the investment as a clean energy investment and demonstrated a viable model for replication in other geothermal projects across Turkey. The carbon produced is utilized in a five hectare greenhouse located close to the project site. In addition, industrial offtakers such as Linde and Habas have been identified for potential expansion of onsite carbon production for use in various processes including dry-ice production, carbonated drinks, and fire extinguishers.
- **Loan risk from the lenders:** The project loans were sponsored by BM Holding for the construction phase and then transferred to the project SPV once the project was in operation. This allowed the bank to judge loan risk during the riskier stage of the project against the larger balance sheet and credit record of BM Holding rather than on the project as stand-alone non recourse finance.

BM Holding took on some of the lenders' risks by sponsoring the project loans for the construction phase before transferring them to the project SPV once the project was in operation. This allowed the bank to judge loan risk during the riskier stage of the project against the larger balance sheet and credit record of BM Holding rather than on the project as stand-alone non-recourse finance

4.2.2 RISK ALLOCATION TO CONTRACTORS

The EPC contract with TAS Energy for the delivery of a custom-made binary ORC turbine and heat transfer system includes clauses for compensation in the case of delays to the power plant construction. This was indexed to a percentage of the overall contract price on a weekly basis. For example, if the commissioning of the plant was delayed by up to four weeks, 0.5% per week of the contract price would be returned to the developer. This extended to 1% per week if there was a delay for more than four weeks. Similar arrangements were put in place for performance risks of the technology once operational.

However, the contract limited the maximum amount that developer could claim to 15% of the contract price. This resulted in more conservative planning on the commissioning timeline of the power units within the cash flow projections at the time of financial close, which allowed for a delay of up to four months. As it happened, the commissioning of the first unit was delayed by seven months due to frequent downtimes in the testing of the turbine and the organic boiling fluid selected for heat transfer in the binary system. R134a was selected by TAS Energy from among the potential options for the organic boiling fluid in binary systems owing to its higher efficiency, particularly for smaller generation units. On the downside, R134a it is reported to be less flexible for temperature / pressure changes and 8-10 times more expensive on the Turkish market than butane, which is used in other plants in the country.

4.2.3 RISK ALLOCATION TO LENDERS

In providing debt finance for the project, Yapikredi ultimately bore the financing risk. Risk mitigation arrangements applied by the bank included:

- The pass-through of more competitive lending rates due to the availability of EBRD capital from the MidSEFF facility. This facility meant that the credit risk of the sponsor could be marginally discounted as the potential for repayment was higher.
- The certainty of revenues through the FiT reduced loan repayment risk further
- Most importantly, leveraging the larger balance sheet of BM Holding as collateral for the construction phase of the project meant that credit risks were reduced significantly.

4.2.4 RISK ALLOCATION TO THE GOVERNMENT

The government (and indirectly, the electricity rate payers) bore the price risk for the project through the FiT guarantee for ten years and the mandatory off-take by the state-owned transmission grid operator. Thereafter, the price risk is transferred to the developer to compete on the daily trading market against other power generators. With the project achieving payback for the developer at that point and operating at a high profitability rate due to the high load factor of geothermal plants, this risk is very low for the developer.

For the government, the risk in providing the FiT is in managing excessive costs to the economy. Although the cost of the FiT mechanism is passed on to the consumer base through electricity bills, as a fast growing emerging economy, a key policy goal of the government is maintaining energy costs at a stable and manageable level.

While the FiT for geothermal was increased in 2010 to over 25% above market prices, the guaranteed ten year lifetime of the tariff is up to 50% less than in other jurisdictions such as Kenya and Indonesia which offer tariffs for 15-20 years (IEA 2014). In addition, tariffs set for wind and hydro installations, the vast majority of new projects availing of the mechanism, are set below market prices, operating more as a price floor for these projects against the market value rather than a top-up premium. Both these features of the FiT regime (the time limitation and relative low tariffs) allow the government to manage the risk of excessive costs.

5. Effectiveness, Replication and Scale-up: Lessons from Gümüşköy GPP in meeting policy goals

This section analyses the effectiveness of Gümüşköy GPP model in meeting Turkey's policy goals as well as lessons for the replication and scale-up of the geothermal sector. The potential value that scaled-up geothermal can add to the Turkish energy mix is first reviewed before analyzing how the project has effectively met policy goals in comparison with other projects in Turkey. Finally, barriers to scale-up and potential solutions are reviewed.

5.1 Potential for scaling up geothermal in Turkey

If Turkey were to harness its estimated potential of 4.5GW of installed capacity it could meet 8% of overall demand in 2030.[12] This is in a lower demand scenario than the Turkish government's official projections which market analysts believe to overstate demand by 18% in 2023 and 34% in 2030 (BNEF 2014). This is due in large part to geothermal's 90% load factor.[13] Its ability to provide power reliably allows it to compete with both traditional baseload power and its flexibility enables it to ramp up and ramp down generation for grid operators looking to balance power supply and demand (Matek & Schmidt 2013).

The official government target was originally set at 600MW by 2023 as part of the government energy sector strategy announced in 2012. This was superseded by an interim target for the 10th Development Plan of 750MW by 2018 (announced in 2013). The National Renewable Energy Action Plan, has again upgraded the target to 1GW (MENRa 2014). While the Government may have underestimated geothermal development since setting targets for the sector, the potential capacity figures pale in comparison to official plans for the energy sector as a whole of 120GW of installed capacity by 2023 and 440GW in 2030 (BNEF 2014).

12 Geothermal for electricity production is estimated to have up to 4.5GW theoretical technical installed capacity potential in Turkey (Mertoglu & Basarir 2013)

13 In other words, on average a geothermal plant generate electricity at full capacity 90% of the time.

5.2 Project's effectiveness in meeting the Turkish government's policy objectives

Any scale up of geothermal must be complementary to Turkish energy policy of meeting demand growth, improving energy security and promoting investment (MENRb 2014; MFA 2014; Government of Turkey 2012). In Table 7 below, we have distilled these into five broad policy goals and sub-indicators for the purposes of measuring the comparative effectiveness of the Gümüşköy project model. We discuss some of these goals in more depth in the following subsections.

The development model adopted in Gümüşköy GPP built the private sector's capacity for geothermal project development and finance, attracted private debt finance, and demonstrated carbon management solutions.

5.2.1 Market liberalization and privatization through greater participation of the private sector

While the developer had access to high-level survey data from the government, the **project represented the greatest participation of the private sector** in exploration on an unproven field. Participation through facilities such as MidSEFF allowed local banks to develop in-house due diligence and decision-making capacities and incorporate EBRD's standards on environmental management.

The project was able to attract debt financing once production wells were proven, similar to debt finance for other projects in Turkey since 2007 when the Guris Gurmat project achieved financial close. This $123m deal was arranged by U.S. bank WestLB with local banks buying into the debt finance after financial close. However, the unsustainable pre-crisis financing

Table 7: Effectiveness of Gümüşköy GPP comparatively with other projects

BROAD POLICY GOALS	EFFECTIVENESS INDICATOR	GÜMÜŞKÖY	PAMUKOREN	GURMAT	DORA 2	MAREN SINEM
Increased competitiveness through market liberalization and privatization	Private exploration	Yes Significant learning and knowledge development	No - MTA proven field	No - MTA proven field	No - MTA proven field	No - MTA proven field
	Private finance in development	50% public debt 20% private debt 30% private equity	73% public debt 27% private equity	67% private debt 33% private equity	Unknown	Unknown
Meet increased energy demand through rapid deployment	Time to deployment from resource confirmation	53 months	43 months	54 months	15 months	24 months
Achieve low cost electricity	Cost Technology	3.8/MW Binary	2.5m/MW Binary	2.8m/MW Flash	3.9m/MW Binary	2.5m/MW Binary
Achieve renewable energy targets	Year of commissioning MW installed	2013 13.2MW	2013 45MW	2009 47MW	2010 11.5MW	2012 24MW
Reduce carbon emissions	Emission reductions	46,726 tCO2/yr	164,879 tCO2/yr	Unknown	39, 815 tCO2/yr	100,206 tCO2/yr
	Management of non-condensable gases	Yes	None	None	Yes	Yes

environment and lack of participation by local financing institutions during the risk assessment meant it was difficult to replicate until 2011 and 2012.

5.2.2 MEETING GROWING ENERGY DEMAND AT SPEED AND LOW COST

The project was comparable in cost and time to deployment with other geothermal projects in Turkey, albeit at the high end. Deployment time suffered due to difficulties in contracting equipment, internal capacity building and long permitting procedures. For new projects under development by BM Holding, development times have halved due to the experience in exploration from Gümüşköy GPP and timely access to equipment. In addition, the contracting of drilling equipment and skills to over 17 new projects through 3 subsidiaries has allowed new projects by other developers to avail of these advances and a dedicated services market to emerge.

Investments costs of $3.8m/MW are similar to other projects the same size in Turkey. This may be partially explained by the economies of scale experienced by larger projects where unit costs can halve (Micale et al 2014). Although accurate data is not available to compare projects across their whole lifecycle, in this case it can be assumed that the costs of an exploration program – including surveying, tests and exploration drilling of an unproven field as well as the acquisition of new equipment and in-house knowledge capacity – can compare well with the costs of winning tender contracts for proven fields from the government estimated at an additional $1.1-1.4m/MW.[14]

When examined from the systems viewpoint of improving energy security, Gümüşköy GPP compares favorably with previous LCOE estimates for geothermal in Turkey and globally, as well as other technologies it may compete against. The project, without public financing, is 12-17% less costly than other geothermal projects or renewable technologies in Turkey over the project lifetime. As a baseload power source, it remains 12% more expensive than coal power in Turkey but provides potentially more stability to the system as it is not subject to price volatility for fuel inputs.

14 Derived from dividing 2013 installed capacity by estimate tender revenues of $442m on 11 fields from 2008-2011 (Harding-Newman 2014)

5.2.3 ACHIEVING RENEWABLE ENERGY TARGETS AND REDUCING CARBON EMISSIONS

The project contributed 13.2MW of installed capacity to Turkey's RE targets. Contributing to carbon emissions goals is more complex due to the high carbon content of some geothermal reservoirs in Turkey, as noted in Box 1. The capture of carbon dioxide as a byproduct of the geothermal heat extraction had been a feature of other projects in the region since 2010 (Future Camp 2011; South Pole 2011) where the gas was sold for use in industrial sites. **In Gümüşköy, carbon production has to date been predominantly used in local greenhouses to improve productivity** – an innovation that requires further scale-up as the market for carbon industrial use is limited in comparison to the potential for geothermal energy production.

5.3 Barriers to scale-up and replication

The relatively high level of current activity in the sector shows that there are significant strengths to the current geothermal power regime, particularly in promoting field development and construction of plants. Public sector action has provided the necessary data and information on resources; the necessary price incentive through the FiT; and the removal of foreign exchange and offtaker risks that encourages the private sector to participate. For their part, lenders and developers have demonstrated appetite to build their capacities and know-how in order to take advantage of opportunities.

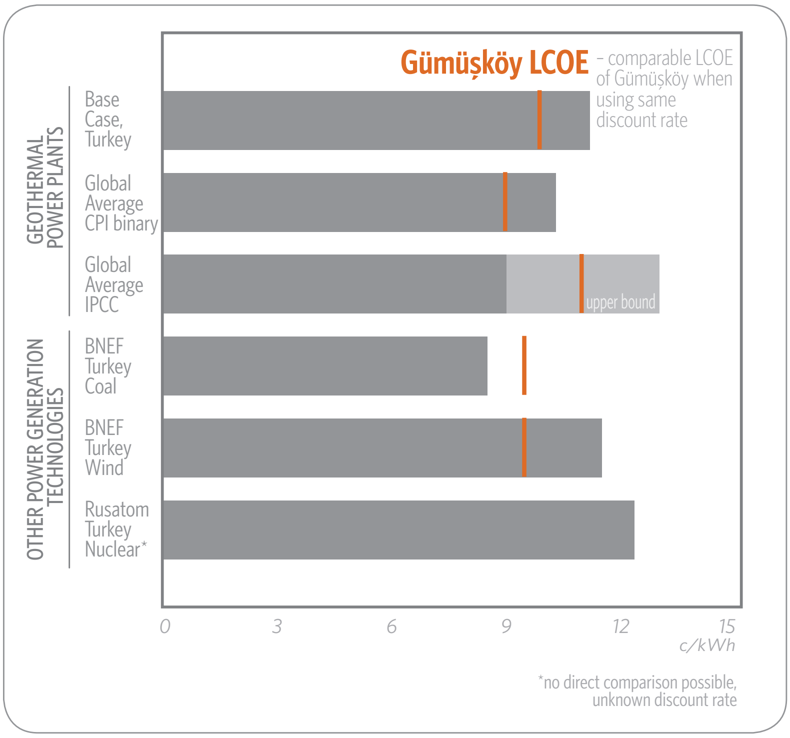
However, there remain barriers to maximizing the potential of geothermal electricity in Turkey. We focus on two main barriers: private sector exploration of unproven fields and management of non-condensable gases (NCGs) and present potential solutions to overcome them.

5.3.1 REMOVING BARRIERS TO PRIVATE SECTOR EXPLORATION

In 40 years of geothermal exploration activity, the public-private development model where the public sector developed fields for tender to the private sector, has resulted in 405MW of installed capacity. However, the potential of geothermal electricity generation in Turkey is over ten times this amount at 4.5GW. If this is to be reached by 2030, it will require an annual growth rate of 16% year-on-year.

Due to the overachievement of official government targets and the reduced activity by the government in drilling, the private sector is likely to take a greater role in exploring and proving potential geothermal fields for electricity generation than has been seen to date.

Figure 7: Competitiveness of Gümüşköy LCOE to other LCOE's experienced in other regions and technologies (Black & Veatch 2012; Micale et al 2014; BNEF 2014; World Nuclear Association 2014)



There are three potential solutions related to overcoming barriers to private sector pursuing exploration projects:

- **Increase private developers' access to finance:** Although the exploration costs in the case of Gümüşköy GPP were wholly borne by the developer due to their capacity development goals, such a model may not be replicable on a purely cost and risk basis for future projects or other developers. For example, few projects may have the resources to spend approximately 25% of total investment costs in equity financing before reaching financial close. Several models by multilateral development banks of providing contingent grants or soft loans for exploration costs are mooted (EBRD 2014). Based on the growth in the sector in recent years, some Turkish Banks are reviewing the possibility of offering finance for production drilling once adequate third-party assessments of feasibility and implementation has been carried out (CPI 2014).

- **Extend exploration to more regions in Turkey through centralized data-sharing:** Of geothermal field tenders awarded by MTA since 2008, 22% were on sites located in central Turkey and 8% in the East (MTA 2014). However, this does not take into account those tenders that attracted no bids of which a high proportion is estimated to be in these regions due to the lack of subsurface surveying or deep drilling data. A centralized data center between government agencies could provide the necessary information to assist the private sector in pursuing exploration at lower risks. This does not only include providing survey data on geothermal exploration but also hydro, oil, gas and mining information where data can be used for cross-purposes. The provision of any public grants or subsidies for exploration costs could be contingent on private developers feeding data into this centralized platform to enable greater exploitation of indigenous resources in Turkey.
- **Prevent and resolve costly disputes over ownership through centralized permitting and license-sharing:** At present, adhering to geothermal regulations for exploration and development set out in the Geothermal Law passed in 2007 requires developers to interact with three different authorities: at the provincial level local administration processes license applications; the General Directorate of Mining Affairs then confirms the exploration license; and finally the MTA carries out quality oversight and inspections. In the early years of the law's implementation, the level of coordination between authorities was poor resulting in a number of legal disputes (Serpen et al 2010; Yildizeli 2014). Some licenses were awarded without a conservative estimation on the effect it would have on existing reservoirs in the area. By as early as 2011, it was reported that over 3,200 exploration licenses had been awarded (Richter 2011). This has resulted in lawsuits between operators on adjacent sites competing for the same resource (Black & Veatch 2012; Yildizeli 2014). One authority to streamline permitting and oversight would decrease development times as well as offer a forum for operators with competing licenses to share exploration results and develop joint ventures for exploiting the electricity potential.

5.3.2 MANAGING CARBON EMISSIONS FROM NON-CONDENSABLE GASES

A scale-up of geothermal electricity would result in the need to manage the carbon content from non-condensable gases (NCGs) in geothermal fluids. Without the sequestration of carbon, estimates put the emissions profiles of new large scale developments at 0.84t CO_2/MWh. This is 39% greater than the average from all power production on the national grid (Atkins 2014), double the emission of combined-cycled gas power plants and not much below the 0.9-1t CO_2/MWh the IEA (2013) estimates for coal power plants. As many of Turkey's existing plants have been developed on reservoirs consisting of carbonate rocks such as marble, limestone, schist and quartzite, the potential that they could emit carbon is high (Aksoy et al 2015).

Project developers can minimize carbon leakage through the use of heat exchangers in binary systems that have the potential to re-inject geothermal fluids directly. In addition, developers can capture carbon as a byproduct for use in greenhouses and industrial sites as BM Holding did with Gümüşköy GPP.

The government has a key role to play here. By increasing coordination between different industries, it can ensure that waste materials from one industry are used in another thereby bringing down production costs across both. One way to achieve this could be grouping areas of geothermal development with greenhouse parks and industrial sites.

The geothermal sector in Turkey will require standardized methods to prevent carbon leakage, increased market demand for carbon as a byproduct for use, and the skills capacity to implement carbon management at geothermal sites to ensure continued support for the sector from international public finance, and depending on the national climate change strategy, also from national policy.

6. Conclusion

Gümüşköy GPP demonstrates that with the right incentive structure, the private sector is willing to bear the risks associated with the exploration and test drilling of geothermal sites.

The government policy framework and access to debt finance from the EBRD facilitated the project in the following ways:

- The 10-year FiT increased the certainty of project revenues for long enough to ensure payback of all investment costs and boosted the project's internal rate of return (IRR) on equity from 10-15%
- Access to EBRD financing decreased project costs, boosting equity IRR from 15-16%

The appetite of the developer to learn new skills and capacities played a major role in its willingness to take on the risks associated with early-stage geothermal exploration. As the local market for drilling services develops and capacities increase, it is likely that both the cost and time spent in resource confirmation by private actors will reduce significantly (Kaya 2012; IGA 2013; BM 2014b).

The availability of these newly developed skills and knowledge in drilling will allow other developers and lenders in Turkey to better understand and manage early-stage risks for geothermal projects. Ensuring access to this know-how in a timely and affordable manner will be key to replicating this purely private project development model.

6.1 Lessons for policymakers

The rapid growth in geothermal power plant developments in Turkey has shown the potential of this energy source in helping to meet the country's growing demand for energy. Once the appropriate incentives and regulations are put in place, geothermal energy's low operating costs and high capacity factor allow it to displace other baseload power sources with volatile fuel costs such as coal and gas.

This rapid growth is also an indication of the strength of Turkey's policy and regulatory environment (IGA 2013). To date Turkey's development model for geothermal has combined public and private actors in the project cycle with the government's General Directorate for Mineral Research and Exploration (MTA) playing an important role in confirming that geothermal fields are feasible for electricity production. However, for the geothermal sector to fulfill its full estimated potential of 4.5GW of installed capacity and meet 8% of overall demand in 2030 it is likely the private sector will need to play a larger role in exploration.

A number of issues must be addressed to stimulate the private sector to take on more early-stage risks.

- Greater disclosure and coordination on resources data once potential fields come out to tender may encourage more private operators to take risks (Black & Veatch 2012; BM 2014; Yildizeli 2014).
- If the encouragement of private exploration of unproven fields is a requirement for scale-up or cost reductions, then specific grants or subsidies may be necessary.

To be low-carbon, geothermal sector scale-up in Turkey will also need to meet challenges related to the capture and sequestration of carbon emissions. Without the sequestration of carbon, estimates put the emissions profiles of new large scale developments at 0.84t CO_2/kWh. This is 39% greater than the average from all power production on the national grid (Atkins 2014). Binary geothermal systems like the one used in Gümüşköy GPP are one solution as they can re-inject geothermal fluids directly, thereby minimizing the possibility of carbon leakage. The key role of the government will be to ensure coordination and capacity building, and to ensure that supply (geothermal plants) and demand (industrial gas, agriculture, foodstuffs) for carbon dioxide products are aligned. Low-cost carbon dioxide may also have possibilities as export products or may attract other industries to locate near geothermal regions.

6.2 Lessons for public finance providers

The MidSEFF facility proved to be an effective way of building the capacity of local commercial banks in geothermal project finance and should ensure greater availability of finance for geothermal projects that have reached the construction phase. The EBRD was able to partner with several local banks open to the possibility of lending to the geothermal sector.

Development Finance Institutions (DFIs) should be careful not to crowd out local commercial banks that have demonstrated an appetite to provide geothermal project finance. Tracking local bank's participation in lending would allow DFIs to focus their lending and resources for improving local banks' risk assessment capacities on those geothermal project stages (construction or exploration stage) where it is most needed.

Attracted by the growth in the sector in recent years, some Turkish banks are examining the possibility of offering finance for production drilling once adequate third-party assessments of feasibility and implementation have been carried out (CPI 2014). Public finance, through concessional funds or first-loss pools, may then focus more on reducing risks in the early exploration stages through guarantee, insurance or shared-costs models.[15]

DFIs may also consider directing geothermal lending to projects where sponsors have concrete processes to address the risk of carbon leakage in order to drive innovation and cost reductions in this area. Public finance providers may also offer support for demonstration projects that support the transportation of carbon from geothermal sites to industrial parks and industrial size greenhouses.

15 Analysis of these instruments will be the subject of the final paper in the program.

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Annexes

Annex 1 – Operational geothermal projects in Turkey by field

YEAR OF FIRST PLANT	FIELD NAME	MTA TENDER	DEVELOPER (ALL PRIVATE)	TOTAL INSTALLED CAPACITY (MW)	YEAR/UNITS/ INVESTMENT	UNDER CONSTRUCTION	TECHNOLOGY
1984	DENIZLI-KIZILDERE	Y	ZORLU ENERGY GROUP	75 MW	1984: 15 MW TEIAS 2013: 60 MW ZORDU	---	TRIPLE FLASH AND BINARY
2006	AYDIN-SALAVATLI	Y	MENDERES	53.4 MW	2006: 7.9MW DORA 1, 2010: 11.5MW DORA 2, 45M 2013: 34MW DORA 3, 68.3M	17 MW DORA 4	BINARY
2008	DENIZLI-SARAKOY	Y	BEREKET	7.3 MW	---	---	BINARY
2009	CANAKKALE-TUZLA	Y	ENDA	7.5 MW	---	---	BINARY
2010	GERMENCIK-OMERBEYLI	Y	GURIS GURMAT	47 MW	2010: 132.5M	123 MW, 970M	DOUBLE FLASH
2011	AYDIN-HIDIRBEYLI	Y	MAREN	66.5 MW	2011: 18.5MW IREM 2012: 24MW SINEM, 60M 2012: 24MW DENIZ,	24MW KEREM	BINARY
2013	AYDIN-GÜMÜŞKÖY	N	BM HOLDING	13.2 MW	2013: 6.6MW UNIT 1 2014: 6.6MW UNIT 2 (TOTAL 49.6M)	---	BINARY
2013	AYDIN-PAMUKOREN	Y	CELIKLER	45 MW	113 M	---	BINARY
---	AYDIN-SULTANHISAR	Y	CELIKLER	---	---	11 MW	---
---	KUTAHYA-SAPHANE	Y	ORYA	---	---	24 MW	---
---	MANISA-ALASEHIR	Y	ZORLU ENERGY GROUP	---	---	45 MW	---
---	MANISA-ALASEHIR	Y	TURKERLER	---	---	24 MW	---