CLIMATE POLICY INITIATIVE

Lessons on the Role of Public Finance in Deploying Geothermal Energy in Developing Countries

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Descriptors

Sector	Geothermal, Renewable Energy, Climate Finance
Region	Global
Keywords	Geothermal, Public and Private finance, Exploration Risks, Binary, Drilling;
Related CPI Reports	• The Role of Public Finance in Deploying Geothermal – Background Paper • Public Finance and Private Exploration in Geothermal: Gümüşköy Case Study, Turkey • Using Public Finance to Attract Private Investment in Geothermal: Olkaria III Case Study, Kenya • Using Private Finance to Accelerate Geothermal Deployment: Sarulla Geothermal Power Plant, Indonesia
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About CPI

Climate Policy Initiative 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 has the potential to provide significant amounts of low-carbon, low-cost electricity in many developing countries. It is broadly cost competitive with fossil fuel alternatives across the world and is the cheapest source of available power in some developing countries with rapidly growing energy demand. It can also provide a clean, reliable and flexible power source that could directly replace coal or gas in the electricity mix and complement higher penetrations of other, intermittent, renewable sources on the grid.

Over the last year, CPI has conducted analysis on behalf of the Climate Investment Funds with the aim of helping policymakers and development finance institutions understand which policy and financing tools to use in order to enable fast and cost-effective deployment of geothermal for electricity. The research involved high-level dialogues between public and private sector stakeholders to share findings and promote discussion, and three case studies on geothermal projects in Turkey, Kenya and Indonesia.[1] The projects studied varied in size (ranging from 13MW to 330MW – the largest in the world), and in terms of the public-private development models used.

With the right policies and financial measures, governments can drive investment that delivers the same amount of geothermal power while providing just 15-35% of the financial resources they would have spent had they built and operated projects themselves

Our case studies show that the increase in tariffs needed to provide sufficient returns to incentivize private investment can be entirely offset by public measures addressing specific risks. As a result, by enabling private investment, governments can achieve the same amount of electricity generation while providing only 15-35% of the financial resources they would have spent had they built and operated projects themselves**.**

In our three case studies we also observed:

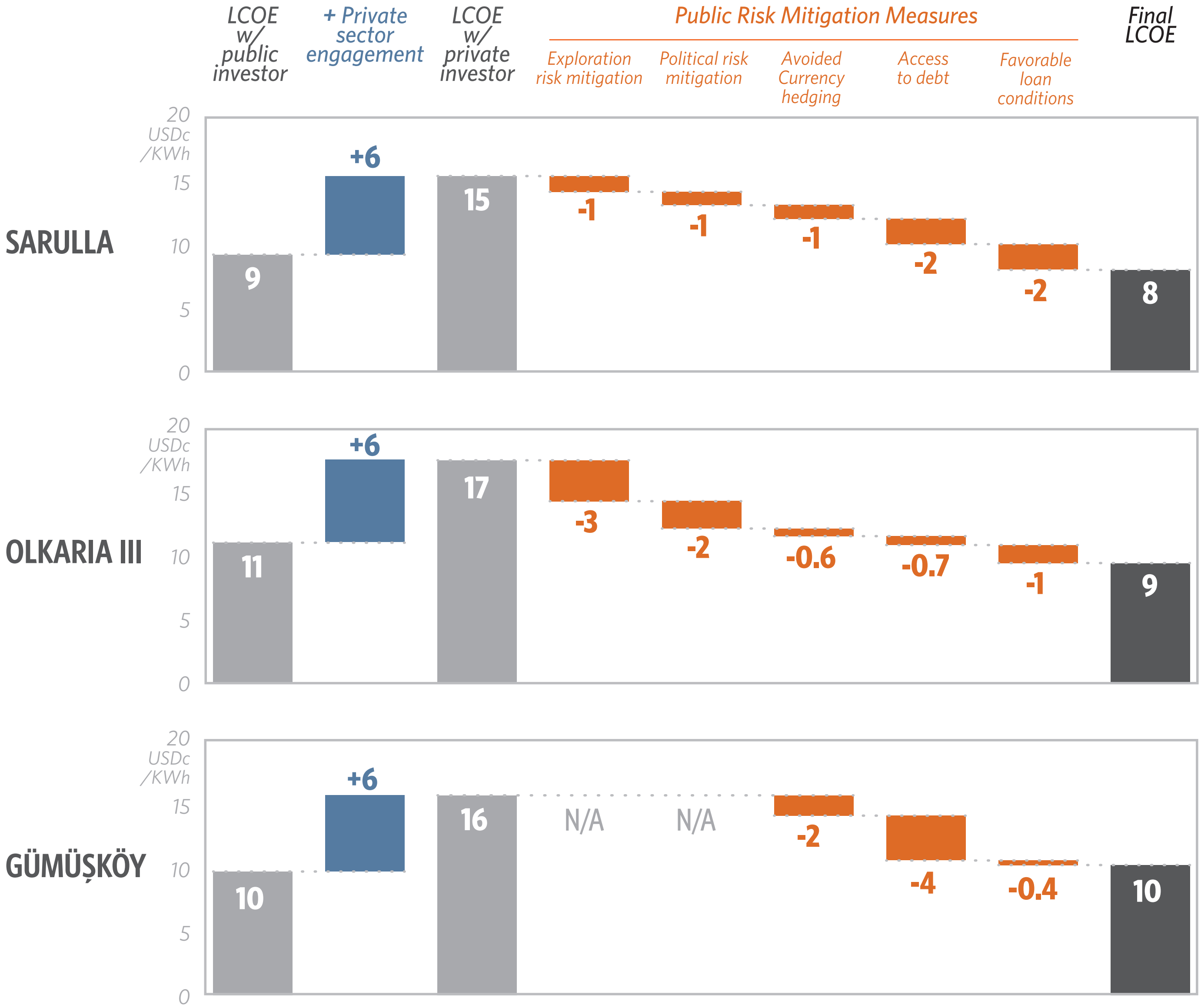
- The private sector's requirements for higher returns can lead to increased levelized cost of electricity (LCOE), and could require a tariff increase of more than 60% if the private investor were to bear all project-related risks
- LCOEs were reduced by 35-48% due to a combination of public policy and finance measures that mitigated specific risks such as resource exploration, political instability and currency fluctuation, and provided access to longer-term, lower-cost debt than available on the commercial market. Reductions in the LCOE varied depending on the amount of risk that the private sector was comfortable taking on.
- The savings that the public sector made by engaging the private sector freed up resources to invest in additional projects to scale up the sector.

We estimate that public finance for geothermal needs to increase 7-10 fold (from USD 7.4 billion currently to USD 56-73 billion) in order to drive enough private investment to meet developing countries' deployment targets of 23GW out to 2030. Governments and DFIs will need to provide 42-55% of the total additional financing of approximately USD 133 billion in the form of low-cost, long-term loans and equity for exploration, drilling, steamfield development and power plant construction. Most of this public finance is needed in countries with some experience with geothermal but challenging private investment markets such as Indonesia and Kenya.

We have identified the following recommendations for policymakers and development finance providers aiming to drive private investment in geothermal deployment.

1 Links to case studies and dialogues are available in the references section (CPI-CIF 2014, 2015a,b; Micale, Trabacchi & Boni, 2015; Oliver & Stadelmann, 2015; Rakhmadi & Sutiyono 2015).

Figure ES-1: Tariff requirements for public and private investors, and contribution of individual public risk and cost mitigation measures



Recommendations for policymakers

- **Set ambitious deployment targets that recognize the potential of geothermal to contribute to stability in a future low carbon electricity system. Targets can act as a signal to international private developers, investors and technology providers.** Countries such as Kenya and Indonesia have set ambitious deployment targets but many others fail to recognize potential in policy plans.

- Feed-in tariffs (FiTs) should balance the need to reduce **private sector risks and incentivize investment while minimizing excessive costs to the public sector.** Monitoring available debt financing conditions and investment return requirements in the country can help governments to set FiTs at an appropriate level. Tariff floors may also be applied to take account of exploration costs to developers.

- **Facilitate centralized data-sharing on geothermal resources between public agencies and fee-paying private developers through a closed database system to reduce exploration risks.** In markets starting to exploit geothermal for the first time, accurate survey data can help attract developers. Once governments start to offer concessions for private exploration, a centralized system can also help identify resource overlaps between fields and prevent costly and lengthy legal disputes on ownership (Çıngıloğlu, 2015; Oliver & Stadelmann, 2015)

Recommendations for development finance institutions

- **Increase both concessional finance and grant support.** Until recent years, much development finance was provided in the form of concessional loans for commercial drilling operations and power plant construction (Audinet & Fridriksson 2015). Developing countries will need more of this finance if they are to meet deployment targets of 23GW by 2030, particularly in countries with high costs of debt finance. In these countries, concessional loans can reduce the power tariff by up to 25%.
- **Continue to rebalance support towards earlier, riskier stages of project development. DFIs** have made significant efforts to shift the distribution of their finance from the construction stage to the early stages of project development and they now account for 11% of commitments. But such commitment should increase to 17% of public finance distributed, The Climate Investment Funds (CIF) have provided up to 55% of public finance currently flowing to the earliest, riskier stages of geothermal projects. With the future of the CIF uncertain, such funds need to be replicated and scaled up in a coordinated manner with other DFIs to maximize private investment.
- **Develop standardized political risk guarantees and partial-risk guarantees in exchange for letters of credit from host-country governments.** Guarantees have played an important role in projects financed by the private sector, however, they do not represent a significant portion of current amount of finance allocated to geothermal by DFIs. DFIs could coordinate on replicable and timely provision of political and off-taker risk guarantees that are specific for geothermal.
- **Consider directing support to countries where geothermal has the greatest potential to increase energy supply at low cost and can achieve most emissions reductions.** In Papua New Guinea and countries along the East African Rift Valley including Kenya, geothermal has the potential to significantly reduce emissions and make a major contribution to the national energy system. In Indonesia, geothermal development has the potential to reduce emissions very significantly (54MtCO_2e/year). Carbon leakage risks that may be prevalent in some locations (e.g. Eastern Turkey) where the carbon content of non-condensable gases in geothermal fluids are high should be taken into account and may be also be mitigated through technology choices.

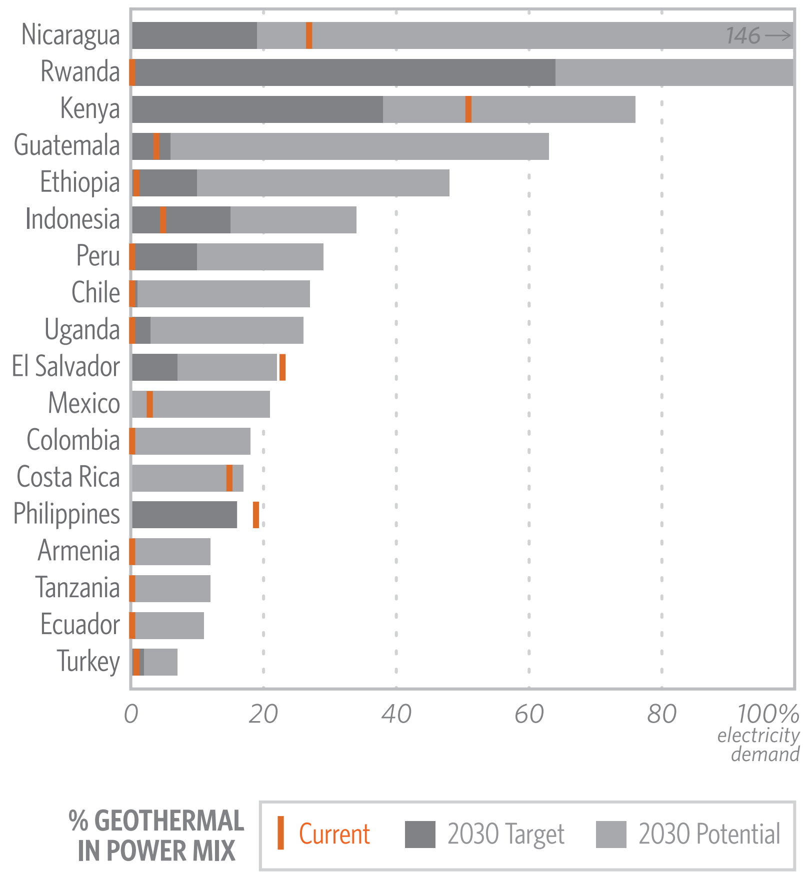
CONTENTS

1. Introduction

Geothermal energy has the potential to provide significant amounts of low-carbon, low-cost electricity in many developing countries. It can provide a clean, baseload and flexible power source that could directly replace coal or gas in the electricity mix and optimize the use of other, intermittent, renewable sources on the grid.

Moreover, even without a carbon price, geothermal energy is broadly cost competitive with fossil fuel alternatives. The levelized cost of geothermal electricity is around 9-13 USDc/kWh, making it one of the cheapest energy options available compared to gas and coal-fired power which ranges 7-15 USDc/kWh (IPCC 2014; Micale et al, 2014).

Figure 1: The potential role of geothermal energy: current, targeted and theoretical potential share of geothermal energy in electricity demand



Source: CPI analysis based on EIA 2015, IGA 2015, REN21 2015, Bertani 2015, IRENA 2015, CIF 2015. Current shares may be more than projected shares due to increases in overall electricity demand.

Developing countries, such as Kenya and Indonesia, that recognize the role geothermal can play in their future electricity mix have set ambitious geothermal deployment targets but there remains much potential unrecognized in other developing countries (Figure 1) The extent of the role geothermal can play depends on the potential in a given country. In 11 countries, theoretical potential could meet over 20% of 2030 electricity demand, if all resources were tapped.[2] In addition, Nicaragua, Rwanda and some small island states in the Caribbean, could generate more power than they need from geothermal allowing them to export power to regional markets.

Despite this potential, geothermal deployment in developing countries has been 3GW below expectations since 2010 (Bertani 2010 and 2015). A total of 3.15GW of power forecasted to be installed by 2015 is still in the ground. The largest share of this unrealized capacity is found in Indonesia and the Philippines, but new markets such as Chile and Ethiopia, where 195MW was expected to be installed by now, have also not performed as market analysts expected. In contrast, Turkey and Kenya exceeded forecasts by 280MW through a combination of solid regulatory frameworks and significant development finance support.

More pressure is on public investments in geothermal to achieve greater leverage from private finance. Many countries with geothermal resources have scarce public resources to invest in exploration and development and are pursuing policies to liberalize energy and electricity markets to attract private finance. Yet significant difficulties remain in attracting private finance for geothermal projects. Identifying and confirming geothermal resources suitable for electricity production is risky where global success ratios of wells drilled during the exploration phase are estimated at 50-59% (IFC, 2013b). Developers typically need to spend up to 40% of a project's overall costs before establishing a project's feasibility for certain (ESMAP 2012).

2 Developing countries listed reflect those with installed capacity, a geothermal specific target, or significant potential identified. Data is derived from estimates of theoretical potential which although unlikely to be fully developed, are more widely available than estimates of economic potential.

Most developing countries with geothermal resources have therefore relied on public sector agencies and companies to explore and confirm resources, while the private sector has participated in the development of power plants and the expansion of proven fields.

CPI conducted analysis on behalf of the Climate Investment Funds with the aim of helping policymakers and development finance institutions understand which policy and financing tools to use in order to enable fast and cost-effective deployment of geothermal for electricity. The research was conducted through a combination of three high-level dialogues between public and private sector stakeholders to share findings and promote discussion, and three case studies on geothermal projects in Turkey, Kenya and Indonesia.[3]

The case studies were diverse in size (ranging from 13MW to 330MW – the largest in the world), and in terms of the different public-private development models applied.

This report distills the lessons on two key analytical questions:[4]

- How can public finance meet geothermal power investment needs in the future and how should it be allocated?
- How do public measures from governments and development institutions help attract private investors for geothermal power and what effect do they have on the final tariff?

3 Links to case studies and dialogues are available in the references section (CPI-CIF 2014, 2015a, 2015b; Micale, Trabacchi & Boni, 2015; Oliver & Stadelmann, 2015; Rakhmadi & Sutiyono 2015).

4 This paper focuses on provision of public finance to help leverage private investment in geothermal. Other measures to enhance the scale-up of geothermal such as licensing procedures, technical capacity building, data-sharing, as well as dealing with carbon risks are noted but not elaborated on in detail. Further information on these areas is available in the case study reports.

2. Channeling public finance to reach geothermal targets in developing countries

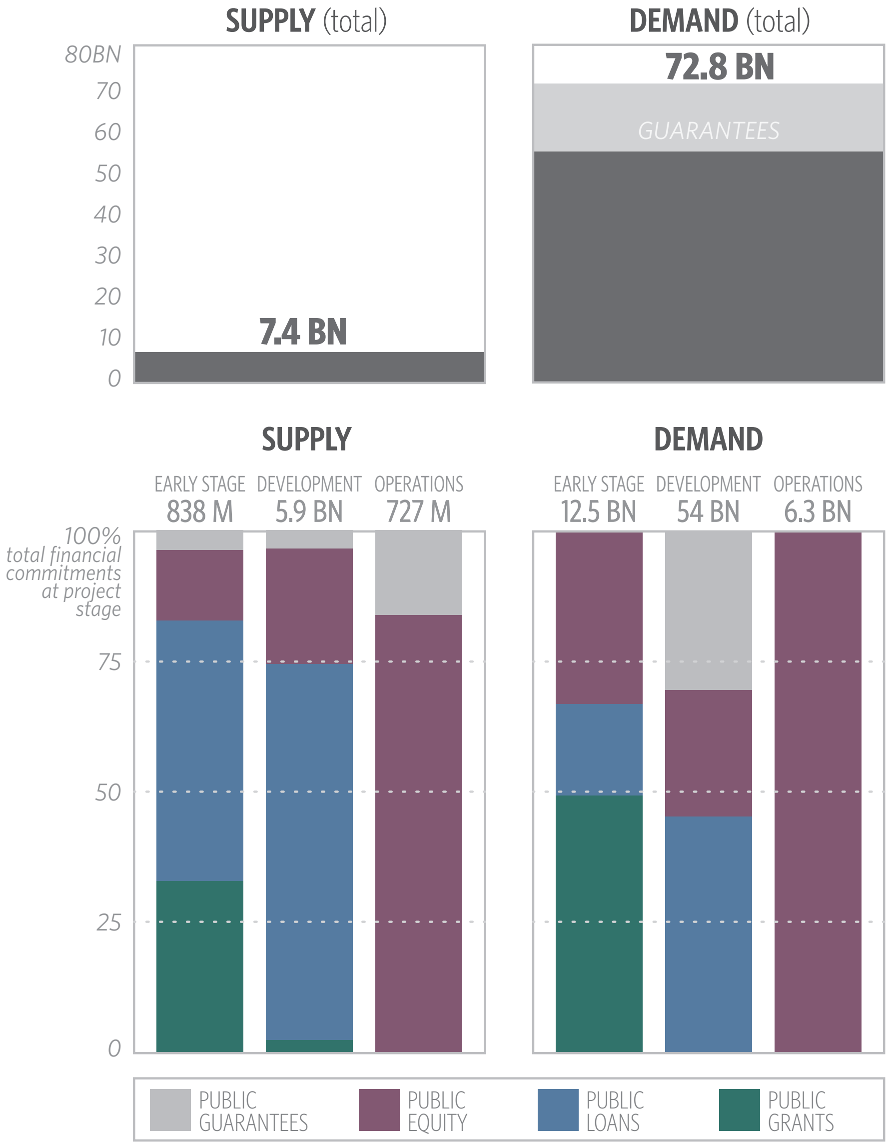
2.1 The investment gap: current supply and estimated demand of public finance to meet geothermal targets

We estimate that public finance currently flowing into geothermal projects needs to increase 7-10 fold (from USD 7.4 billion to 56-73 billion) to mobilize enough private finance to meet geothermal targets in developing countries. We estimate approximately USD 7.4bn in public finance is currently allocated to projects, programs and lending facilities for geothermal development in developing countries.[5] This is projected to mobilize USD 16.3bn of geothermal investment in total[6] with the participation of private developers and commercial banks.[7]

But in order to achieve deployment of another 23GW to meet policy targets, we estimate that total additional financing of approximately USD 133 billion is needed for geothermal in developing countries out to 2030.

Our analysis suggests that the public sector may need to commit 42-55% of this amount, USD 56-73 billion, to drive private investors to provide the rest. Based on analysis of the maturity of geothermal markets in developing countries and the investment environment for the private sector, we estimate where expected public finance instruments such as grants, public equity investment, guarantees and concessional loans could be needed in the future to cver risks at each project stage.[8]

Figure 2: The investment gap between the public finance currently provided and the public finance needed to reach geothermal targets in developing countries by instrument type



International development finance plays a substantial role in current supply of public finance, representing 5.4 billion or 73% of total public finance. The vast majority of this is debt finance with the remainder including different kinds of grants and guarantees. Public equity provided by publically-owned utilities and developers particularly in Kenya, Indonesia and Mexico represent the remaining 27%.

5 Our sample covers countries where projects/programs have reached financial close since 2009 including Armenia, Chile, Colombia, Costa Rica, Djibouti, Dominica, Ethiopia, Indonesia, Kenya, Mexico, Nicaragua, the Philippines, Tanzania, and Turkey. See Annex 2 for further information on programs and projects.

6 In order to estimate capital allocated to early, development or operations phases, we split the program/project amounts based on weightings from an indicative cost per MW of a typical geothermal project available in ESMAP 2012. In areas where aggregated amounts are assigned across instruments and domestic or international sources, the amount has been equally distributed.

7 25% private investment flows are expected to be sourced domestically and 22% internationally.

8 See Annex 1 for more details on demand estimates.

To drive enough private investment to meet developing countries' geothermal deployment targets, at least seven times more domestic and international public finance will be required than is currently available and a larger proportion of this finance will need to be allocated to the earlier riskier stages of geothermal projects.

Efforts have been made to broaden public finance toolkits to cover early-stage risks. DFIs support is focused on high-risk exploration activities through the form of grants, contingency grants,[9] and concessional loans,[10] mainly from the Climate Investment Funds, the World Bank, and other DFIs. This is evident in programs in Indonesia and Turkey. In recent years, new programs have begun to offer support either focused solely on overcoming early-stage risks (22% of projects and programs) or both early and development stages (42%). More specifically, provision of contingency grant financing for both exploratory and production drilling stages is growing through programs such as the Geothermal Risk Mitigation Facilities in East Africa and Latin America, and country-focused programs in Chile and Mexico. Drilling insurance mechanisms have not yet resulted in many projects receiving financing despite a pilot scheme undertaken in Turkey since 2011.

To meet deployment targets, we estimate that international development finance institutions (DFIs) will have to provide the biggest share of public finance (37-47%) in the form of loans in markets where costs of debt are high. Equity investments from governments will be the next most in-demand source of public finance (32-42%). The loans would be low-cost and long-term to lower the cost of capital for a project and support investment in the production drilling and construction phases. In countries with more challenging investment environments for the private sector, government agencies can also play an important role (32-42%) through steam supply services offered on a commercial basis to private developers, especially when they have years of experience in the geothermal sector (e.g. government agencies may develop their own resources as the Geothermal Development Company in Kenya does or contract out development work to the private sector while retaining ownership).

Grants or contingent grants from governments and DFIs could be used to cover the cost of preliminary surveys and surface exploration or to reduce exploration drilling risks for private developers. Insurance and guarantees could also be needed to back private equity and debt financing in countries with more challenging private investment environments, and could cover up to 23% of public investment needs.

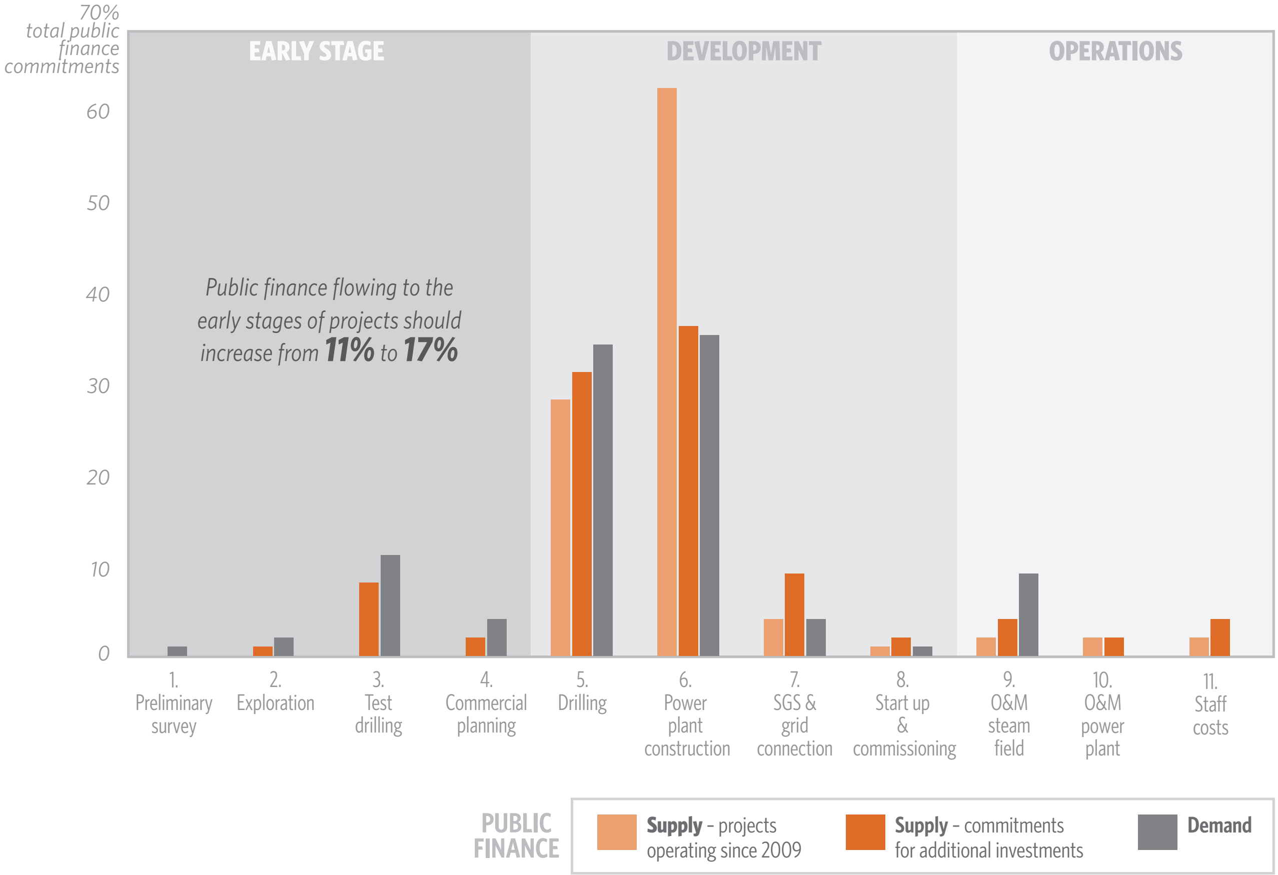
2.2 Scaling up and refocusing public finance flows to cover key geothermal risks

More efforts are needed to re-direct more public support to the earlier and riskier stages of project development. Figure 3 illustrates the significant progress made at the global level in shifting the distribution of public finance commitments from the construction stage to the early stages of project development. In projects commissioned since 2009, 95% of public finance has been in less risky development stages, in particular power plant construction. But, public finance flowing to the early stages of projects has grown from 1% in commissioned projects since 2009 to 11% or 838m in projects currently under development or active programs (stages 1-4). But this share should increase to up to 17% of public finance (USD 12.5bn) out to 2030 with a greater share going to the test drilling phase in particular. Part of current public finance could also be refocused on the management of resource risk during the later stages of project operations (stages 9-11 in Figure 3).

9 A contingency grant is partially repaid if activities are successful.

10 By which we mean lower-cost, longer-term loans than available commercially in the debt markets of particular countries.

Figure 3: Comparing the allocation of public finance across project phases in past and current geothermal projects and programs to the distribution of finance needed to meet developing countries' 2030 deployment targets



84% of commitments from international DFIs are focused on the capital intensive, but less risky development stage, mostly in countries with active private developers such as Turkey, or public utilities such as Costa Rica and Indonesia. The Climate Investment Funds (CIF) are instead relied upon as major source of finance for early-stage project exploration and development. CIF provide up to 55% of international development finance or USD 400m currently allocated to these stages (stages 1-4). Other providers include the World Bank, the German development bank, KfW, the EU-Africa Infrastructure Fund, and the Japanese International Cooperation Agency. With the future of the CIF uncertain, such providers will need to coordinate to pool available capital and increase funding to meet the USD 12.5bn required for early stages as identified in the previous section.

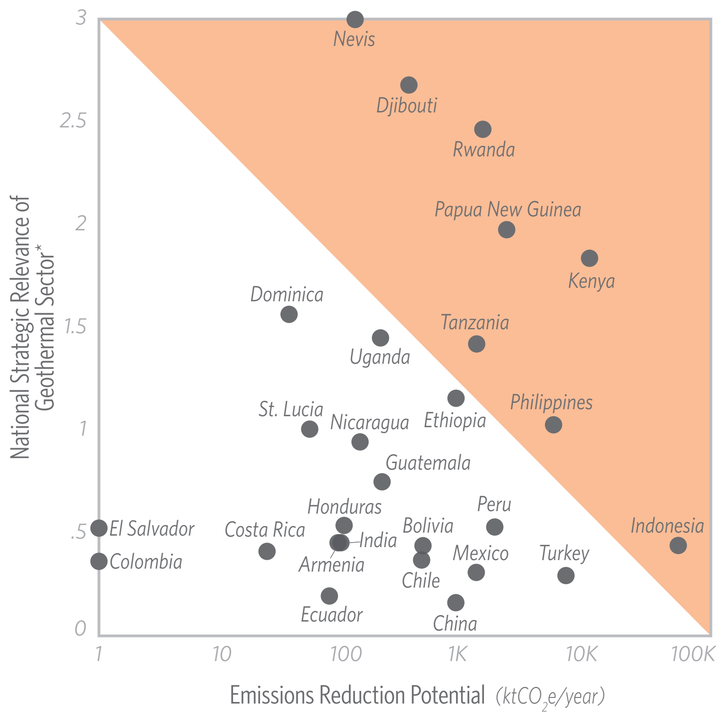
2.3 Directing international public finance to maximize emissions reductions and development impact

At a country level, we estimate that more than 80% of the public financing needed to meet geothermal targets may be required in countries with some geothermal experience but challenging private investment environments. Such countries, including Indonesia and Kenya, find it difficult to attract private investment due to political, macroeconomic or regulatory risks. The public sector may be required to step in to decrease key perceived risks to facilitate the participation of private investors, particularly in the production drilling and construction phases of the project.

As these countries account for the largest proportion of geothermal targets, this is where much of the public finance will need to be focused. The remaining share of public finance would be focused on countries across East Africa, Latin America and the Caribbean which have little geothermal experience and challenging investment environments. Countries with more developed banking sectors and relatively mature geothermal sectors, such as in Philippines and Turkey, should instead shift towards a more privately driven model in geothermal, with public intervention targeted mostly at exploration drilling risk technology-specific risks and related costs.

To speed up geothermal deployment, DFIs could strengthen support in those countries where geothermal has the greatest potential to increase energy supply at low cost and also achieve significant emissions reductions. In Papua New Guinea and countries along the East African Rift Valley, such as Kenya, geothermal has the potential to significantly reduce emissions and make a major contribution to the national energy system. In Indonesia, the development of the geothermal sector is likely to have a moderate impact on the already low 8 USDc/kWh electricity bill, and the population already enjoys relatively high levels of access to electricity, however geothermal development has the potential to reduce emissions very significantly (54MtCO2e/year).

Figure 4: Where development finance could focus support for the most impact



(*) The compound indicator "National strategic relevance of geothermal sector" is estimated by giving equal weighting to the impact of geothermal on the country-level electricity tariff (from various sources including Climatescope, 2014 and NREL, 2015), on the share of population without access to electricity (World Bank, 2015) and the potential weight of geothermal in the future energy mix (see chapter 1 for more information). Emission Reduction Potential is considered gross, it does not exclude site-specific emissions from non-condensable gases linked to some geothermal development activity. It is calculated from the potential additional electricity generation to achieve country targets, forecasts or planned projects. No targets, forecasts or planned projects are currently available for Colombia or El Salvador.

3. Lessons from our case studies on attracting private investment while reducing tariff costs

In our three in-depth case studies,[11] we examined the role public finance instruments play in driving private investment and the impact of private sector participation on the cost of electricity. These are illustrated in Figure 5.

Typically, private investors require greater returns on a project than a public investor because their costs of capital are greater and they have a profit-seeking motive. This can, in turn, put pressure on agreed electricity tariffs with utilities to cover the cost of these increased returns over the project lifetime. [12]

Our case studies show that the increase in tariffs needed to incentivize the involvement of private investors can be entirely offset by public measures addressing specific risks. As a result, by enabling private investment, governments can achieve the same amount of electricity generation while providing only 15-35% of the financial resources they would have spent had they built and operated the project themselves.

- We observe the private sector's requirements for higher returns can lead to increased levelized cost of electricity (LCOE), and in turn, to a tariff increase of more than 60% should the private investor bear all project-related risks
- In our three case studies, LCOEs were reduced by 35-48% due to a combination of public policy and finance measures that mitigated specific risks such as resource exploration, political instability and currency fluctuation, and access to longer-term, lower-cost debt than available on the commercial market. Reductions in the LCOE varied depending on the amount of risk that the private sector was comfortable to take on.[13]
- By enabling private investment in electricity generation while addressing project-specific risks such as currency fluctuations through dollar-denominated feed-in tariffs, and mitigating exploration risk, governments enabled deployment and kept tariffs low while committing just 15-35% of the financial resources that they would have spent had they developed and operated the projects themselves. These savings can then free up resources for additional projects and scale up the sector. [14]

Distilling our analysis, we have identified four ways for the public sector to help private developers to scale up flows for and reduce the cost of geothermal investment. They are:

1. Stable revenues over the project lifetime
2. Differentiated public support in the exploration phase
3. Access to favorable debt conditions to lower the cost of capital
4. Tailored risk mitigation tools and capacity building to unlock debt markets

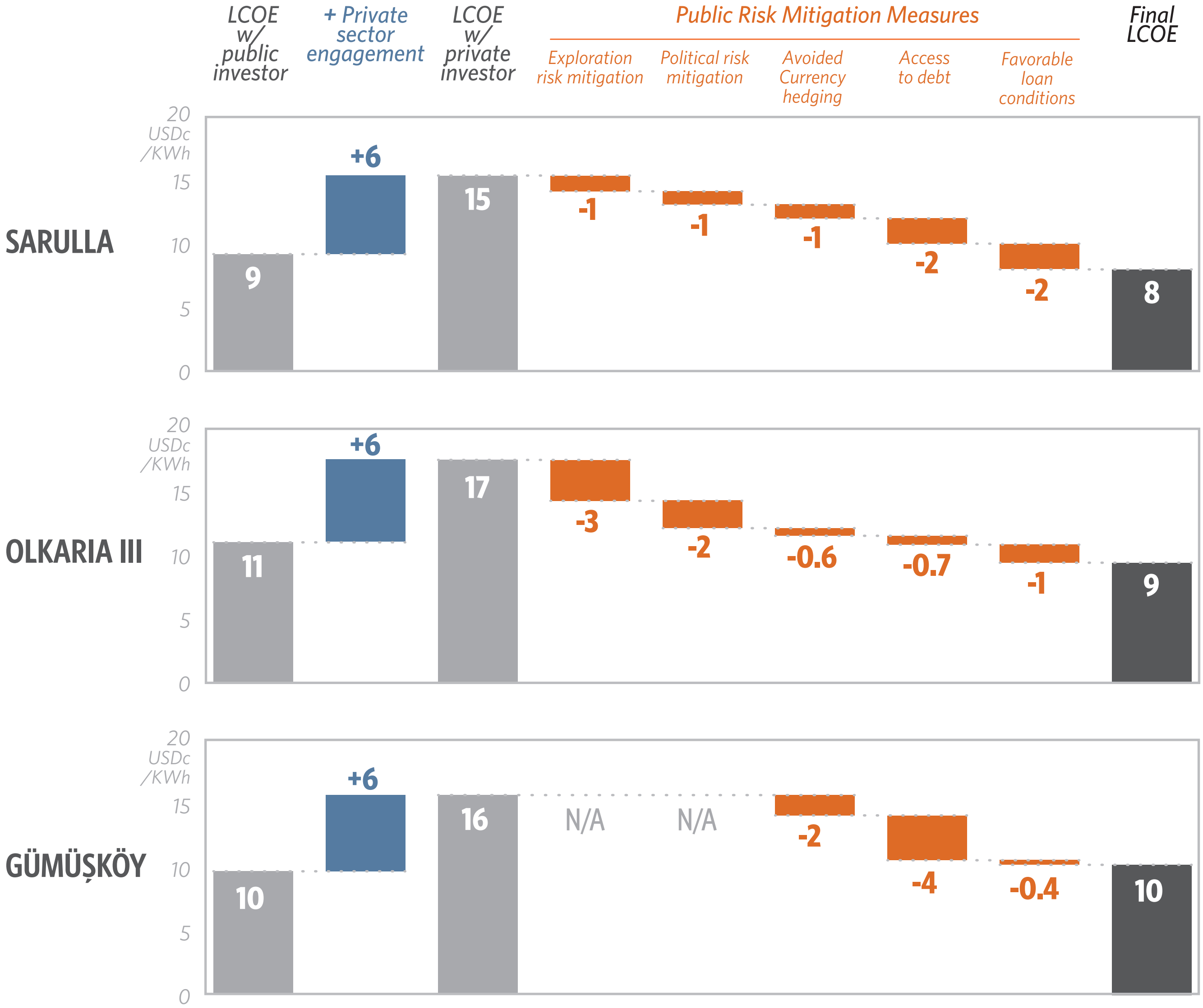
11 Oliver & Stadelmann, 2015; Micale, Trabacchi & Boni, 2015; Rakhmadi & Sutiyono, 2015.

12 In many contexts, the public off-taker is forced by the governments to offer social tariffs, often lower than they are required to pay for the cost of generation. Costs are then borne by the off-taker itself. We estimate that equity IRR requirements for developers engaged in the geothermal sector and bearing all project related risks range from 16% observed in lower risk countries like Turkey, to 18-24% observed in countries with higher perceived political risk like Kenya. We assume that the public sector/government only requires the project to generate enough returns to cover its borrowing costs, corresponding to the yields of local currency long-term bonds. Country-level yields are based on recent issuances (ranging from 6.6-8.25% in Indonesia, to 11-12.5% in Kenya). Such estimates for public return requirements, purely based on financing requirements, are however conservative as they do not reflect opportunity costs normally associated with public investment.

13 In Gümüşköy, the developer took both exploration risks and political risks, which are either perceived lower or mitigated internally at a lower cost. Only 35% of the tariff costs need to be mitigated by the public sector, largely through access to debt, to reach a desired level of the tariff, a much lower effort than what is required for Olkaria III in Kenya and Sarulla in Indonesia, corresponding to 46% and 48% of tariff costs respectively.

14 Figure is derived from combining the costs of exploration risk mitigation and avoided currency hedging costs. It is important to note that levelized costs of electricity do not incorporate the costs of risk mitigation measures for the public sectors, so no statement on the overall economic costs of measures can be made. However, tariffs are an important measure to show the political viability of geothermal, as they reflect costs to rate payers and/or local utilities.

Figure 5: Tariff requirements for public and private investors, and contribution of individual public risk and cost mitigation measures



Note: CPI own elaborations based on project-specific financial models: we estimated tariff requirements using the LCOE of observed projects, discounted at each project's equity IRR. We then identified the impact of individual public risk and cost mitigation measures on the tariff based on the sequence that such measures follow along the project development timeline. Access to debt implies the savings made due to leveraged commercial debt finance while favorable loan conditions implies the additional savings made related to debt, when more favorable rates and tenors are made available.

3.1 Provide stable and sufficient revenues over the project lifetime

Supportive regulatory frameworks and a feed-in tariff (FiT) aligned as much as possible with the lifetime of the project, and/or its financial payback, can allow private developers to manage financing risks in geothermal projects.

- **As in other renewable energy sectors, supportive regulatory frameworks for geothermal are the basic condition for growth.** In Kenya, deployment of geothermal capacity has increased following the introduction of a supportive regulatory framework that includes a 20-year Feed-in-Tariff, a zero-rated (0%) import duty, removal of Value-Added Tax (VAT) on geothermal equipment, and the creation of the Geothermal Development Company (GDC) to carry out the early exploration and development stages of the project. In Turkey, geothermal deployment took off when a dedicated geothermal tariff was introduced, which complemented a streamlined licensing regime.
- **FiTs can also help attract the private sector as long as it is aligned with the project's lifetime or available loan conditions in the local debt market.** FiT design should aim to strike a balance between the specific needs of developers and the payback of loans commercially available on local financial

markets on the one hand and the ability of the public sector to manage excessive costs on the other. In challenging private investment environments like Indonesia and Kenya, governments use long-term tariffs aligned with the project's lifetime. In Kenya the tariff is 8.8 USDc/kWh, and it lasts 20 years, allowing for renegotiation. In Indonesia, regulation provides for a mandatory offtake by PLN (state-owned electricity company) that can cover up to 30 years with a tariff that ranges between 11.8-29.6 USDc/kWh depending on year of commission and location. In more developed private markets like Turkey, on the contrary, the FiT is 28% higher than market rates with a shorter 10-year timeline. Such a structure ensures a payback of investment costs within eight years, in alignment with the tenor of private commercial loans available in the market, while meeting expected equity returns of 16%, similar to other geothermal projects in Turkey.[15]

- **FiT design can also shift revenue risks considered most critical by the private sector to the public sector.** All FiTs in Turkey, Indonesia and Kenya are denominated in USD, removing the risk that devaluation in a local currency will reduce returns for private investors and jeopardise repayments to lenders, while avoiding potential increases in the tariff by up to 10% (see Figure 5). In Kenya, the power purchase agreement (PPA) of Olkaria III also shifted other operational risks to the Kenyan government by including: 1) Partial adjustments to the agreed tariff according to inflation in the Consumer Price Index in order to compensate the escalation of operation costs and related maintenance costs; 2) A relief formula that guarantees capacity payments even if the plant should produce less power because of resource degradation due to force majeure. To keep the burden on public balance sheets and payment default risks as low as possible, transfer of risks to public off-takers should focus only on key risks for the private sector.

15 Under current Turkish policy, projects operational after 2020 would not be eligible for the FIT. This has not translated into a slowdown in project development to date but may deter new private investments (Çıngıloğlu, 2015).

3.2 Provide different kinds of public support in the exploration phase depending on the country context

Our case study analysis indicates that for geothermal projects, the exploration phase is the most challenging for investment, but country contexts differ and require different levels of support:

- **For markets with challenging private investment environments, early public exploration and tendering of proven fields can be critical for attracting private investment.** In Kenya with Olkaria III the government provided the private developer with a proven field and exploratory data during the tender process.[16] Indonesia could also benefit from early public exploration to attract more private investment. The experience in Sarulla suggests that private sector appetite increases when it gains access to proven fields as the developer paid a substantial amount to compensate for previous exploration works.[17] Measures such as provision of data and test wells increased the profitability of the Olkaria III and Sarulla plants and were crucial to private investors' decision to pursue these projects. In many developing countries identified in section 2, governments and DFIs will continue to play an important role in financing such exploration.
- **In more mature markets where the private sector has capacity to manage the relevant risks, critical survey data can help attract investors.** In Turkey, engaging the private sector earlier in the exploration phase proved that this development model can be a viable option to scale-up deployment. Conducting their own exploration did not prevent the developers of the Gümüşköy geothermal power plant (GPP) from providing a levelised cost of electricity 12-17% cheaper than comparable geothermal plants globally and other power sources in Turkey. Further, the developer expects to halve the time and costs spent on exploration and drilling in the future thanks to the experience gained. Accurate initial survey data from government agencies are critical to

16 The government provided the developer with wells and exploration data for the Olkaria III field from work carried out in the nineties.

17 Unocal North Sumatera Geothermal (UNSG) undertook exploration and test drilling in the mid-nineties, but later sold its rights to the government after the Asian Financial Crisis. The Sarulla project was only retendered to the current developer in 2006.

support the exploration phase of developers, who can use them as a starting point for their exploration drilling activities. Data-sharing among government-sponsored drilling activities including from other sectors, such as oil & gas, minerals and metals, can also help to engage the private sector in early exploration of the field. Such approaches will be particularly useful in similar markets such as Mexico and the Philippines.

- **Private models for exploration may require higher tariff levels to reflect the risk-adjusted return requirements of the developer.** Private-led models internalize the costs of exploration risk management, making this cost transparent in the tariff (see figure 5). Such costs may include the cost of drilling, or the cost of steam purchased from a third party performing the exploration drilling (e.g. GDC), and/or the costs for insuring the drilling activities. The true cost of exploring, confirming and managing geothermal resources add on to the price tag compared to 'free' wind and solar resources or even other fossil fuels. For example, the cost of exploring and mining coal, gas or oil resources are rarely internalized in the financial model of a single power plant, as may be expected in the case of geothermal power, where the plant must be located to the resource and sometimes in remote locations. In Kenya, for example, in the case of Olkaria III, we estimate that, without previous drilling activities of KenGen, the project's expected equity returns would be insufficient to incentivise the private developer to invest in exploration without an 18% tariff increase. Without a reflection of such costs, geothermal would be less competitive. Indonesia has a tariff ceiling ranging from 11.8 to 29.6 USD cents per kWh to allow for flexibility, depending on the location and whether the geothermal resource covered by the concession is proven or not.

3.3 Provide longer-term, lower-cost debt to bring down the cost of capital

- **Geothermal development requires significant upfront investment, so access to debt financing is critical to free equity resources for further development of new or existing fields.** In Kenya, in the case of Olkaria III, DFIs refinancing of Ormat's initial equity investment freed additional equity resources for the subsequent development phases of the project; debt financing now totals 85% of the investment costs. In Gümüşköy GPP in Turkey, debt financing of up to 75% of the total project provided by European Bank for Reconstruction and Development (EBRD) through a credit line extended to local bank, Yapikredi, came in when the developer was ready to build the first 6MW power plant. It then allowed the developer to reinvest in drilling for the second 6MW plant while applying the lessons it had learnt.
- **Favorable loan conditions can lead to a 25% reduction in the tariff, by far the most important factor in lowering costs. This is particularly critical in certain country contexts with high costs of capital (e.g. Kenya and Indonesia) to ensure the projects' financial viability.** In Kenya, loans provided and arranged by DFIs for Olkaria III were unmatched in the local commercial market,[18] with a 10-to-19-year tenor and estimated 6.2% interest rate. Similarly in Indonesia, the Sarulla project benefitted from a 20-year tenor, unusual in Indonesia where most corporate debts are issued with a tenor of 10 years or less, while corporate bonds have an average tenor of 5 years. In both cases, the availability of longer-term debt with lower interest rates improved expected returns by as much as four percentage points, making the projects a more attractive investments and economically viable.

18 At the time when loans were provided, average commercial rates for infrastructure investment in Kenya were around 15% (Central Bank of Kenya, 2015), and tenors no longer than 5 years.

Table 1: Impact of loan conditions on project equity IRRs

	AFTER TAX EQUITY IRR	WITHOUT FAVOURABLE LOAN TERMS
SARULLA INDONESIA	14-16%*	10-12%
OLKARIA III KENYA	16%	12%
GÜMÜŞKÖY TURKEY	16%	15%

(*) range based on geothermal projects in Indonesia, comparable with the project's IRR.

3.4 Use risk mitigation tools and capacity building to unlock debt markets and de-risk investment

Other specific risks can exist in developing countries such as off-taker risks, political risks, and unfamiliarity with geothermal as a technology. These can further inhibit the provision of debt finance. These risks are magnified for the equity investor (private developer) because they have to finance up to 40% of investment themselves before debt finance is accessible.[19] Governments and DFIs can deploy tailored risk mitigation measures to enable projects to more easily access financing. These measures could be important tools for scaling up geothermal deployment in a given country.

- **Government guarantees for contractual off-take obligations seem to be crucial to accessing debt finance in contexts with significant off-taker risk.** This is particularly true where power off-takers are state-owned electricity companies often legally obliged to provide subsidized tariffs to the end consumers. Olkaria III in Kenya, for example, was for a long time financed by equity, and only a security package[20] provided by the Government of Kenya backing the off-taker (Kenya Power and Lighting Company - KPLC) and attached to the PPA was able to address public off-taker risk enough to finally unlock debt financing and bring the project to completion. Similarly, in Sarulla in Indonesia the government provided a 20-year BVGL (Business Viability Guarantee Letter), through which the government provides guarantees on the off-taker's (Perusahaan Listrik Negara - PLN) abilities to service its financial obligation, was crucial in unlocking debt finance.
- **DFIs' political risk mitigation tools can further lower the cost of capital, unlock additional capital, and reduce tariff requirements by up to 12%.** In Kenya, Olkaria III's project developer Ormat benefitted from Multilateral Investment Guarantee Agency's (MIGA) Political Risk Insurance (PRI). The PRI provides coverage against restrictions on money transfers, expropriation, war and civil disturbance, for both current investment amounts and standby amounts. Return requirements for the private sector in Kenya are usually in the range of 18-23% but the PRI helped lower requirements for Olkaria III to around 16%. Similarly, in Sarulla the participation in the project of a pool of development banks mitigated the developer's perceived risk sufficiently for them to accept a 2% lower equity return (Table 1). In addition, a political risk guarantee[21] provided by the Japan Bank for International Cooperation (the largest public lender in the project) to private lenders covered the full amount of their loans, and impacted the rates and tenors they provided to the project.

19 In Olkaria III, project developer Ormat's equity commitment lasted 10 years before financial close covering the first 48 MW of the plant. In Turkey, BM Holding invested up to USD 12m (24% of the total investment costs of Gümüşköy GPP) in exploration and development prior to financial close. This is due to remaining high perceived risks linked with resource availability which, combined with country risk, limit the ability of attracting debt finance at this stage.

20 The main elements of the security package were a Letter of credit (LC) from the off-taker Kenya Power (KPLC) and a Letter of Comfort from the Government of Kenya.

21 The Japan Bank for International Cooperation's (JBIC) political risk guarantee covers war, expropriation, change of law and non-payment of the tariff by the Government of Indonesia.

- **DFIs can increase the technical capacity of private lenders as well as developers and service providers that will allow more private debt to the field development stage of geothermal projects.** In Turkey, channeling long-term, low-cost debt from a credit line provided by the European Bank for Reconstruction and Development (EBRD), proved to be an effective way of building the capacity of a local private lender in geothermal project finance. 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. Lenders are also comforted if developers and service providers receive technical assistance and capacity building through DFI programs.
- **Carbon leakage risks may also be mitigated through technology choices.** Some geothermal resource consist of reservoirs where the carbon content of non-condensable gases (NCGs) in the geothermal fluids are high, for instance, in Eastern Turkey. Without capture and sequestration, the potential greenhouse gas emissions impact of a scale up of the sector could be significant (Oliver & Stadelmann 2015). Certain technology choices can reduce the risk of leakage and carbon may be captured and produced as a byproduct for use in greenhouses and industrial sites provided the market is large enough.

4. Conclusions

Scaling up geothermal electricity particularly in developing countries is challenging in the context of modern energy markets. Geothermal energy can provide many important benefits to power systems as a clean source of stable and flexible electricity that can complement the output of other intermittent sources. However, the risks associated with the exploration and drilling necessary to prove that geothermal resources can feasibly provide power are a major barrier to investment. Exploring, confirming and managing geothermal resources add to its cost compared to 'free' wind and solar resources and even for fossil fuels, the cost of exploring and mining coal, gas or oil resources are rarely internalized in the financial model of a single power plant, as may be expected in the case of geothermal power where the plant must be located close to the resource and sometimes in remote locations. Despite this, geothermal still provides one of the cheapest sources of power available in many countries around the world.

The response of government policy makers in developing countries with more successful geothermal deployment has been to establish stable regulatory frameworks and appropriate pricing or fiscal incentives. The majority of countries also rely on public agencies to carry out, or public funds to finance, surface surveys and exploration drilling in order to attract private developers. However, public funds are limited and, given the USD 133 billion we estimate will be needed to meet developing countries' geothermal deployment targets over the next fifteen years, deploying the right instruments and risk mitigation tools to cost-effectively drive increased private investment is critical. We have identified the following key recommendations for policymakers and development finance providers looking to achieve this.

4.1 Recommendations for policymakers

- **Set ambitious deployment targets that recognize the potential of geothermal to contribute to stability in a future low carbon electricity system. Targets can act as a signal to international private developers, investors and technology providers.** Countries such as Kenya and Indonesia have set ambitious deployment targets but much potential remains unrecognized in policy plans.
- **Feed-in tariffs should balance the need to reduce private sector risks and incentivize investment while minimizing excessive costs to the public sector.** Monitoring available debt financing conditions and investment return requirements in the country can help to set FiTs at an appropriate level. Tariff floors and ceilings may also be applied to take account of exploration costs to developers.
- **Facilitate centralized data-sharing on geothermal resources between public agencies and fee-paying private developers through a closed database system to reduce exploration risks.** In markets starting to exploit geothermal for the first time, accurate survey data can help attract developers. Once governments start to offer concessions for private exploration, a centralized system can also help identify resource overlaps between fields and prevent costly and lengthy legal disputes on ownership (Çıngıloğlu, 2015; Oliver & Stadelmann, 2015)

4.2 Recommendations for development finance institutions

- **Increase both concessional finance and grant support.** Until recent years, much development finance was provided in the form of concessional loans for commercial drilling operations and power plant construction (Audinet & Fridriksson 2015). Developing countries will need more of this finance if they are to meet deployment targets of 23GW out to 2030, particularly in countries with high costs of debt finance; concessional loans can reduce the tariff by up to 25%.
- **Continue to rebalance support towards earlier riskier stages of project development.** Significant improvements have been made at a global level to shift the distribution of commitments from the construction stage to the early stages of project development, which now accounts for 11% of current commitments. But such efforts should increase to up to 17% of public finance distributed), The Climate Investment Funds have provided up to 55% of public finance currently flowing to the earliest, riskier stages of geothermal projects.

With the future of the CIF uncertain, such pools need to be replicated and scaled up in a coordinated manner with other DFIs to maximize private investment.

- **Develop standardized political risk guarantees and partial-risk guarantees in exchange for letters of credit from host-country governments.** Guarantees have played an important role in projects financed by the private sector, however, they do not represent a significant portion of current amount of finance allocated to geothermal by DFIs. DFIs could coordinate on replicable and timely provision of political and off-taker risk guarantees that are specific for geothermal.
- **Consider directing support to countries where geothermal has the greatest potential to significantly increase energy supply at low cost and can achieve most emissions reductions.** In Papua New Guinea and countries along the East African Rift Valley including Kenya, geothermal has the potential to significantly reduce emissions and make a major contribution to the national energy system. In Indonesia, the development of the geothermal sector is likely to have a moderate impact on the already low 8 USDc/kWh electricity bill, and the population already enjoys relatively high levels of access to electricity, however geothermal development has the potential to reduce emissions very significantly (54MtCO2e/year).

Annex I: Indicative public and private financial needs in different country contexts

We estimate the total investment need out to 2030 based on country targets and plans as USD 133 billion by using the median cost estimate of each phase of project development for 50 MW geothermal plant (USDm/MW) provided by ESMAP (2012) and supplementing this with the weight of operational expenditure costs needed for 20 years for a plant operating with an 80% capacity factor (Micale et al, 2014).

Our figures for demand for finance seek to provide an indicative estimate of the breakdown of public and private finance needs by country and instrument. To achieve this, we first allocate developing countries into four country groups, classified according to:

- The maturity of a geothermal sector in a country estimated as a function of the geothermal capacity installed to date in the country. The threshold for a mature sector was set at 100 MW geothermal power installed (Bertani, 2015) after which a country will have moved from making geothermal land available for exploration, to gain enough experience with projects at later stage of development.
- The nature of the investment environment for the private sector: calculated as a function of country risk ratings (OECD, 2015), presence of private energy-related investment in the economy, and average lending interest rates in the years 2010-2014 (World Bank, 2015). Countries considered to have more developed private investment environments had to perform better than the average (across all countries considered) on all indicators combined (using equal weights for all indicators) and on at least two out of the three indicators considered individually.

We then consider the following categories of public instruments with specific assumptions on how they would be used for project stages in the four country classifications:

- Public equity: investment from domestic public agencies/utilities/developers; (this would be in the form of government equity as represented in the last transaction to a project. Such government equity may be financed indirectly by development finance assistance or may be delivered by private actors through public sector contracts, although the public sector retains ownership).
- Public loans: concessional or commercial loans from domestic or international development finance institutions;
- Public grants: direct grants, in-kind grants and contingent grants from domestic or international development finance institutions.
- Public guarantees: loan guarantees, political risk guarantees and insurance products covering private equity or debt investment in the project.

Our assumptions on sources of finance and instruments required derive from observed trends and discussions with geothermal stakeholders (CPI-CIF, 2014, 2015a and 2015b). They are qualitative midpoints of estimates designed to give an illustration of the extent and type of support needed and do not represent a forecast. More research would be required to make bottom-up estimates based on country contexts, sources of finance and instruments used to take account of the potential flows.

See table below for specific assumptions on instruments and the extent they would be applied in different country groupings as well as illustrations of results by country grouping and project stages in Figures 6 and 7. Where alternative options for financing may be pursued in different project stages, the midpoint between each option was used.

The following figures show how assumptions cited above impact on the assessment for public finance needs by country groups and by phase of geothermal project development.

Figure 6: Public financial requirements per country groups based on the maturity of investment environment of the geothermal sector

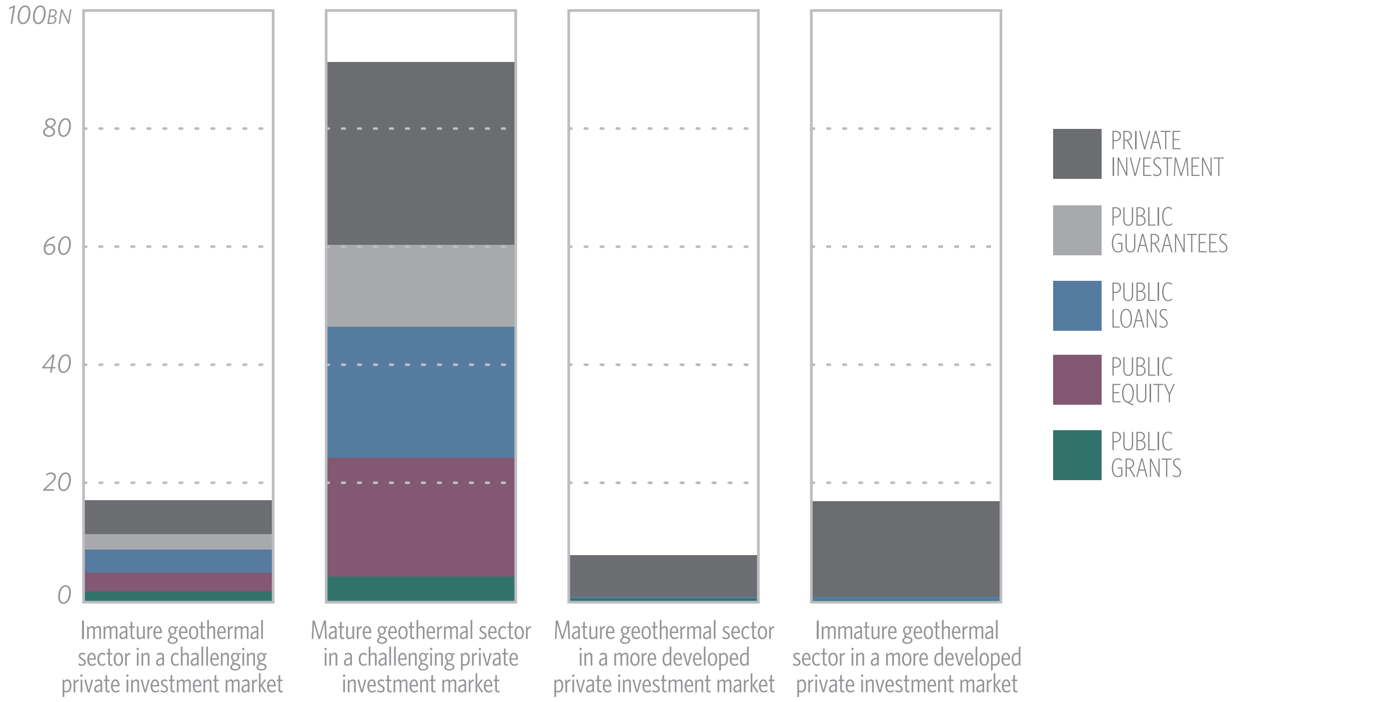
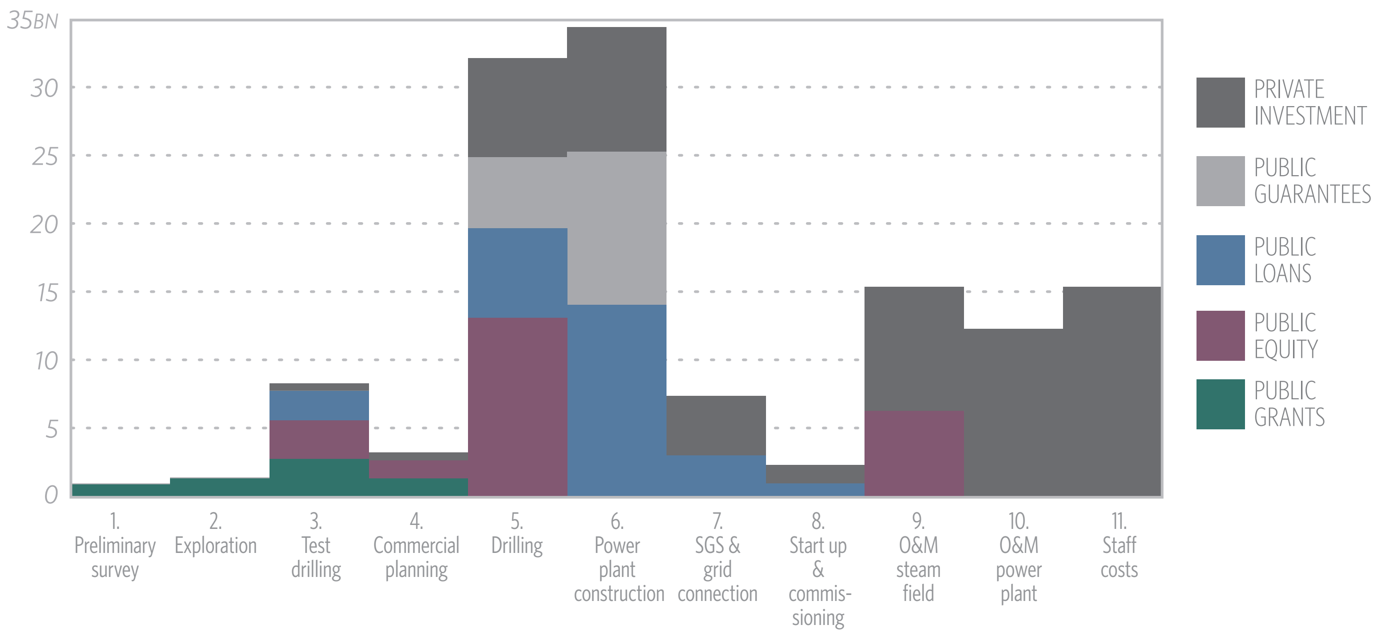


Figure 7: Public financial requirements per phase of geothermal project development



<table>
<tr><th>Inexperienced geothermal sector in a more developed private investment market</th><th>Mature geothermal sector in a more developed private investment market</th></tr>
<tr><td>Chile, China, India, Nevis, , Peru,</td><td>Mexico, Philippines, Turkey</td></tr>
<tr><td>– Preliminary surveys and surface exploration: Public grant entirely financing or co-financing preliminary surveys to incentivize private participation at earlier stages of exploration.
– Exploration drilling: DFIs channel public loans through local banks to support early investment in geothermal and transfer knowledge to banks, with contingent grants covering initial exploration risk (public loan and grant).
– Feasibility study and contracts: Privately driven (0% public involvement);
– Production drilling: Privately driven, using private loans and private insurances to address drilling risk (0% public involvement)
– Construction and commissioning: privately driven, using private loans markets (0% public involvement);
– Operations: privately driven (0% public involvement).</td><td>– Preliminary surveys and surface exploration: Private sector bearing costs. In some countries partial public co-finance via grant may still be important (public grant).
– Exploration drilling: DFIs channel public loans through local banks to support early investment in geothermal and transfer knowledge to banks (public loan covering share of investment);
– Feasibility study and contracts: Privately driven (0% public involvement);
– Production drilling: Privately driven, using private loans and private insurances to address drilling risk (0% public involvement)
– Construction and commissioning: privately driven, using private loans markets (0% public involvement);
– Operations: privately driven (0% public involvement).</td></tr>
<tr><th>Inexperienced geothermal sector in a challenging private investment market</th><th>Mature geothermal sector in a challenging private investment market</th></tr>
<tr><td>Armenia, Bolivia, Colombia, Djibouti, Dominica, Ecuador, Ethiopia, Guatemala, Honduras, Papua New Guinea, Rwanda, St. Lucia, Tanzania, Uganda</td><td>Costa Rica, El Salvador, Indonesia, Kenya, Nicaragua</td></tr>
<tr><td>– Preliminary surveys and surface exploration: the local public sector covers this phase (100% public in-kind grant);
– Exploration drilling: the local public sector covers this phase (100% public in-kind grant);
– Feasibility study and contracts: Public international companies support private sector in the design effective contracts (100% public finance either in the form of in-kind contribution or as a sale of services);
– Production drilling: public loans from DFIs to support investment in initial production drilling phase and lower cost of capital (public loan covering share of investment), with public guarantees provided for covering the remaining private portion of the investment (80% of guarantee assumed) / Alternatively, the local public sector bears entire production drilling risks and manages resource risk as part of its steam supply services to the private developer (100% public investment);
– Construction and commissioning: public loans from DFIs to facilitate participation of private lenders and lower cost of capital (public loan covering share of investment), with public guarantees provided for covering the remaining private portion of the investment (80% of guarantee assumed)
– Operations: May be privately driven (0% public involvement) or the public sector covers O&M costs as part of its steam supply services to the private developer (100% public finance assumed)</td><td>– Preliminary surveys and surface exploration: the local public sector covers this phase (100% public in-kind grant);
– Exploration drilling: DFIs provide public loans for the exploration drilling with contingent grants covering initial exploration risk (public loan and grant). / Alternatively, the local public sector bears entire exploration drilling risks and manages resource risk as part of its steam supply services to the private developer (100% of public investments)
– Feasibility study and contracts: Public international companies support private sector in the design effective contracts (100% public finance either in the form of in-kind contribution or as a sale of services)
– Production drilling: public loans from DFIs to support investment in initial production drilling phase and lower cost of capital (public loan covering share of investment), with public guarantees provided for covering the remaining private portion of the investment (80% of guarantee assumed) /Alternatively, the local public sector bears entire production drilling risks and manages resource risk as part of its steam supply services to the private developer (100% public investment);
– Construction and commissioning: public loans from DFIs to facilitate participation of private lenders and lower cost of capital (public loan covering share of investment), with public guarantees provided for covering the remaining private portion of the investment (80% of guarantee assumed);
– Operations: May be privately driven (0% public involvement); or the public sector covers O&M costs as part of its steam supply services to the private developer (100% public finance assumed)</td></tr>
</table>

Annex II: Geothermal Development Finance Programs

PROGRAM	REGION/ COUNTRY	PROGRAM TOTALS (USDM)	PROJECT STAGES		
			EARLY STAGE	DEVELOPMENT	OPERATIONS
Geothermal Clean Energy Investment Project	Indonesia	574.7	Y	Y	
Indonesia Geothermal Electricity Finance Program	Indonesia	2320	Y	Y	
Private Sector Geothermal Program	Indonesia	2600	Y		
Development of Olkaria VI GPP of 140MW	Kenya	500.5	Y	Y	Y
Ethiopia Geothermal Sector Development Project	Ethiopia	336.7	Y	Y	
Ethiopia Geothermal Sector strategy and regulations project	Ethiopia	1.5			
Geothermal Exploration Project	East Africa (multiple countries)	13	Y		
Geothermal Power Generation Project	Djibouti	31.23	Y		
Geothermal Risk Mitigation Facility	East Africa (multiple countries)	1315	Y		
Menengai Geothermal Development Project	Kenya	746	Y	Y	Y
UNEP-ARGeo	East Africa (multiple countries)	35.6	Y		
Geofund 2: Armenia Geothermal Project	Armenia	2.33	Y		
Geothermal Development Lending Facility	Turkey	327.4	Y	Y	
Geothermal Exploratory Drilling Project	Armenia	116.7	Y		
Turkey GeoFund	Turkey	9.7	Y	Y	
Catalytic Investments for geothermal	Colombia	2.7			
Geothermal Development Facility for Latin America	Latin America (multiple countries)	1075	Y		
Geothermal Financing and Risk Transfer Facility	Mexico	1146	Y	Y	
Geothermal Resource Development in Saint Lucia	St. Lucia	1.16	Y		
Geothermal Risk Mitigation Program (MIRIG)	Chile	932.7	Y	Y	
Sustainable Geothermal Development Project	Chile	4			
Vanuatu energy sector development project	Vanuatu	2.75			
Geothermal Power Development Project	Tanzania	70	Y	Y	
African Clean Energy Finance	Sub Saharan Africa (multiple countries)	20			
Projects (BNEF)	Various	2640			

Sources: CIF 2015; BNEF 2015; Lonsdale 2015; Various DFI websites

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