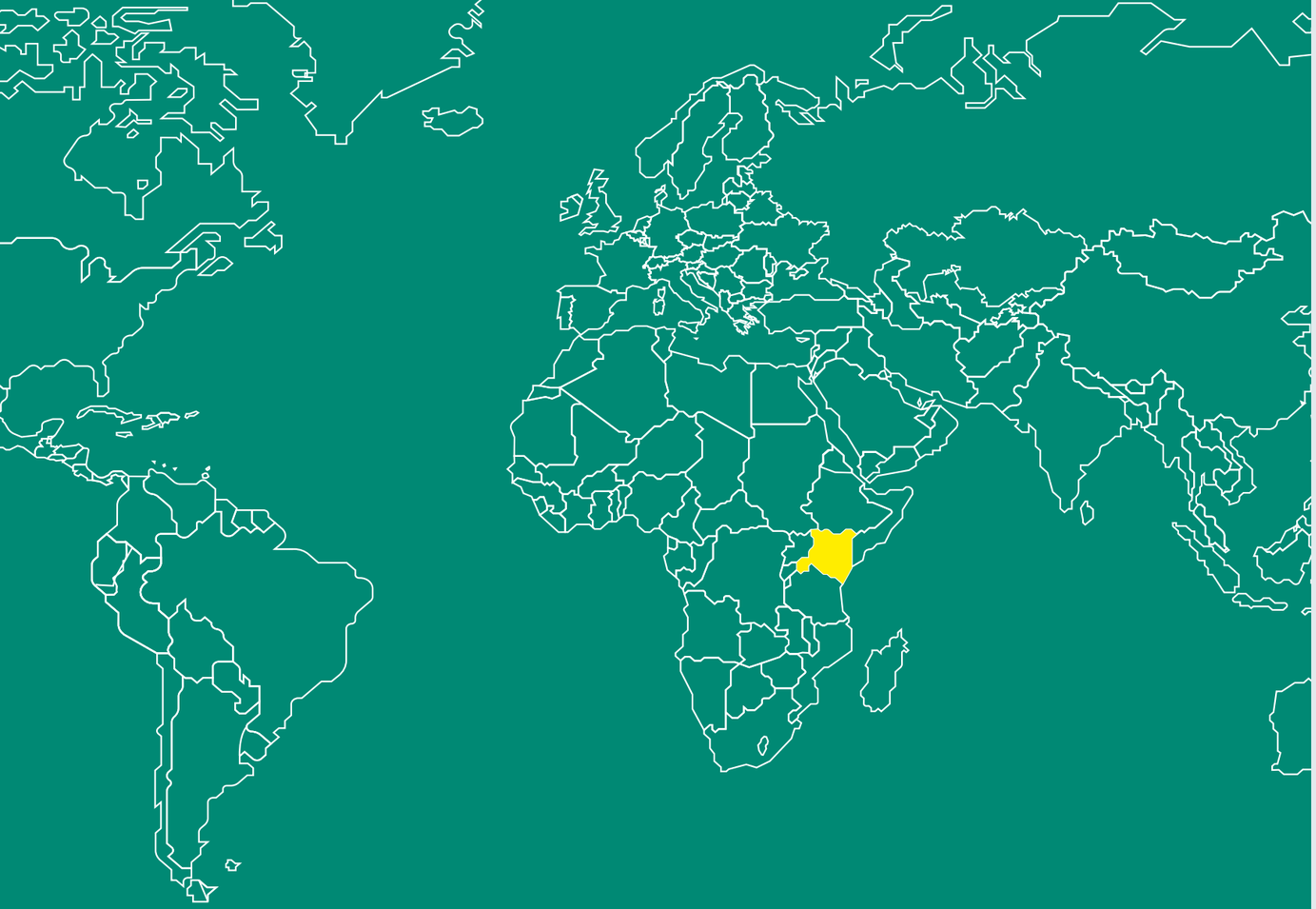
CASE STUDY | JUNE 2018

GEOTHERMAL ENERGY POWERING KENYA'S FUTURE

Menengai Geothermal Field Development Facilitated by Public-Private Partnerships



PROJECT DATA

PARTNER ORGANIZATION
Climate Investment Funds
African Development Bank (AfDB) Geothermal Development Company (GDC)

ORGANIZATION TYPE
Governmental agency

DELIVERY CHALLENGES
Mitigate resource, credit, and financial risks to attract public and private investment in geothermal energy development

DEVELOPMENT CHALLENGE
Secure a reliable, sustainable, and affordable power supply to meet current and future demand

COUNTRY AND REGION
Kenya, Africa

PROJECT TOTAL COST
Menengai Geothermal Development Project (AfDB – USD 120 million; CIF – USD 25 million)

PROJECT DURATION
2011-2018

ORGANIZATIONAL COMMITMENT

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Cover Photo: @AfDB

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In Brief

DEVELOPMENT CHALLENGE

Secure a reliable, sustainable, and affordable power supply to meet current and future demand. Kenya's electricity supply has long been heavily dependent on large hydropower, accounting for almost half of the country's installed capacity. It has become increasingly unreliable due to climate change impacts and short-term, high-cost, fossil-fuelled thermal generation. Moreover, Kenya has not yet been able to meet its rapidly growing demand for energy.

DEVELOPMENT SOLUTION

Increase renewable energy supply by generating geothermal energy at an affordable cost in appropriate public-private partnerships. Kenya has significant geothermal resources, estimated between 7,000 to 10,000 megawatts (MW). Its National Energy Policy set an ambitious goal of moving from 660 MW of geothermal energy in 2017 to 1,600 MW by 2020 and 5,000 MW by 2030.

PROGRAM SOLUTION AND RESULTS

Attaining Kenya's geothermal development targets will require investment at a level beyond what the government can make available. While the private sector may be interested in developing the power supply (downstream), a combination of significant capital investment needs and high resource risks translates into reduced private interest in exploration and field development (upstream). In response, the Kenyan government established the Geothermal Development Company to carry out surface exploration, exploratory and production drilling, and sales of steam to third parties, including independent power producers. The Menengai field is the first developed under this model combining public and private financing, along with risk mitigation instruments, to improve the project's commercial viability. The Climate Investment Funds and the African Development Bank provided resources to support the first phase of the Menengai project.

Executive Summary

Securing a reliable, sustainable, and affordable energy supply to meet current and future demand is a major development challenge for Kenya. The country is fortunate to have great geothermal energy potential, offering a cost-effective alternative to expensive fossil fuel power. In 2017, installed geothermal capacity in Kenya stood around 660 megawatts (MW); the government has established a target of 5,000 MW by 2030.

Reaching this target requires more geothermal power projects and more investment from the public sector, private developers, and development partners. Private developers tend to invest in power plant construction and operation rather than energy exploration and field development. These are characterized by high resource needs, significant risks, and long gestation. The public sector and off-take agreements for the sale of steam can provide appropriate compensation mechanisms to cover risks.

In 2008, with a view to addressing this issue, the Government of Kenya set up the Geothermal Development Company (GDC) to facilitate the entry of independent power producers (IPPs) into the geothermal sector. The public-private partnership approach that developed from this initiative is known as the "GDC model" or the "Menengai model" after the first major project developed by GDC: the Menengai Geothermal Development Project. With activities stretching across three phases, the project expects to produce enough steam from the site to generate 400 MW of power.

From 2011 through 2018, the African Development Bank (AfDB) supported the initial phase of GDC's Menengai Geothermal Development Project through financial contributions from AfDB and the Climate Investment Funds (CIF). By early 2018, Menengai Phase I was largely developed and ready to provide steam for 105 MW of power generation. Three IPPs were selected in a tender procedure and negotiations were finalized between the steam provider, GDC, the power off-taker (Kenya Power and Lighting Company, or KPLC), and the three IPPs, as well as between the IPPs and their lenders. The IPPs' next step is to begin construction of the power facilities, expected to take approximately 18 months.

This case study covers the implementation of Menengai Phase I and draws some lesson learned in relation to the following questions:

Question 1

How does the Menengai public-private partnership model address barriers and challenges to attracting public and private investment?

By absorbing the resource risks associated with exploration and field development, the GDC model helps overcome the barrier to private sector entry posed when the extent of the energy resource is largely unknown. The Menengai experience shows that overcoming the resource risk barrier may be a necessary—though not sufficient—condition for attracting private developers to generate power using geothermal steam. IPPs also worry about government entities involved (GDC and KPLC, in this case) not honoring their commitments. This makes attracting debt financing from private lenders more difficult. To address this creditworthiness risk, the Menengai Project put in place a security package in the form of a partial risk guarantee (PRG).

At the power tariff offered by the government under its feed-in tariff policy, IPPs may not see the revenue stream from power sales as sufficient to reach their required profitability while meeting the minimum levels of debt service required by lenders. To address this, low-cost, concessional financing is another important ingredient in the financing package.

Question 2

What role do development finance institutions (DFIs) play in supporting the private and public sectors in the development of geothermal steam fields and power plants?

A relatively small and new organization with limited financial and technical capacity, GDC faced a delivery challenge in developing a geothermal steam and power project on the scale of Menengai. For this reason, GDC sought and received support from the AfDB. In addition, GDC sought support from development finance institutions to address creditworthiness risk. The PRG set up with AfDB support (and backed by the government) covers non-payment by the power off-taker, KPLC, and non-delivery of steam by GDC.

The challenge for IPPs is to achieve a sufficiently attractive return on their investment to allow them to cover all capital, operational, and financing costs. In the case of Menengai, the CIF's Clean Technology Fund (CTF) provides the IPPs with a concessional loan through AfDB to help improve the bankability of the power generation project.

Question 3

Does the Menengai Project provide a cost-effective model for future geothermal energy development?

In the GDC model, the public agency, GDC, develops the geothermal field and sells steam to a third party, such as one or more IPPs, for power generation.

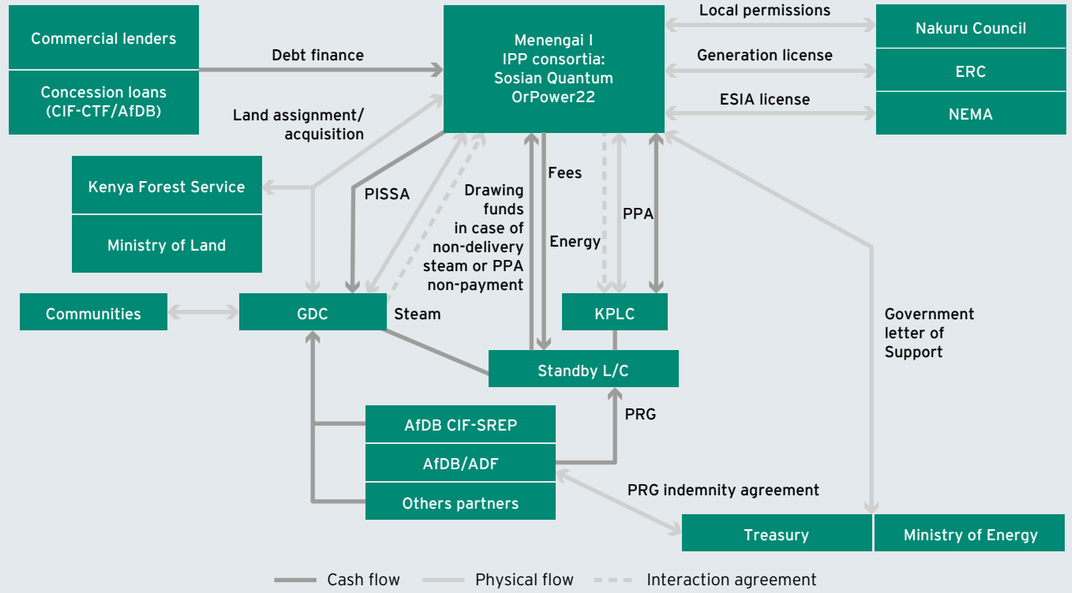
Assuming the IPPs successfully operate the plants in the years to come, Menengai demonstrates that public-private partnerships in geothermal development can be effective.

Other public-private partnership models involve joint development of the exploration and field development phase or even full IPP development of the geothermal field and power facility. However, involvement in the earlier development phase comes with higher costs that would have to be matched by higher tariffs or other public sector support. Higher tariffs may not be a priority for Kenyan policymakers, who are largely concerned with ensuring power is provided to customers at affordable rates. The GDC model tries to strike a balance. Public sector support plays a significant role in covering the high cost and risks of the upstream geothermal development phase. This keeps the cost of steam generation at a level that maintains the tariff paid to the IPP within the limits set by the feed-in tariff policy.

In the Menengai public-private partnership, DFI-supported investments by the public sector in the exploration and field development phase permitted an effective package of financial incentives and risk assurance to get the private sector on board. Consequently, a number of stakeholders have been involved (see **Box 1**). While complex, this way of doing business has provided an optimum mix of knowledge, financing, and risk mitigation that one party alone would not have been able to provide. Over time, the track record of GDC and KPLC is expected to enhance the perceived risk profile of future projects and allow concessional funding to be phased out. This Kenyan approach to developing geothermal energy has already sparked international interest. The AfDB is using learning from the Menengai experience to contribute to geothermal planning in other countries in the region with similar power sector frameworks. ■

BOX 1 **MENENGAI GEOTHERMAL PROJECT: MAIN KENYAN PROJECT PARTNERS AND STAKEHOLDERS**

- The *Geothermal Development Corporation (GDC)*. GDC is responsible for undertaking the integrated development of geothermal steam resources through the initial exploration, drilling, resource assessment, and promotion of direct utilization of geothermal energy. GDC owns and operates the Menengai steam field and is the implementing agency for the steam supply agreement (PISSA) with the IPPs.
- The *Kenya Power and Lighting Co. (KPLC)*. KPLC is the off-taker, buying power from the IPPs based on negotiated power purchase agreements (PPA) for onward supply and distribution to consumers.
- The *Kenya Transmission Company (KETRACO)*. For the first 105 MW, KETRACO has built a substation and transmission line over 7 kilometers (km), connecting the Menengai site with the main national grid (132 kV Menengai-Soilo line).
- *Sosian Menengai Geothermal Energy Ltd, Quantum Power East Africa (QPEA) Menengai Limited*, and the consortium *OrPower Twenty-Two Ltd.* These three independent power producers (IPPs) were selected to generate power from the Menengai field in Phase I. They will build, own, and operate three plants (of 35 MW each) and enter into PISSAs with GDC and PPAs with KPLC. The three IPPs were selected after a tendering procedure in which 12 firms expressed interest.
- *Energy Regulatory Commission (ERC), National Environment Management Authority (NEMA)*, and *Nakuru County Council*. IPPs must obtain power generation licenses from the *ERC*, an environmental and social impact assessment (ESIA) license from *NEMA*, and local permissions from the local county council.
- The *Treasury/Ministry of Finance*. The Treasury/Ministry of Finance issues tax and duty exemption licenses and, with the Ministry of Energy and Petroleum, backs the Government's Letter of Support of the PISSA and PPA, in turn backed by the PGA that is supported by the African Development Fund.
- *Kenya Forest Service* and private landowners/communities. The land in the Menengai caldera, which is nationally owned and administered by *Kenya Forest Service*, is neither settled by people nor utilized for farming or grazing. To gain access for roads and the water piping system, some land was purchased from individual owners.



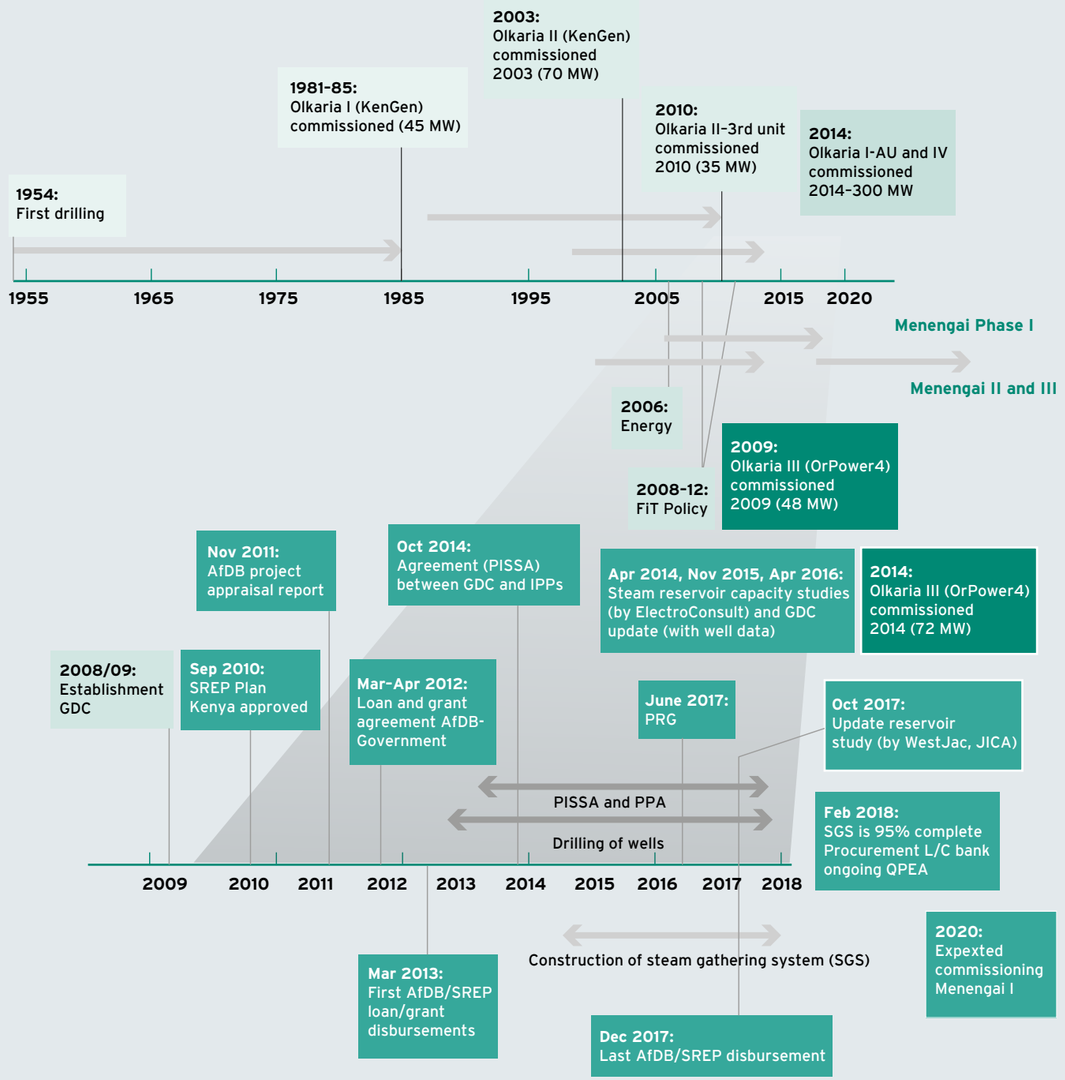
Source: Drafted by author based on information provided by GDC, AfDB, and Quantum Power.
PISSA: Project Implementation and Steam Supply Agreement; PPA: Power Purchase Agreement; IPP: independent power producer; L/C: Letter of Credit; PRG: Partial Risk Guarantee; ESIA: Environmental and Social Impact Assessment;
AfDB: African Development Bank; ADF: African Development Fund, CIF: Climate Investment Funds, CTF: Clean Technology Fund; SREP: Scaling-Up Renewable Energy in Low Income Countries Program.

Introduction

This case study examines the experience of the Menengai Geothermal Development Project from its launch in 2011 to near-completion of Phase I in 2018 (see **Box 2**). The three-phase project aims to contribute to an increase in Kenya's geothermal power capacity as a way to address a major development challenge: securing a reliable, sustainable, and affordable power supply to meet current and future demand for energy. It received support from the Climate Investment Funds (CIF) and the African Development Bank (AfDB) to facilitate the entry of private independent power producers (IPPs) into subsequent phases of the project. The study focuses on how Phase I of the project was implemented and the delivery challenges it confronted during the implementation process.

The case study highlights lessons from the Menengai case by addressing the following questions: How does the Menengai public-private partnership model address barriers and challenges to attracting public and private investment? What role do development finance institutions (DFIs) play in supporting the private and public sectors in the development of geothermal steam fields and power plants? Does the Menengai Project provide a cost-effective model for future geothermal energy development? ■

BOX 2 **TIMELINE OF THE MENENGAI PROJECT AND KEY EVENTS MENTIONED IN THE CASE STUDY**



Source: Own elaboration, based on information provided by GDC, AfDB and Quantum Power.

Context

Geothermal energy can be extracted from high-temperature hydrothermal resources available near the earth's surface. Drilling through cap rock allows pressurized hot water to vent in a mixture of hot water and steam, which can be recovered at the surface and piped to a power station to generate electricity through a steam turbine. Low-pressure steam at the exhaust end of the turbine is condensed and returned underground, with the water, via injection wells.

In 2017, worldwide installed geothermal capacity stood at about 12,900 MW.[1] Globally, geothermal energy represents a small share of the power supply, but countries like Kenya show that where the resource is available, geothermal power can have a significant impact. Kenya generates nearly half of its electricity from geothermal power.[2] It is the only country in Sub-Saharan Africa with operational geothermal power plants, with some 660 MW of installed capacity as of 2018.[3]

Traditionally, Kenya's electricity supply has been dominated by large hydropower resources. The country faces frequent power cuts, partly due to dependence on rain-fed hydropower which is affected by climate change impacts. More severe cuts have been avoided through increased reliance on emergency, diesel-based power generation, but this has pushed operating costs up sharply.[4] The Government of Kenya's long-term national development strategy, *Vision 2030,* identifies the need for reliable and affordable energy as an enabler for the country's socio-economic development. **Securing a reliable, sustainable, and affordable power supply to meet current and future demand is a major development challenge for the country.**

Geothermal energy can play an important role as a cost-effective alternative to expensive fossil fuel power. Moreover, it is a renewable, green energy source that produces no greenhouse gas emissions.[5] The Kenyan government has undertaken detailed surface studies of the most promising areas for geothermal development in the country (Simiyu, 2008). With more than 14 potential high-temperature sites in the Rift valley (see **Box 3**), Kenya's estimated overall geothermal energy potential is between 7,000 and 10,000 MW.

Until recently, geothermal energy deployment has been slow. Kenya began geothermal exploration in the Great Rift Valley's Olkaria area in the 1950s, but it was another 30 years, 1985, before the first geothermal power plant was fully developed (Olkaria I, with a 45 MW capacity) and another 30 years before KenGen, the state power company, brought its geothermal power plants in the Olkaria I, II, and IV fields to their currently installed capacity of about 516 MW.[6]

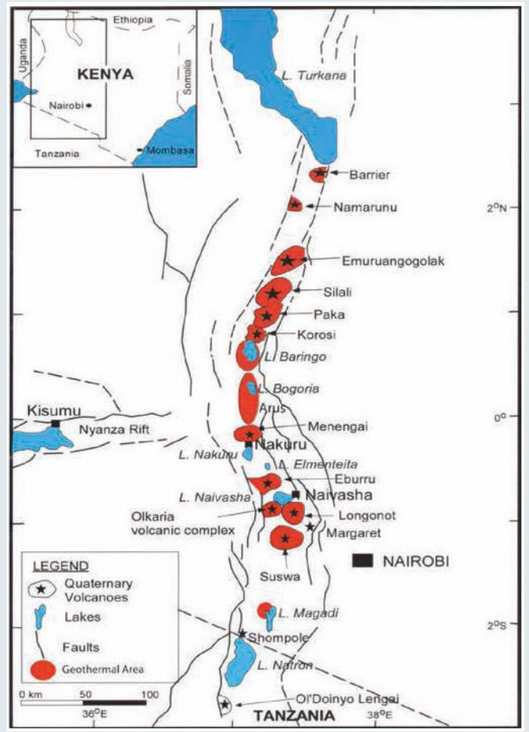
As part of its *Vision 2030* national development strategy, Kenya has set an ambitious target of increasing geothermal power capacity from 660 MW, the capacity in 2017, to 5,000 MW by 2030. The country's Energy Regulatory Commission reports that this would represent about a quarter of Kenya's total installed power capacity, which is projected to grow to 19,200 MW by 2030 (ERC, 2011).

Vision 2030 sets out the government's commitment for "continued institutional reforms in the energy sector, including a strong regulatory framework, encouraging more private generators of power, and separating generation from distribution."[7] Reforms of the legal, regulatory, and institutional framework, including establishing clear policy targets, well-defined tendering processes for IPPs, and feed-in tariffs, have been a key enabler for private sector involvement. These reforms (described in more detail in Annex A.2) have provided a framework for independent energy production, including geothermal power.

Additional investment from development partners and the private sector is needed to speed up Kenya's geothermal power generation development. But, the inherent *resource and exploration risks* of geothermal energy projects make it difficult. A look at the main phases of geothermal project development (explained in more detail in **Box 7** in Annex A.1) illustrates these risks. The three phases are:

1. Exploration and field development (upstream phase), consisting of a) surface exploration and appraisal drilling, and b) drilling of production wells, c) logging and testing of wells, and d) construction of the steam gathering system;

BOX 3 GEOTHERMAL AREAS IN KENYA



Source: GDC, Kenya

1 Globally, USA leads in geothermal power with 3,591 MW installed, followed by Indonesia (1,809 MW), Philippines (1,868 MW), Kenya, Mexico (951 MW), New Zealand (980 MW), Iceland (710 MW), and Italy (944 MW) (Omenda, 2018).

2 In 2015, 4,059 gigawatt-hours (GWh) of geothermal energy (generated with 598 MW) out of a total generation of 9,201 GWh (system total of 2,299 MW) and a domestic supply of 8,138 GWh. (ERC, 2015).

3 Own estimates, based on information in Karingithi, 2018. Information on KenGen is available at www.wikipedia.org and Matek, 2016.

4 The capacity in 2017 (2,370 MW) supplied the peak demand of 2,000 MW but taking into account suppressed demand (340 MW) and a 30 percent reserve margin (660 MW), the true peak demand was closer to 3,00MW (Karingithi, 2018).

5 For comparison, average electricity generation cost in Kenya's grid was USD 0.113/kWh (2014). Feed-in tariffs for other renewable energy projects (above 10 MW) are USD 0.0825/kWh for hydro, USD 0.12/kWh for grid-connected solar PV, USD 0.10/kWh for biomass and USD 0.11/kWh for wind (Feed-on Tariff Policy; MEP 2015; CPI (2015a).

6 2017 figure from Karingithi, 2018, including well-head generation of about 75 MW; and en.wikipedia.org/wiki/Kenya_Electricity_Generating_Company. Adding the privately-owned capacity of 144 MW at Olkaria) gives a total national geothermal installed capacity of 660 MW.

7 Government of Kenya, *Vision 2030 (abridged version)*; paragraph 3.5.

2. Power development (downstream phase), consisting of the construction of the power plant(s) and transmission substation(s); and
3. Operation and maintenance of steam production and power generation facilities.

Risks in the first phase relate to uncertainties about resource size, steam temperature, where to drill, drilling success rate, and well productivity. Substantial investment is required to prove the steam resource in the field development phase, which can involve long lead times of five to 10 years. Other types of renewable energy projects do not require such a time commitment.

As of early 2018, Kenya had only one privately operated geothermal power plant: the 110 MW Olkaria III. Financed mainly by private actors,[8] Olkaria III represents an important first step towards private sector investment in geothermal development; however, it involved lengthy negotiations and took more than ten years to develop (1998–2009, see **Box 2**). Moreover, private investment in Olkaria III was limited mainly to the power development phase, with minimal investment in field development (production drilling). Steam exploration and part of the field development were carried out by KenGen, which provided exploration data and the first production wells.

Rather than trying to replicate the Olkaria III public-private partnership arrangement, Kenyan government planners moved toward a more formalized and streamlined approach to providing public sector support for financing geothermal development. In 2008, the government established the Geothermal Development Company (GDC) to address resource and drilling risks in the steam development phase. The government hoped that by taking on responsibility for proving the availability and suitability of geothermal resources, GDC could facilitate the entry of IPPs in the power plant development phase, and perhaps even facilitate joint development of the geothermal field with IPPs.

Under this *GDC model*, GDC addresses the exploration and field development phase, while third parties (either KenGen or IPPs through competitive bidding) are responsible for developing the power plants that use the steam. This approach is sometimes referred to as the *Project Implementation and Steam Supply Agreement (PISSA)* model, in reference to the agreement the IPP signs with GDC to purchase steam. This model shifts exploration and resource risks away from private investors (the IPPs) that purchase steam from GDC at the official feed-in-tariff. Since the development of the Menengai geothermal field is the first major project undertaken using the GDC public-private partnership model, it is also known as the *Menengai model*. ■

8 The plant is owned by the OrPower 4 consortium, led by the USbased company Ormat, also a participating partner in one of the Menengai IPPs.

Tracing the Menengai Implementation Process

The Menengai geothermal area, located in the geothermal-rich Rift Valley (see **Box 3**), is the first geothermal site to be developed in Kenya outside Olkaria. The Menengai Geothermal Development Project (hereafter "the Menengai Project") is the first geothermal project that GDC has developed from exploration to production drilling and steam field development. It aims to develop the Menengai field to produce enough steam for at least 465 MW power generation.[9]

EXPLORATION AND FIELD DEVELOPMENT PHASE

As a new organization, GDC faced some challenges with the Menengai Project in terms of its *financial and technical capacity to undertake large-scale geothermal field development*. As it started operations in 2009, GDC's financial base was still relatively small; its core funding came from the government and the sale of steam to KenGen from 26 wells it inherited from KenGen in Olkaria.[10]

9 Theoretical potential of the whole Menengai area could be 1,600 MW.

10 After splitting up the state power utility into separate power, distribution, and transmission companies (see Annex A.2), GDC inherited the Olkaria geothermal wells from KenGen and subsequently expanded to the current 59 wells it now operates in the Olkaria area. The steam is sold to KenGen for power generation.

The government sought support from development finance institutions (DFIs) to fill its financial gaps, and between 2011 and 2013 worked with the AfDB to formulate the three-phase Menengai Project. Phase I was designed to lead to the generation of 105 MW of power, Phase II 60 MW, and Phase III 300 MW.[11]

The total cost of developing the Menengai geothermal field was estimated at about USD 847 million (GDC, 2018; AfDB, 2011). GDC received financial support from AfDB, CIF, other development partners, and a local budget provided by the government (see **Box 4** for more on CIF and **Box 1** for more on partners).

Initial CIF funding was provided through its Scaling Up Renewable Energy Program (SREP) to support Phase I of the project. The funds were channeled through the AfDB as part loan (USD 17.5 million) and part grant (USD 7.5 million), while the AfDB itself provided a loan equivalent to USD 120 million.[12]

These resources partly covered the costs of drilling exploration and production wells, construction of the steam gathering system, equipment, consultancy services, and social-environmental planning.

Through the Menengai Project, the AfDB has provided support to strengthen GDC's technical capacity. Other development partners, such as Japan International Cooperation Agency (JICA),[13] US Agency for International Development (USAID), the African Union, and Iceland, have also supported capacity building at GDC in such areas as technical expertise in the geosciences, drilling, and reservoir engineering; commercial negotiation skills; and legal and contracting knowledge. This has helped advance a broader GDC aim to build its own staff capacity and become a knowledge hub for the Africa Geothermal Centre of Excellence (AGCE). Being established in cooperation with KenGen, the Centre will have Kenyan offices in Navaisha and Nakuru, and will feature labs and training facilities.[14]

GDC faced steam development challenges during phase I of the Menengai Project resulting in slow progress in the completion of critical activities including drilling and construction of the steam gathering system.

By early 2018, the Phase I steam gathering system was close to completion.[15] A total of 42 of 50 planned wells had been drilled, for a production capacity of 105 MW of steam, while 23 wells had been tested for power generation (AfDB, 2017b, 2017c). Meanwhile, the Master Plan Study for Phase II and Phase III was moving forward.

Well drilling for Menengai II was in progress, and water and road infrastructure was in place.

11 Tenders for the development of three modular power plants of Phase I were issued in July 2013, on the assumption that all power generated by these plants would be purchased by Kenya Power and Lighting Company (KPLC) under a 25-year power purchase agreement, and that the private investors would be responsible for raising the equity and debt financing to implement the project under 'Build, Own and Operate' schemes.

12 An AfDB Project Appraisal Report (PAR) was drafted and the financing it proposed was approved, together with the SREP funding, in 2011. The AfDB's SREP loan and grant agreements with the Government of Kenya were signed early in 2012. The PAR mentions a SREP allocation of USD 40 million (see **Box 4**) with USD 25 million through AfDB and USD 15 million through the World Bank. The 15 million allocation via the World Bank will be not be used.

13 Japan International Cooperation Agency (JICA), *Project for Reviewing GDC's Geothermal Development Strategy*; AfDB, *Menengai Geothermal Development Project Kenya*. QPEA, p.c. and GDC (wrapup meeting, 07/02/18, p.c.)

14 Supported by UN Environment, the Iceland Development Programme, African Union, Kenya and other development partners (UN Environment, 2017).

15 As reported by GDC, the system was 95 percent complete. The SGS contract was awarded to a contractor at a price of USD 43 million. Eighteen contracts were awarded for the supply of the three drillings rigs, drilling materials, fuel (diesel), and consultancy services.

BOX 4 CLIMATE INVESTMENT FUNDS

The Climate Investment Funds (CIF) provide 72 developing and middle-income countries with urgently needed resources to empower transformations in clean technology, energy access, cli- mate resilience, and sustainable forests. Financing is channeled through five multilateral development banks, including the AfDB and World Bank.
The Government of Kenya has introduced several policies to ex- pedite development of its renewable energy resources, and CIF funding is helping to remove some of the technical capacity, economic, financial and social constraints. Concessional funding from CIF's Scaling Up Renewable Energy in Low Income Countries Program (SREP) and Clean Technology Fund (CTF) are particularly focused on de-risking geothermal power.

For more information, see:
www.climateinvestmentfunds.org/

POWER DEVELOPMENT PHASE

While steam development at the Menengai geothermal field was progressing, in 2013 GDC selected three IPPs—Sosian Energy, Quantum Power East Africa, and OrPower 22—via a tender procedure to set up three Phase I power plants (35 MW each, for 105 MW in total).[16]

A numberof obstacles emergedin theprocess of reaching agreement on the most effective package of financial incentives, support, and government guarantee for private investment in the power plants. Negotiations between GDC and KPLC, and with the three IPPs, were scheduled to conclude by 2015, and the plants commissioned by 2017. In reality, they took over three years, pushing the commission date of the first power plant to 2019.

16 Shareholding in the OrPower consortium is divided as follows: Ormat Technologies 51 percent, Symbion Power 24.5 percent, and Civicon Ltd. 24.5 percent.

A delivery challenge for Menengai geothermal development was *creating a reward-risk ratio attractive to private developers*. Because the Kenyan government will not or cannot provide a sovereign guarantee to cover KPLC and GDC contractual financial obligations, geothermal IPPs in Kenya face the risk of these two government entities failing to honor their commitments (CTF, n.d.). Under government energy policy, the power off-taker (KPLC) must provide power to low-income consumers at a social rate,[17] which weakens KPLC's financial profile and raises doubt about its continued ability to pay on schedule for power sales at the agreed feed-in tariff.[18] There are also steam non-delivery risks related to GDC. These *credit worthiness risks can deter private developers as well as debt financing from private lenders*. Since IPP private debt repayment obligations remain regardless of whether one of these risks materializes, lenders need reassurance that these risks are fully mitigated before they agree to a financing package.

In response to this issue, the Kenyan government asked the African Development Fund (ADF), through the AfDB, for a partial risk guarantee (PRG) of approximately USD 11.27 million (ADF, 2014). Under the PRG, at the request of KPLC and GDC, a commercial bank issues Letter(s) of Credit (L/C) which the IPPs have the right to draw upon in the event of non-payment under the PPA (power purchase agreement) or inability to generate electricity due to GDC default under the PISSA (steam purchase agreement). For its part, the bank, enters into reimbursement and credit agreements with KPLC and GDC, through which these would repay the bank any amounts drawn by any of the IPPs, within a specified agreed reimbursement period. Meanwhile, the Treasury of the Government of Kenya enters into an indemnity agreement in which it undertakes to repay the AfDB on demand for any reimbursement made to the L/C bank under the PRG. The total guarantee period is 15 years (ADF 2014; AfDB 2017b).

Negotiations among GDC, KPLC, and the three IPPs on these arrangements took some time, concluding in June 2017. A tender procedure to select the commercial bank for the PRG was launched in October 2017.

Another delivery challenge has been *achieving an attractive return on investment for private developers and lenders*. The Menengai Project IPPs typically finance power plant construction with a mix of equity (30 percent) and debt financing (70 percent), investing about USD 70-80 million per 35 MW plant. As part of risk guarantee analysis, the IPPs produced financial models showing a 12 percent internal rate of return (IRR) on equity. Such an IRR is not considered sufficient by project sponsors for sourcing debt and equity at a cost that makes the IPP projects bankable.[19] In 2016, the project therefore reached an agreement to increase bankability by accessing concessional financing through the Dedicated Private Sector Program (DPSD) of CIF's Clean Technology Fund (CTF) (see **Box 4**). CTF support creates a concessional lending program of USD 29.7 million via the AfDB for two IPP projects (USD 15 million in CTF concessional debt per power plant). This relatively small investment lowers the cost of capital enough to make the two IPP projects bankable (SREP, 2017; CTF, n.d.) [20]

By the end of 2017, GDC and the three IPPs (Sosian Energy, QPEA, and Ormat) wereintheprocessoffinalizing a number of financial modalities and agreements. QPEA was on track to begin plant construction early in 2018, and the first commissioning was expected 18 months later, in 2019. Sosian's launch was expected to follow. In early 2018, OrPower22 was awaiting a JICA-financed independent study on steam supply (AfDB, 2017c).

Despite this progress, resource risk remained a relevant issue in negotiations even as GDC advanced with production drilling. This highlights another delivery challenge: *uncertainty on the exact potential of the Menengai steam reservoir*.

Most private investors will not consider providing finance until about 70 percent of the power capacity available in the wells has been drilled (CPI, 2014). This has delayed agreements with the IPPs. Expected power capacity by the end of Phase I was originally estimated at around 165 MW. Three steam status and reservoir studies provided results of 150 MW, 133 MW, and 90 MW respectively (AfDB, 2017c).21 GDC subsequently updated its internal steam status and resource assessment report in 2017, incorporating the latest data from recently drilled wells (23 of which had been tested for power production) to confirm a sustainable reservoir capacity of 105 MW plus 20 percent reserve margin (AfDB, 2017c) for the 25-year PPA period. GDC's assessment report was accepted by QPEA and Sosian, but OrPower22 requested an independent study, which was planned for early 2018. ■

17 Reduced rate to make power affordable. Lifeline consumers (using less than 50 kWh per month) pay USD 0.025/kWh. Residential clients that consumer between 5—1500 kWh pay USD 0.1275/kWh and thereafter USD 0.2057 (2017) (ERC, 2014 and https://africacheck.org/factsheets/factsheet-cost-electricity- kenya/).

18 See paragraph 4.1.1. in CPI, 2015a.

19 The IPPs have produced comprehensive financial models that demonstrate the financial viability of each plant, indicating equity internal rate of return (IRR) of 12% (and financial IRR of 16.5%). See https://www.afdb.org/fileadmin/uploads/afdb/Documents/ Projectand-Operations/Kenya__AR-GDC_Menengai_105MW IPP_Partial_Risk_Guarantee.pdf.

20 Increasing the IRR with 2 to 4 percentage points. (SREP, 2017 and Quantum Power, p.c.

21 These were produced by Electroconsult Spa (ELC) and dated April 2014, November 2015, and April 2016.

Lessons from the Case Study

Kenya's experience with the Menengai Project offers a number of lessons for other geothermal-rich countries in Africa and worldwide. These lessons are reflected in the responses to the research questions posed at the beginning of the case study.

Question 1

How does the Menengai public-private partnership model address barriers and challenges to attracting public and private investment?

Under the GDC model of public-private partnership pioneered in the Menengai geothermal area, GDC is responsible fo rexploration and field developmen tand sells steam to power producers, both private investors (IPPs) and KenGen, in competitive tendering. By *absorbing the resource risks* of the geothermal development phase, GDC helps private sector actors overcome reluctancy to get involved in projects where the extent of the resource is uncertain. Yet, overcoming the resource risk barrier is still not enough to attract private developers to generate power using geothermal steam. This is because IPPs face an additional *creditworthiness risk of government entities involved not being able to honor their commitments.*

Question 2

What role do development finance institutions (DFIs) play in supporting the private and public sectors in the development of geothermal steam fields and power plants?

The AfDB and CIF supported loans and grants that helped GDC, a relatively new organization with limited financial resources, undertake exploration and drilling in the Menengai field. *This DFI support was crucial in permitting the national public sector to play its role of attracting private involvement by absorbing the high initial development costs and mitigating resource availability risks.*

In addition, AfDB support (with resources from the African Development Fund), allowed a security package to be put in place for the Menengai Project to address creditworthiness risk. The *partial risk guarantee (PRG)* covers payments to the IPPs as revenue lost in case of non-payment by the power off-taker (KPLC) or failure by GDC to provide steam. It took several years to achieve agreements with all the parties involved. *This experience demonstrates that more standardized risk mitigation instruments covering political, financial, and other risks are needed to speed up negotiations on steam supply and power sales.*

The price offered by the government under its feed- in tariff policy does not necessarily produce a revenue stream from power sales sufficient to reach IPP's required profitability. Low-cost financing has therefore been important to improving the attractiveness of the investment. A relatively small concessional loan provided by CIF's Clean Technology Fund (CTF) through AfDB has reportedly helped increase the bankability of the Menengai Project (QPEA, p.c.; CTF, n.d.).

DFI-supported investments by the public sector in the steam development phase underpinned an effective package of financial incentives and risk assurance that attracted private sector investors. The perceived risk profile of future projects is expected to improve over time based on positive GDC and KPLC track records, making it possible to eventually phase out the use of such financial instruments (CTF, n.d.).

Question 3

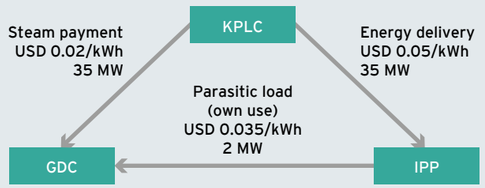
Does the Menengai Project provide a cost-effective model for future geothermal energy development?

Public sector support plays a significant role in covering the high cost and risks of the steam development phase. The agreed Menengai tariff is USD 0.07/kWh, of which USD 0.02/kWh is for the purchase of steam (see **Box 5**). Although GDC sells the steam at this price, the true cost of geothermal development is higher.[22]

As GDC initiates the development of other geothermal fields, alternative public-private partnership models are being considered in which the private sector plays a bigger role in earlier stages. The s o-called *Joint Development Agreement (JDA)* model sees IPPs fully involved in construction and development in the power phase and contributing 40 to 80 percent of investment for drilling production wells and steam field development. The private sector may adopt a larger role and even undertake both steam and power development in *full IPP concessions*. These other public-private partnership models are described in Annex A.

If an IPP carried drilling and steam field development costs, tariffs would need to rise by 60 to 75 percent, possibly reaching between USD 0.14 and 0.17 per kWh (GDC, 2014; CPI 2015b). Tariffs higher than the USD 0.088/kWh offered in the current policy could allow project developers to take on higher risk and participate at an earlier stage in the geothermal project development cycle. However, higher tariffs may not be a priority for Kenyan policymakers, who are largely concerned with providing customers with power at affordable rates.

BOX 5 **PAYMENT STRUCTURE**



The tariff will be capped at USD 0.085 per kWh (exclusive of value added tax) for 35 MW of power. This is in line with the latest version of Kenya's feed-in Tariff Policy (2012) which states that the tariff should not exceed USD 0.088/kWh. The generation component will be capped at USD 0.05 per kWh. The steam supply component will be paid to GDC (at USD 0.02 per /kWh) as a passthrough cost by KPLC for the net power delivered to the grid. The IPPs shall, from their revenue, pay GDC for the steam consumed for generation of electricity for their own use (parasitic load) at the stated rate of steam. The tariff is scalable, and the scalable portion of the tariff will be 20 percent for the first 12 years and 15 percent thereafter.

Source: ADF (2014), QEPC, p.c.

In fact, there is a push at the policy level to lower the cost of energy and tariffs.[23]

The tariff policy goal will thus influence which public-private business model prevails. In the GDC (or Menengai) model, the need for higher tariffs to incentivize private sector participation in geothermal power development is offset by public measures, such as GDC's lead role in the steam development phase and concessionary loans and grant support from DFIs to address specific risks. ■

22 GDC, 2014 mentions that tariffs for IPPs entering before test drilling would be USD 0.14–0.17 per kWh and for IPPs entering after test drilling about USD 0.065-0.105 per kWh.

23 See, for example, Karingithi, 2018.

Potential for Scaling Up and Replication

The Menengai model of public-private partnership consists of de-risking geothermal field development with public sector support and selling steam to third parties that develop the power plant phase. Various private investors have expressed interest in investing in geothermal power generation, provided that other risks (political, financial) can be mitigated and a combination of appropriate feed-in tariffs and concessional finance produce sufficient returns on investment for the private investor.

Under its policy objective of increasing investment in geothermal fields, the Government of Kenya would welcome private investors venturing into developing the steam phase. Their additional risk exposure and costs would need to be covered by higher feed-in tariffs and/ or additional grant and loan financing. This is at odds with the government's policy objective of keeping tariffs affordable for citizens. In this context, the GDC model seems to strike a good balance between the two policy objectives.

Lessons from the Menengai Project help identify the pros and cons of the model and demonstrate how the model helps manage overall costs and risks. The Menengai experience is highly relevant for future geothermal energy development and can contribute to the geothermal planning in other countries in the region with similar power sector frameworks, such as Ethiopia, Comoros, and Tanzania, which in 2013 established the Tanzania Geothermal Development Company. The new African Geothermal Center of Excellence (AGCE) in Nakuru-Navaisha will also help build capacity at the regional level. ■

How the Case Study Informs the Science of Delivery

This case study generates a number of lessons relevant to the five elements of the GDI's know-how approach to the science of delivery.

FOCUS ON WELFARE GAINS OF CITIZENS

Under Kenyan regulation, the Menengai Project cannot supply power directly to nearby communities. Power will be fed into the main grid and distributed to consumers by KPLC. Nevertheless, the project indirectly helps expand power generation capacity to meet unmet demand and, in future, supply newly connected consumers. This is significant given that a bout 80 percent of households lacked connections in 2010 (CPI 2015a). Geothermal development in Kenya is also accompanied by various socioeconomic initiatives, such as supplying heat for fish farming, greenhouses, milk processing, and other heat applications (see **Box 6**). Attracting agro-industrial and other companies will create employment and bring additional income generation to the Menengai area.

MULTISECTOR AND MULTI-STAKEHOLDER APPROACH

The Menengai Project involves a number of stakeholders, including government ministries and agencies, private investors and developers, private banks, development finance institutions, and multilateral and bilateral donor organizations (see **Box 1**). While this may appear to be a complex way of doing business, it creates an optimum mix of knowledge, financing, and risk mitigation to support an expansion of geothermal installed capacity that one party alone would not be able to provide.

EVIDENCE TO INFORM LEARNING

For GDC, entering into commercial-type tendering and negotiations with IPPs and government partners was a new activity that required considerable time to "learn-by-doing," with steam delivery and power purchase agreements drafted almost from scratch. Learning from this experience, agreements can be reached more quickly in the future.

ADAPTIVE MANAGEMENT AND CHANGE

Under the GDC model, GDC is responsible for exploration and field development to stimulate private investment in power generation using geothermal steam. Kenya is also experimenting with other public-private partnership models with greater private sector involvement, including full IPP concession of both steam and power development (see **Box 9** in Annex A.3). Whatever the model, public-sector financing remains important to achieve goals, such as offsetting financial risks, proving resource potentials, and keeping power tariffs down.

BEING ADAPTIVE, FLEXIBLE, AND ITERATIVE WHEN IMPLEMENTING SOLUTIONS

The GDC model applied in the Menengai Project places resource and exploration risk with the public sector. The project has benefited from a set of financial and risk mitigation solutions that address resource and exploration risk (GDC support through DFI loans and grants) and credit risk (the partial risk guarantee). In addition, the desired commercial rate of return was ultimately achieved by means of concessional loans. It took several years to reach this set of agreements and financing solutions. Learning from this experience can help future public-private partnerships in geothermal energy move more quickly.

BOX 6 **DIRECT USE OF GEOTHERMAL HEAT: A HOT CONCEPT**

Geothermal heat can be used to generate electricity, but also for industrial and agro-industrial heat applications. GDC is pioneering the use of geothermal heat in four pilot projects at the Menengai project site to pasteurize milk, launder clothes, and heat fishponds and greenhouses. It is a win-win situation. Industrial boilers consume a great deal of energy currently provided by expensive, imported fuel and electricity. The pilots show that savings in a greenhouse can be up to 40 percent. Savings in milk pasteurization were 7 percent of the production cost. Heat is also important for fishponds: tilapia reportedly grow 30 percent faster if ponds are kept at 29°C.

Since transporting heat has limitations, geothermal heat can only be used when demand is nearby. To bring the application of geothermal heat to an industrial-commercial scale, GDC and KenGen are planning to establish an industrial park near the steam fields along the geothermal belt, including the Menengai project site. This is located in Kenya's agricultural belt, where there is an urgent need for drying agricultural produce at low energy cost.

For GDC, geothermal heat sales mean an additional revenue stream. For local communities, attracting companies to the industrial park will create employment and generate additional in- come, while the use of greenhouses and fishponds will increase food security. For the country, everyone will benefit from reduced greenhouse gas emissions and dependency on fossil fuels.

Source: GDC, 2016b.

Besides selling steam for power generation, revenue can be generated through the sale of hot water and steam for industrial and agricultural activities (replacing fuel for heat in commercial applications, such as drying produce, boilers, and greenhouses). Both KenGen and GDC are experimenting with direct geothermal energy use in pilot projects (see **Box 6**). ■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ANNEX A:

Geothermal Energy Development in Kenya

A.1 RISKS IN GEOTHERMAL ENERGY DEVELOPMENT

The earth's surface is not dormant. Phenomena such as volcanoes and geysers are evidence of heat generated in the earth's interior and stored below the surface making its way up. This is reflected everywhere in a general temperature increase with depth. However, the availability of this heat varies from place to place. As the earth's plates slowly move over the underlying mantle, they collide, sink, or rise in relation to each other at their boundaries. This produces large bodies of magma that intrude into the crust and may rise to the surface to form volcanoes or heat up the higher layers of rock.
A water-tight cap rock above a magma hot spot enables an accumulation of pressurized hot water stored in the pores and spaces of the rock layer. Geothermal energy can be extracted where such high-temperature hydrothermal resources are available near the surface. Drilling through the cap rock allows the pressurized hot water to vent off in a mixture of hot water and steam. At the surface, the steam can be recovered and piped to a power station to generate electricity through a steam turbine. At the exhaust end of the turbine, low-pressure steam is condensed and, with the water, returned underground via injection wells.

Proving the geothermal resource is a major risk with uncertainties in resource size, steam temperature, where to drill, drilling success rate, and well productivity. These risks have implications across all phases of geothermal project development, including the following (see **Box 7**):

1. Exploration and field development (upstream phase), consisting of:
   - 1a. Exploration and analysis:
     - Preliminary surveys (with selection of promising sites) and surface exploration studies (surface geological, subsurface geophysical, geochemical, seismic data)
     - Site infrastructure
     - Exploration (drilling holes and wells, well testing and reservoir simulation)
     - Project review and planning (feasibility study, drilling plan);
   - 1b. Implementation of field development:
2. Production wells and re-injection wells
   - Well and reservoir simulations and energy production study
   - Steam gathering system;
   - Implementation of the downstream phase: power plant design, construction (power plant and transmission substations) and commissioning;
3. Operation and maintenance of steam production and power generation facilities.

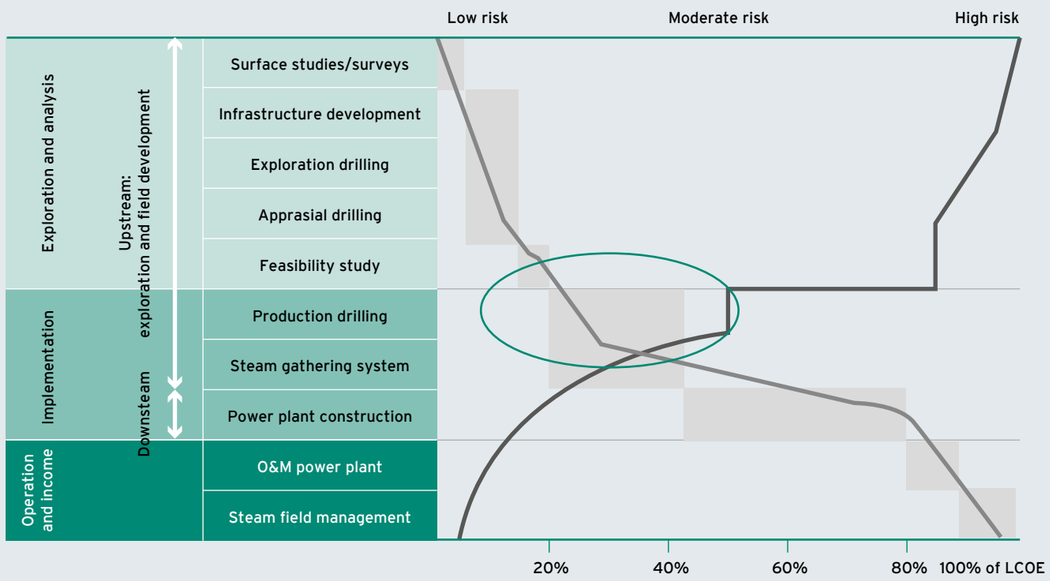
Average success rates for exploration drilling range between 50 and 59 percent globally for initial wells and between 70 and 80 percent when the resource has been confirmed (IFC, 2013). The first two phases can take five to 10 years, much longer than many conventional or other renewable energy technologies. Gestation periods have been even longer in Kenya, where, on average, the first three phases have taken about 15 years.

BOX 7 **UNIT COST OF ENERGY AND RISKS IN GEOTHERMAL ENERGY DEVELOPMENT**

The levelized cost (LCOE) is the value of lifecycle costs, initial investment, and annual costs (e.g. in USD/kWh) of producing a unit of energy (kWh) of a specific technology. The LCOE is the price that must be received per unit of output to reach a financial return (break-even) over the lifecycle. The average LCOE is about USD 0.06-0.18/kWh globally, depending on the region, size of the power plant, technology used, and the nature of the geothermal resource. The figure presents the share of exploration and test drilling, field development, plant construction, and project operations in the LCOE. The field development (production drilling and steam gathering system) and power plant provide over 60 percent of LCOE cost.

The project risk of upstream geothermal resource development is high in the first phase of surface reconnaissance and exploration and appraisal drilling, is moderately high for the subsequent phase of production drilling, and gets to low levels in the downstream phase of power plant construction and operation. Public sector finance plays a significant role in the high-risk, but relatively low-cost upstream phase, while private capital for power production is more accessible at the downstream phase. A difficult zone is between these phases with moderate risk (uncomfortable for private developers) and a relative high cost share (difficult for the public sector to develop without additional public or private capital).

The figure and accompanying text have been compiled from data and information presented in CPI (2014), CPI (2015a), REN21 (2016), CDKN (2017), WB-ESMAP (2012) and WB-ESMAP (2018).



A.2 GEOTHERMAL ENERGY DEVELOPMENT IN KENYA

Until recently, geothermal energy deployment has been slow. Kenya began geothermal exploration in the Olkaria area of the Great Rift Valley in the 1950s, but the state utility Kenya Power Company (KPC) did not embark on systematic efforts to survey and exploit geothermal potential until the 1960s (see **Box 2**). It took 30 years (1955–1985) to fully develop Kenya's first geothermal power plant, Olkaria I (45 MW). Developing subsequent Olkaria units took between 16 and 23 years (105 MW), while the 280 MW of Olkaria II and IV took 16 years to develop (1998–2014).[24] By 2015, KenGen (the state Kenya Electricity Generation Company Ltd), had set up geothermal power plants that were generating about 516 MW in 2017[25] and had plans to develop another 650 MW. GDC plans to contribute over 1,000 MW to the government's 5,000 MW initiative.

A first step has been a series of reforms that provide a framework for the independent production of renewable energy. The liberalization of Kenya's energy market in the 1990s saw the unbundling of the state power utility Kenya Power into entities responsible for generation (KenGen) and distribution (Kenya Power and Lighting Company, KPLC). The Energy Act (2006) created several new institutions in the power sector: the Rural Electrification Authority (REA), the Geothermal Development Company (GDC), the Energy Regulatory Commission (ERC), and the Kenya Electricity Transmission Company (KETRACO). Though transmission and distribution have remained bundled, power generation is increasingly carried out by independent power producers (IPPs) who, in 2015, accounted for about 28 percent of Kenya's capacity (ERC, 2015).

A feed-in tariff has been introduced for a number of renewable energy technologies. For geothermal power projects between 35 and 70 MW, this feed-in tariff is USD 0.088 per kWh, applicable over 20 years from the date of first commissioning (MEP, 2014). In 2011, a zero-rated import duty was introduced, and the value- added tax eliminated for renewable energy equipment and accessories (CPI, 2015a).

As of 2018, Kenya had only one privately operated geothermal power plant, the 139 MW Olkaria III, whose development, including field development, has been financed mainly by private actors. The plant is owned by the consortium OrPower 4, led by the US-based Ormat.

Olkaria III represents a first step from publicly-based geothermal development towards models with increased private participation. It offers several lessons. One is that public-private partnerships in geothermal development can be effective. Olkaria III was the first attempt in Kenya to use public and private financing and risk mitigation instruments for geothermal energy. Local and international public financial support helped lower the cost per unit kWh,[26] keeping the project profitable at the tariff KPLC pays to OrPower4, about USD 0.09/kWh (CPI, 2015a). This covers the cost of power generation and operation and some of the production drilling costs. The tariff does not cover the full cost of

24 GDC, 2014.

25 "KenGen sets ambitious 5-year 580 MW geothermal development target" in Think GeoEnergy – Geothermal Energy News". www.thinkgeoenergy.com. Adding the 143 MW of the privately developed Olkaria III (Ormat, Oserian) gives an installed geothermal capacity of 660 MW in 2017 (own estimate).

26 Unit cost of steam and power development of Olkaria III is estimated at USD 0.17/kWh of which the private investor's cost at USD 0.06/kWh (some production drilling and power development). The total unit cost (LCOE) was lowered to USD 0.09/kWh per various risk mitigation measures (KenGen's role in exploration, USD -0.03; political risk mitigation (MIGA guarantee) and currency hedging, USD -0.026, and access to favourable loans, USD -0.017/kWh (CPI 2015b). MIGA: Multilateral Investment Guarantee Agency of the World Bank.

steam exploration and development, which was significantly mitigated by the government. KenGen provided exploration data and 8 MW of production wells to Ormat and costs were reduced by attracting long- term debt finance and developing a security package to back up the creditworthiness of the power off-taker, KPLC.[27]

It took from 1998 to 2009 to reach financial closure on Olkaria III, and its first 84 MW were not commissioned until 2013.[28] Lengthy negotiations on the structure and exact terms of the PPA were partly responsible. To mitigate the financial and political risks faced by IPPs, a financial security package was set up in 2007, consisting of an L/C from KPLC under which the consortium OrPower 4 would be entitled to make demand in the case of payment default. This was accompanied by a "letter of comfort" from the Government of Kenya, reassuring the consortium that it would take all means within its power to ensure KPLC issued payments under the PPA.

A case study on Olkaria III (CPI, 2015a) cites the average unit cost of power generated for the geothermal projects (the public sector Olkaria I, II and IV) at USD 0.092/kWh, with the public-private Olkaria III at USD 0.08/kWh.[29] The Menengai Phase I IPPs will sell power at USD 0.05/kWh (of which cost of steam in Menengai is computed at USD 0.02/kWh). *This suggests that the model of private developer (with public sector support) has been important in holding down costs of geothermal power development.*

27 Poster Powering the Nation for Vision 2030: Green Energy Development, Geothermal Resource Development in Kenya, GDC. Without the previous KenGen drilling, the tariff would have been at least 18 percent above the current feed-in tariff for a private developer to have sufficient equity return (CPI, 2015b).

28 See Figure 3 in CPI, 2015a.

29 Using a discount factor of 12 percent. (CPI 2015a).

A.3 PUBLIC-PRIVATE PARTNERSHIP MODELS FOR GEOTHERMAL ENERGY DEVELOPMENT IN KENYA

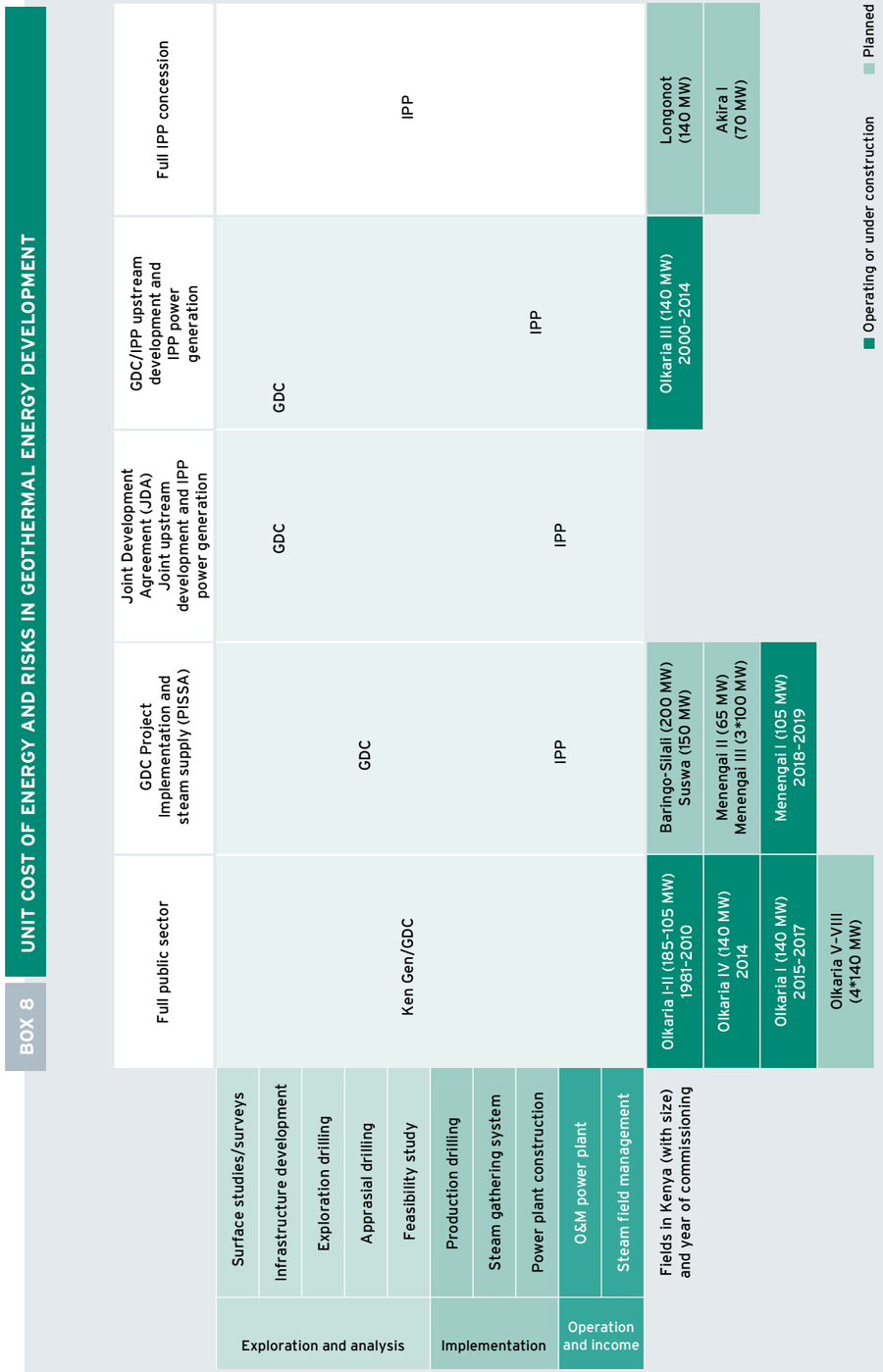
As GDC embarks on the development of other geothermal complexes, such as Baringo-Silali and Suswa, it is considering alternative public-private partnership models in which the private sector plays a greater role in earlier stages of geothermal development. The so-called *Joint Development Agreement (JDA)* model sees IPPs fully involved in construction and development during the power phase and contributing 40 to 80 percent of investment for drilling production wells and for geothermal field development (see **Box 8**).

The private sector could play an even larger role in exploratory drilling and production drilling under an *IPP steam development* model, and could even undertake both steam and power development in *full IPP concession* models. For example, the Akiira and AGIL companies have been licensed to undertake development of the Akiira One and Longonot fields, respectively.

If an IPP carried drilling and steam field development costs, tariff would need to rise by 60 to 75 percent, perhaps reaching between USD 0.14 and 0.17 per kWh (GDC, 2014; CPI 2015b). Tariffs higher than the USD 0.088/kWh offered in the current policy could allow project developers to take on higher risk and participate at an earlier stage in the geothermal project development cycle. However, higher tariffs may not be a priority for Kenyan policymakers, who are largely concerned with providing customers with power at affordable rates. In fact, there is a push at the policy level to lower the cost of energy and tariffs.[30]

30 See, for example, Karingithi, 2018.

BOX 8 UNIT COST OF ENERGY AND RISKS IN GEOTHERMAL ENERGY DEVELOPMENT



Source: Drafted by the author, based on information in CPI (2015a), KenGen (2018), GDC (2014), GDC (2016a), and GDC (2018a).
IPP: independent power producer. Note that the figure does not include power capacity at wellheads (about 80 MW) or small pilot plants (e.g. Eburru, 2.4 MW; Olkaria-Oserian, 3.3 MW).

Public sector support plays a significant role in covering the high cost and risks of the exploration and field development phase. This allows the unit cost of energy to remain between USD 0.065 and 10.5/kWh (as of 2018, the tariff was capped at USD 0.088/kWh).

Attracting private investors means financing the additional costs and risk to private developers either through such higher feed-in tariffs, or by a mix of grant funding, concessional loans, and drilling risk insurance. Akiira and AGIL have applied for such additional funding from the African Union's Geothermal Risk Mitigation Facility (GRMF) for their steam development activities (see **Box 9**).

Inthe GDC (or Menengai) model, the need for increased tariffs to incentivize private sector geothermal power development is offset by public measures addressing specific risks: GDC's lead role in the upstream phase (exploration and field development), supplemented by concessional loans and grant support.

It raises an important question: Is geothermal field and power development paid for through taxes (in the case of public support for steam development) or by the electricity consumer (through power tariffs)? It has also been suggested that an innovative alternative to public sector or public-private financing would be the use of insurance capital to help target specific risks the private sector faces in geothermal energy development (CDKN, 2017).

Which public-private partnership model is most appropriate depends on 1) the size and characteristics of the geothermal resources, 2) the technical and financial capacity of government and agencies, and 3) the level of private sector interest, which is related to the investment climate, the institutional and regulatory environment, and the tariff regime. ■

BOX 9 GRANT FUNDING FOR GEOTHERMAL ENERGY

The Geothermal Risk Mitigation Facility (GRMF) of the African Union Commission is providing infrastructure, surface studies, drilling, and development continuation grants to East African countries. For Kenya, both GDC (for drilling in Silali prospect, Suswa, Paka and korosi fields) and private companies (Agil, drilling in Longonot; Akiira, drilling Akiira I; as well as surface studies, such as by Arus Energy, Arus; Maralal Energy, Chepchuk, and Olsuswa, Barrier field) have applied in four rounds at an approved total of about USD 35 million (AUC, 2018).

ANNEX B:

List of interviewees

Jectone ACHIENG	*Manager, Project Management* Geothermal Development Company (GDC)
Solomon Abebe ASFAW	*Principal Power Engineer* African Development Bank (AfDB) – Nairobi
Samuel KAMARA	*Principal Country Program Office* AfDB – Nairobi
Shammah KIPTANUI	*Project officer, Project Management* GDC – Nakuru Office
Pascal MANAN	*Senior Officer, Community Relations* GDC – Nakuru Office
Everlyne MAPELU	*Project Officer, Project Management* GDC – Nairobi office
Lucas MBUGUA	*Business Associate* Quantum Power East Africa (QPEA)
George MWENDA	*Deputy Manager, Project Management* GDC – Nairobi Office
Dickens SERONEY	*Project Development Engineer* Quantum Power East Africa (QPEA)
Michael SIMIYU	*Chief Engineer, Project Management* GDC – Nairobi Office
Venugopal VARANASI	Sosian Energy

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