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Paving the Way for Investment in Geothermal Power Deployment in Developing Countries

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Working Papers on Development and Global Governance

No. 13

May 2016

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The *UAR Working Papers on Development and Global Governance* publish outstanding papers of students from the Master Programmes of the UA Ruhr Graduate Centre for Development Studies.

Bibliographic Notes:

Adisorn, Thomas (2016): Paving the Way for Investment in Geothermal Power Deployment in Developing Countries. Duisburg/Bochum: UAMR Graduate Centre for Development Studies (Working Papers on Development and Global Governance - No. 13).

Abstract

Geothermal power represents a unique source of electricity, for instance due to its low-carbon and base-load character. Some developing countries have a great potential for deploying geothermal power and, thus, for providing climate-friendly electricity to their economies and people. However, in order to reap the benefits of geothermal power substantial barriers must be overcome. By having screened the relevant literature, important hurdles to geothermal power deployment were defined: financing barriers, institutional barriers and uncertainty, lack of human resources, information barriers and social opposition. Through desk research carried out for Indonesia and Kenya, both of which are frontrunners in terms of installed geothermal power capacity, this study identifies options that contribute to overcoming aforementioned barriers. Hence, it offers recommendations primarily to developing countries in order to realize geothermal power production and, thus, to contribute to climate change mitigation.

Keywords: geothermal power, renewable energy sources, climate change, deployment barriers, investment and policy framework, Indonesia, Kenya, developing countries

Zusammenfassung

Geothermie-basierte Stromproduktion ist einzigartig, beispielsweise aufgrund geringer Emissionen und gleichzeitiger Bereitstellung von Grundlastelektrizität. Einige Entwicklungsländer haben enorme geothermische Potenziale und sind somit in der Lage, klimaneutralen Strom für ihre wachsenden Ökonomien und Bevölkerungen bereitzustellen. Allerdings erschweren Barrieren die Umsetzung von geothermie-basierter Stromproduktion. Im Zuge der Studie wurden folgende Barrieren bestimmt: Finanzierungsbarrieren, institutionelle Barrieren und Unsicherheit, Mangel an Humankapital, Informationsbarrieren und sozialer Widerstand. Durch Literatur-gestützte Analyse für die Fallstudien Indonesien und Kenia, die bereits über enorme geothermische Kapazitäten verfügen, werden Handlungsoptionen identifiziert, die dazu beitragen, die genannten Barrieren zu überwinden. Folglich bietet diese Studie Empfehlungen v.a. für Entwicklungsländer, um geothermie-basierte Stromproduktion umzusetzen und damit einen Beitrag gegen den Klimawandel zu leisten.

Keywords: Geothermie-basierte Stromproduktion, Klimawandel, Entwicklungsbarrieren, Investitions- und Politikrahmen, Indonesien, Kenia, Entwicklungsländer

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Abbreviations

AGID	African Geothermal Inventory Database
ADF	African Development Fund
AMDAL	Environmental Impact Assessment (in Indonesia)
APEC	Asia Pacific Economic Cooperation
API	Indonesian Geothermal Association
ARGDF	African Rift Geothermal Development Facility
AUC	African Union Commission
Bappenas	State Ministry of National Development Planning
BBC	British Broadcasting Corporation
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung
Bn	billion
BP	British Petrol
BTI	Bertelsmann Stiftung's Transformation Index
CIA	Central Intelligence Agency
CIF	Climate Investment Fund
CO_2	Carbon dioxide
CVGHM	Centre of Volcanology and Geological Hazard Mitigation
DC	Developing country
DG NREEC	Directorate General for New and Renewable Energy and Energy Conservation
EIA	Environmental Impact Assessment
ERC	Energy Regulatory Commission

FiT	Feed-in tariff
FS UNEP	Frankfurt School of the United Nations Environment Programme
GDC	Geothermal Development Company
GDP	Gross domestic product
GEF	Global Environment Facility
GFF	Geothermal Fund Facility
GHG	Greenhouse gas
GoI	Government of Indonesia
GoK	Government of Kenya
GPC	Geothermal Power Conference
GRMF	Geothermal Risk Mitigation Facility (Kenya / East Africa)
GW	Gigawatt
GWh	Gigawatt hour(s)
HRD	Human resource development
ICEIDA	Icelandic International Development Agency
ITC	Information and communications technology
ITF	European Union Africa Infrastructure Trust Fund
IEA	International Energy Agency
IFC	International Finance Corporation
IGF	Infrastructure Guarantee Facility
IISD	International Institute for Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent power producer
IRENA	International Renewable Energy Agency
ITB	Institute of Technology Bandung
KEN	National Energy Policy

KenGen	Kenya Electricity Generating Company
KfW	Kreditanstalt für Wiederaufbau
kWh	Kilowatt hour(s)
MGI	McKinsey Global Institute
LCPDP	Least Cost Power Development Plan
LoC	Library of Congress
MGI	McKinsey Global Institute
MIF	Multi-Infrastructure Facility
mn	million
MoEMR	Ministry of Energy and Mineral Resources
MoEP	Ministry of Energy and Petroleum
MW	Megawatt
NEMA	National Environmental Management Authority
NGCBP	National Geothermal Capacity Building Program
NTB	Nusa Tenggara East
NTT	Nusa Tenggara West
OPEC	Organization of Petroleum Exporting Countries
PIP	Indonesian Investment Agency
PLN	Perusahaan Listrik Negara
PPP	Power purchasing parity
PwC	Pricewaterhouse Coopers
REP	Renewable Energy Portal (Kenya)
RET	Renewable energy technology
UGM	Unitersity of Gadjah Mada
UNEP	United Nations Environment Programme
UNEP FI	Financing Initiative of the United Nations Environment Programme

UNDP	United Nations Development Programme
UNU-GTP	United Nations University Geothermal Training Programme
UoA	University of Auckland (New Zealand)
UoM	University of Manado (Indonesia)
U.S.	United States
USD	United States Dollar
U.S. DoE	United States Department of Energy
VOC	Dutch East India Company
VSI	Volcanological Survey Indonesia
Web GIS	Web Geographic Information System (Kenya)
WEC	World Energy Council

1. Introduction

The scarcity of electricity represents a bottleneck to the socio-economic development in developing countries (DCs). Most frequently, literature refers to children living in DCs, who cannot study beyond nightfall because they lack access to electricity. Moreover, electricity is tremendously important for business and industry in order to continue services and production whenever necessary. Hence, electricity is relevant for, at least, two reasons – for promoting human development and for driving economic growth (Karekezi et al. 2012; Emberson et al. 2012).

Electricity can be produced from a variety of energy sources including fossil fuels (coal, oil, gas) and non-fossil or green energy sources such as solar-, wind-, hydro- and geothermal sources. However, the use and expansion of fossil fuel-based power production should be avoided as much as possible because, when combusted, fossil fuels emit greenhouse gases (GHG) into the atmosphere, which, in turn, accelerates climate change (Emberson et al. 2012). This does not only apply to industrialized countries, even though they, admittedly, have predominantly caused the stock of GHG emissions in the Earth's atmosphere (Grubler et al. 2012). Likewise DCs with high levels of GHG-emissions as well as DCs only emitting small levels of GHG must avoid increasing emissions. While the former must strive to reduce power sector emissions, the latter are challenged by keeping GHG-levels low. The transformation towards a global low-carbon power sector, to which every country should make its contribution, matters to DCs more than to industrialized nations because DCs are more vulnerable to the effects of climate change and have less capacity to deal with its consequences (Emerson et al. 2012).

Electricity generated through geothermal power can contribute to supplying electricity to households, public and commercial services and industries with hardly causing any climate-destroying emissions in DCs. Hence, in DCs with geothermal resources available, this type of power production can facilitate a low carbon development pathway. The energy source of geothermal power is heat energy emanating from the Earth's inner core. Through extensive drilling activities, such heat energy is made accessible and can be transformed into power (Gehringer & Loksha 2012a; Goldstein et al. 2011). However, in order to reap the benefits of geothermal power, a set of barriers must be overcome. By drawing on the cases of Indonesia and Kenya, this study establishes recommendations for other developing countries, how geothermal deployment barriers can be overcome so as to ensure their sustainable supply of electricity.

Geothermal resources for power production are available in several developing countries. Peru, for instance, is considered to have geothermal resources of around 3,000 Megawatt (MW), none of which has been developed yet but is sought to be explored with the help of the Government of Japan (Nippon Koei, Fuji Electric & Yokogawa Electric 2014). Likewise Papua New Guinea has been found to have substantial geothermal resources available for power deployment (Kuna & Zehner 2015), and the United States-(U.S.-)based Geothermal Energy Association (GEA

2014a, p. 2) estimates that “East Africa, Central America, the Caribbean, and the South Pacific are some of the fastest growing geothermal nations worldwide. Together these nations are developing nearly 730 sites and another 12.1 GW[Gigawatt] of potential power.” This shows that the geothermal power sector is in flux at the moment and that it is important to seek an understanding, as to what needs to be done in order to overcome barriers to geothermal power deployment in DCs with geothermal resources available.

Given this study’s objective, findings obtained are relevant for different target groups. First, DC-governments, that increasingly attempt to deploy geothermal power, can draw on the results delivered through this study in order to design and implement a policy framework that creates an investment friendly environment for the private sector. Findings may also be of interest to donor organizations, civil society groups as well as private sector actors including geothermal power developers and investors in order to lobby for more benevolent government action. Additionally, as few papers have been published in renowned academic journals on the role of geothermal power policies and measures and given the exceptional role of geothermal power, this study may kick start the debate in the scientific community.

Following this section, Chapter 2 provides information on geothermal power showing its rather low global level of penetration, despite the technology’s advantages. By reviewing the literature comprehensively, different types of barriers are identified that negatively affect geothermal power expansion particularly in developing countries. This allows for dividing the central research question into supplementary questions guiding the analytical part. But prior to diving into the case studies, the methodological approach is presented including the reasoning for the selection of cases. Chapters 4 and 5 with the respective case studies on Indonesia and Kenya are structured in the same way. Country and power sector background information is initially given and pursued by more detailed information on geothermal resources and power production in the countries. The analysis, eventually, focuses on how the governments of Indonesia and Kenya seek to overcome barriers to geothermal power deployment. Findings in the case studies are merged in Chapter 5. The study is wrapped up in Chapter 6.

2. Theoretical Background

The central research question of this study is the result of comprehensive screening of the relevant literature available at present. The body of literature considered can be structured into four information packages, which, admittedly, overlap with regard to the questions: How does geothermal power generation work? How is it developed? What are the advantages of geothermal power and what are barriers to investment and, thus, deployment? The subsequent sections give an overview of the literature screened and provide answers to the questions above.

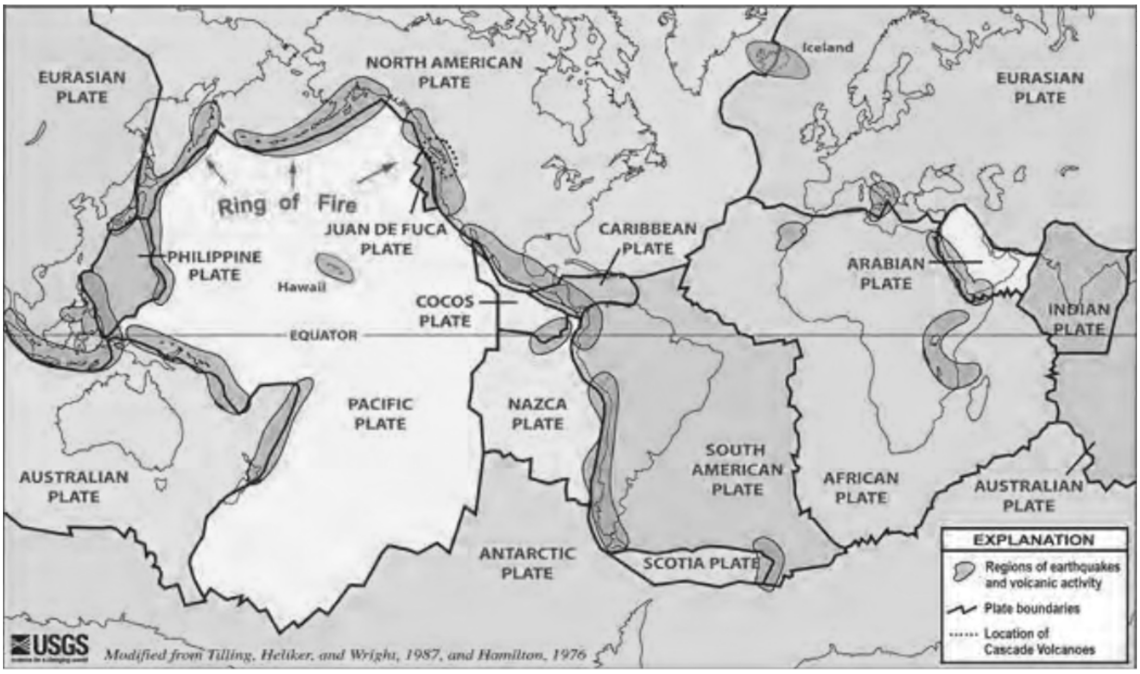
2.1. From geothermal resources to geothermal power

Information on the functionality and history of geothermal energy is given by Goldstein et al. (2011) published with the Intergovernmental Panel on Climate Change (IPCC) discussing the nexus between "Renewable Energy Sources and Climate Change Mitigation." Goldstein et al. (2011) focus on both types of the uses of geothermal energy, that is heating and electricity generation. The "Technology Roadmap for Geothermal Heat and Power" offered by the International Energy Agency (IEA 2011) confirms facts stated by Goldstein et al. (2011), while Salmon et al. (2011) focus exclusively on the indirect use or electricity generation, which is also the core of this study. Gehringer and Loksha (2012) concentrate on geothermal power generation in developing countries and provide great insights into the indirect uses of geothermal energy. The source has proven to be very valuable for this study. Both, Gehringer and Loksha (2012) and a report published by the German-based International Geothermal Association et al. (2013) provide a detailed description of geothermal power development, which they structure into eight stages (further described below). Deloitte (2008) divides the complete development process into four phases only, but the main assignments necessary to be carried out during this process remain the same.

In simple terms, geothermal heat is stored below the Earth's surface. The heat is generated from the Earth's inner core, where temperatures are estimated to range between 5,000 and 7,000 degree Celsius. Moreover, heat is generated from the decay of natural radioactive elements, which are located in several layers of the Earth's crusts. The geothermal heat resource can be employed for power production. In general, near-surface resources, which are normally less hot, can be used for generating heat energy, while deeper resources can be used for producing electricity. Exceptions to this rule are due to locations with "volcanically active areas" (Gehringer & Loksha 2012a, p. 15), where attractive geothermal resources are less deep in the Earth. Figure 1 provides a rough indication of such volcanically active areas.

According to Salmon et al. (2011, p. 2) "[g]eothermal power plants work similarly to traditional thermal plants in many respects in that they convert heat to electricity using a turbine-generator." However, instead of combusting fossil fuels such as coal, oil or gas to generate heat, geothermal power plants use heat stored in geothermal fluids underground. As of today, two kinds of geothermal power plants have penetrated the market, steam-condensing and binary power plants (Goldstein et al. 2011; IEA 2011; Salmon et al. 2011). Before successfully supplying geothermal-based electricity to consumers, several processes must precede. This section only sketches the development process based on Gehringer and Loksha (2012) and the International Geothermal Association et al. (2013).

Figure 1: World map indicating tectonic plates and volcanically active regions



Source: United States Geologic Survey n.d. as found in Gehringer & Loksha 2012, p. 14

In the first phase, geothermal power developers must seek to identify attractive resource spots. In order to be successful, developers must collect nationwide data and, then, pre-select promising areas. The initial stage is generally referred to as the preliminary survey phase (Phase I) and precedes the resource exploration phase (Phase II). The latter includes in-depth surveys at pre-selected locations. Through, among other things, geological, geophysical and geochemical studies, developers seek to obtain as much knowledge as possible of "resource temperature, depth, [and] productivity" (International Geothermal Association et al. 2013, p. 8). Such information is vital in order to preliminarily calculate future costs (e.g. for drilling) and returns. However, resources can only be confirmed through test drilling, which is the reason why the literature screened refers to this phase as test drilling or confirmation drilling phase (Phase III). For test drilling it is not only necessary to have heavy machinery (e.g. drilling rigs) available, but also to have access to the areas in focus and to ensure that transport routes can bear "dozens of heavy full size containers, including fuel and power generators, long steel pipes (casings), drilling mud, and cement [that] have to be transported to the drilling site" (Gehringer & Loksha 2012a, p. 57). With confirmed resource data, geothermal power developers can adjust their original documents, "size the planned development, and secure power purchase agreements on which financial models can be built" (International Geothermal Association et al. 2013, p. 10). As developers must obtain financing from banks, such models are also essential from a financing perspective. Gehringer and Loksha (2012) refer to this phase as the project review and planning phase (Phase IV). Having established a solid financing regime, the field development phase (Phase V) can commence involving the drilling of production and reinjection drilling (see Figure 1 above). The amount of wells varies from location to location, but the operation of more than one rig is not unusual in order to shorten the total time required to drill a sufficient amount of wells. In the construction phase (Phase VI), the power plant, pipelines, transmission lines etc. are completed and the geothermal power plant can be commissioned (Phase VII) (Gehringer & Loksha 2012; International Geothermal Association et al. 2013).

2.2. Historical development of geothermal power

The International Renewable Energy Agency (IRENA 2015) and the Geothermal Energy Association (2014) offer information on the status of geothermal power in comparison to other renewable energy technologies (RETs). Information can also be verified via the excel-spreadsheet provided by British Petrol (BP 2014) that gives quantitative information on geothermal power capacity installed in different countries worldwide. While IRENA's database, called "RESOURCE," hosts purely quantitative and easy-to-access data, the Geothermal Energy Association annually publishes relevant information on global geothermal power deployment. In order to employ data on global investments in geothermal power, this study makes use of data from the Collaboration Center for Climate and Sustainable Energy Finance of the Frankfurt School and the United Nations Environment Programme (FS UNEP 2014).

The track record of geothermal power generation dates back to the beginning of the 20th century. The first power plant using geothermal resources was built in Italy in 1904. Countries such as the United States (U.S.), New Zealand, Iceland or Japan followed (Goldstein et al. 2011; IEA 2011; Salmon et al. 2011). The global expansion of geothermal power deployment very slowly started to take off in the 1970s with an oil crisis forcing governments to seek alternatives to oil-based power production (GEA 2012).

As of 2013, the global frontrunners in terms of total geothermal capacity installed are the U.S., the Philippines and Indonesia as shown in Figure 2.

Figure 2: Global top-ten countries regarding total installed geothermal power capacity as of 2013

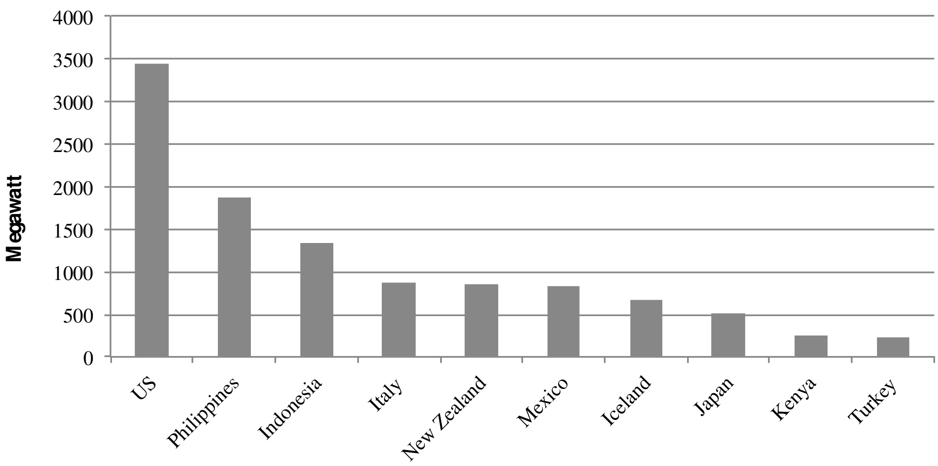


Figure based on: BP 2014

Still, geothermal energy is rather a footnote compared to other renewable energy technologies. It contributes to only 0.7% of the total globally installed renewable energy capacity (as of 2013). Hydropower, wind and solar energy lead the field with shares of 67%, 19% and 8%, respectively (IRENA 2015). A major reason is the lack of financing available for the development of geothermal resources (FS UNEP 2014). In particular, as a result of the 2008 financial crisis geothermal funding deteriorated (Salmon et al. 2011) and as pointed out by Wang et al. (2012, p. x),

> [g]lobally the limited amount of commercial financing that was available for geothermal development has worsened since the 2008 financial crisis as many of the commercial banks that used to support geothermal development withdrew or went bankrupt.

However, between 2004 and 2013, data suggests an upwards trend as global funding for geothermal power increased from U.S. Dollar (USD) 1.3 billion (bn) in 2004 to USD 2.5bn in 2013 (FS UNEP 2014).[1] Whether funding for geothermal power will substantially increase in the future, also depends on investment friendly policy frameworks to be established in countries with geothermal resources available and how these frameworks contribute to overcoming barriers to geothermal power deployment.

2.3. Benefits of geothermal power production

Gehringer and Loksha (2012a) provide a balanced account on the benefits of geothermal power as well as its deployment challenges, while other sources also touch upon that issue (Deloitte 2008; McIlveen 2011; Goldstein et al. 2011; Salmon et al. 2011; IEA 2011).

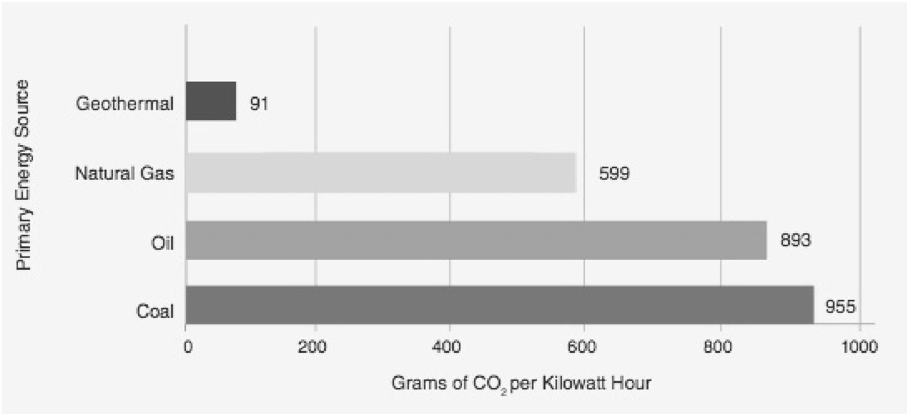
First, geothermal resources are categorized as renewable resources because “the Earth endlessly generates heat at its core through radioactive decay” (Gehringer & Loksha, p. 20). While geothermal heat is inexhaustible on a global scale, proper field management is crucial: “Even though geothermal power generation usually depends on a reservoir of hot water or steam (i.e., geothermal fluid), the volume extracted can be reinjected, making its exploitation sustainable when appropriately managed” (ibid.). Due to this unlimited availability, geothermal-based power generation can be advantageous to countries that presently have to rely on conventional resources for electricity production. The implications of (partly) substituting conventional resources are country-specific and require an assessment of the respective power system. For instance, the lifespan of fossil fuel reserves can either be extended or energy imports for power production be reduced.

While Bravi and Basosi (2013) offer a contrary standpoint, in the literature screened geothermal power is considered to be highly advantageous from a climate change perspective. Geothermal power plants, in general, produce a moderate amount of GHG, but these “are negligible compared to those of fossil fuel combustion-based power plants” (IFC 2007, p. 3). According to Goldstein et al. (2011, p. 418 referring to

[1] Please note that the literature screened did not give any hints why funding increased between 2004 and 2013.

Bertani and Thain 2002), geothermal power stations have been found to produce between four and 740 g CO_2/kilowatt hour (kWh) and on average they produce 122 g CO_2/kWh. In the U.S., conventional primary energy sources have significantly higher emissions than geothermal sources as shown in Figure 3 below.

Figure 3: CO_2 emission per primary energy source in the United States

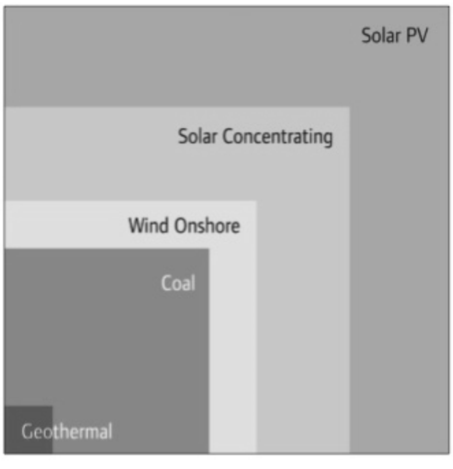


Source: Friedleifsson 2008 as found in Gehringer & Loksha 2012a, p. 63

The exact quantity of CO_2 is site-dependent, since "[g]eothermal fluids contain […] variable quantities of gas, mainly CO_2" (Goldstein 2011, p. 418). The kind of power plant technology used can also reduce emissions. For example, in certain circumstances emissions of binary geothermal power plants can be almost zero (ibid.).

Moreover, it is noteworthy that geothermal power plants require less land per MWh installed than other types of power plants as shown in Figure 4 (McIlveen 2011; Gehringer & Loksha 2012, p. 20). Since geothermal power plants are site-constrained, as will be discussed further below, the low need for land is a huge advantage, in particular, if resources are located beneath surfaces covered with human settlements and / or environmentally unique landscapes. Due to the low demand for areas of land, less people are affected by the risk to lose their habitat.

Figure 4: Land use of different types of power generation (MWh / acre)



Source: McIlveen 2011, p. 25

Geothermal power is also considered to be resilient to changing weather conditions and, thus, to climate change (Goldstein 2011). From a longer-term energy perspective, climate change is an important variable to be taken into account for green electricity system planning. For example, hydroelectricity depends to some extent on wet seasons and could strongly be affected by climate change. Thus, dry periods may not only trigger a water crisis in some areas but also a power crisis, which may kick off a socio-economic downward spiral. Geothermal power is not only independent of changing climate conditions but also of changing weather conditions. As heat from the earth is generated constantly, geothermal power can be provided on a daily basis and throughout the year (“base load”). While demand for electricity may fluctuate, for example, it may increase in the mornings, it is, generally, never below this base. Solar and wind, for instance, cannot guarantee a stable electricity supply without expensive storage solutions because these technologies are dependent on weather conditions. In contrast to wind and solar power, geothermal power is in a position to ensure base load (Goldstein 2011; IEA 2011).

2.4. Barriers to geothermal power production in developing countries

A vast body of literature exists discussing barriers to attracting geothermal power developers. These barriers do not necessarily only apply to developing countries. However, it can be assumed, that DCs are more affected by these barriers than industrialized countries. Based on the literature screened, the barriers can be structured into five clusters:

- Financing barriers
- Institutional barriers and unreliability
- Insufficient human resources
- Information barriers
- Social opposition.

The bankability of any geothermal power project is, generally, the capacity of a project to attract commercial financing. In the initial phases, the attractiveness of geothermal power projects is low, mainly for three reasons: high upfront costs, high resource risks and long lead-times to generate returns. While expenses for operating a geothermal power plant are low, deploying such a power station involves high upfront costs as shown in Table 1, which provides an overview of the cost structure for a 50 MW geothermal power plant.

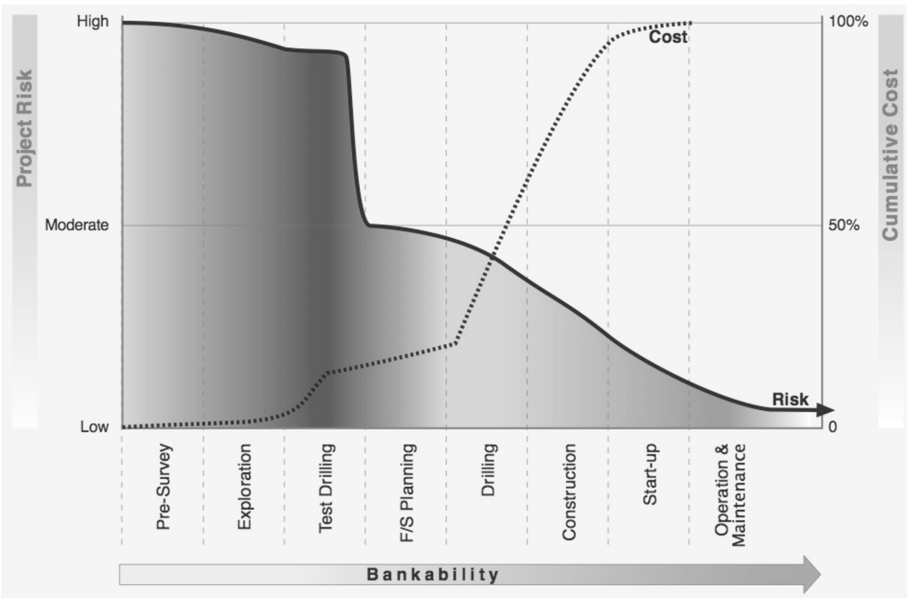
The first three project phases deserve special attention because they may require between 10% and 14% of the total project costs. In particular, high costs in the initial project phases are particularly problematic as these phases are associated with high risks of not finding adequate resources. The risk-cost structure is provided in Figure 5 (Gehringer & Loksha 2012, p. 66ff.).

Table 1: Cost estimates of individual geothermal power project phases of a 50 MW power plant and project schedule

Project years (Average lead-time)		1	2	3	4	5	6	7	Cost estimates in million USD		
									Low	Medium	High
Project phase	1) Preliminary survey								1	2	5
	2) Exploration								2	3	4
	3) Test drillings								11	18	30
	4) Project review & planning								5	7	10
	5) Field development								45	70	100
	6) Construction								75	91	117
	7) Start-up and commissioning								3	5	8
∑									142	196	274

Table based on: Gehringer & Loksha 2012, p. 41

Figure 5: Financing barriers to geothermal power development



Source: Gehringer & Loksha 2012, p. 4

Even if surface studies and theoretical evidence exist, only information delivered through test drilling about the quantity and quality of geothermal resources enhances the resource knowledge and, thus, reduces the risk to a medium level. Hence, as shown in the Figure 5, the project risk assumed is significantly lower after test drilling is completed (Phase III). Drawing again on the example of a 50 MW geothermal power plant (see Table 1), a private sector developer successively needs to have USD 14 million (mn) to USD 39mn in order to successfully carry out Phases I to III. However, few financing institutions will be willing to lend such an amount to developers with project risks being very high, which would oblige developers to carry out these Phases I to III with their own capital. For instance, one of the few private sector developers that is able to do so, is the U.S. based oil company Chevron, which "has the financial resources to fund the [geothermal] project using hydrocarbon revenue and to take all the risk from exploration to power generation" (Gehringer & Loksha 2012, p. 9). Table 1 also shows that a geothermal power plant has a lead-time of seven years on average before a geothermal power plant can be put into operation. The lead-time ranges from five to ten years (ibid.).[2] With respect to the bankability of a geothermal project, the long lead-time is a major investment barrier as financial returns can only be generated at later dates.

Due to the long lead-time that is associated with geothermal power projects, institutional barriers are of particular concern. For instance, institutional barriers may refer to the (in)capacity of relevant authorities in charge of facilitating geothermal projects. Generally, geothermal project developers must apply for licenses or clearances from government authorities while developing geothermal fields. For example, if authorities are not sufficiently trained to process licenses, project delays can be the result, which increase the costs of borrowed capital and the time until returns from power generation can be expected. Apart from that, institutional barriers may also refer to legislative issues preventing geothermal power deployment. New Zealand is an interesting case, where "almost half of the identified geothermal resources are in protected areas where [geothermal] development is limited or forbidden (International Geothermal Association et al. 2013, p. 6). Ideally, a competent government body "in charge of the energy sector whose functions include explicit planning for geothermal energy development" (Gehringer & Loksha 2012, p. 77) taking into account the technology's unique characteristics is established that can identify and overcome institutional barriers. Moreover, uncertainty in the institutional set-up for geothermal power deployment reduces the private sector's incentive to investment. The Financing Initiative of the United Nations Environment Programme (UNEP FI 2012, p. 13) found by interviewing private sector stakeholders of the renewable energy sector in Africa that renewable energy expansion targets are essential:

> Targets are considered key as they provide the backbone of any country's overall renewable energy strategy and the framework within which incentive mechanisms, such as feed-in tariffs or quotas, are placed. Most critically, clear targets and a formulated government vision provide certainty to private sector actors and make subsequent public incentive instruments more reliable and trustworthy from the perspective of financiers.

Additionally, reluctance of investors can also be caused by information either not being available, accessible or up-to-date. As Gehringer and Loksha (2012, p. 5) state

> [i]nformation is the first key element that supports the development of a geothermal project or program. The country government has an important role to play in making geothermal resource information available to potential developers and investors. At a minimum, the government should keep public records on such geothermal attributes as seismic data (events, fractures, etc.) and deep drilling data (temperature, pressure, faults, permeability).

[2] One major exception is the Ngatamariki geothermal plant in New Zealand, commissioned in 2013 and built in a record time of 24 months (Ormat Technologies 2013).

Moreover, the information gap may refer to different issues including information on licenses and clearances, which need to be acquired for developing a geothermal power plant, and on obtaining government project approval. For instance, the U.S. Geothermal Technologies Program of the U.S. Department of Energy (U.S. DoE) established the so-called Geothermal Regulatory Roadmap guiding geothermal developers through a complex web of individual regulations installed in ten U.S. federal states (U.S. DoE 2015).

The lack of skilled personnel is another challenge to geothermal power deployment. As the United Nations University Geothermal Training Programme (UNU-GTP 2015), points out, experts must come from different disciplines, such as geochemistry or geophysics to name a few only. Alternatively, expertise could be imported, which, however, would increase project costs. UNU-GTP has been training geothermal personnel from developing countries since the 1970s and many other capacity enhancement programs have been made available through aid agendas of donor organizations. However, recently, the availability of such programs has become limited as Wambugu (2010) points out:

> The UNU-GTP is at present the only international graduate school offering specialized training in all the main fields of geothermal science and engineering. Two international schools were established in 1970 in Italy and in Japan and in 1978, two more were established in Iceland and in New Zealand. Unfortunately the Pisa school in Italy has not held its course since 1993 due to drastic cuts in government funding however, it has occasionally held short courses (1-3 weeks) in developing countries. The International Group Training Course at Kyushu, Japan was discontinued in 2001 while the Diploma course at the University of Auckland in New Zealand was also discontinued in 2003 due to withdrawal of government financing.

While there is some flexibility in finding a proper location for other types of power plants, geothermal power stations are bound to specific locations, where adequate resources are available. Unfortunately, geothermal heat energy cannot be transported but must be turned into electricity close to the location of the resource. Even though the construction-related footprint of a geothermal power plant is low compared to other types of power plants (McIllveen 2011; Gehringer and Loksha 2012), site-constraints can trigger social opposition (Pacific International Center For High Technology Research 2013).

In a nutshell, in order to attract private sector investment, it is crucial for governments to overcome financing barriers, institutional barriers as well as uncertainty, the lack of human resources, information barriers and social opposition.

2.5. Research question

In the preceding section, this study identified the main barriers affecting geothermal power deployment. Hence, this study deals with the central research question of how developing countries can overcome barriers to geothermal power deployment so as to ensure the sustainable supply of electricity for people and the economy. The supplementary research questions are as follows:

- How can DCs overcome financing barriers to geothermal power deployment?
- How can DCs overcome institutional barriers and unreliability to geothermal power deployment?
- How can DCs overcome the lack of human resources to geothermal power deployment?
- How can DCs overcome information barriers to geothermal power deployment?
- How can DCs overcome social opposition to geothermal power deployment?

3. Methodological approach

In order to answer the central and supplementary research questions, this study carries out case-centric studies on Indonesia and Kenya using extensive desk research. The subsequent sections, first, discuss the method applied and, second, justify the case selection.

3.1. Discussing the method

A case-centric study design was deliberately chosen for this paper because this, according to Blatter, Janning and Wagemann (2007, p. 127), allows research to provide a more precise and comprehensive picture of single cases. Hence, the method allows for investigating into a few cases (Indonesia and Kenya) in close detail and exploring factors that contribute to facilitating geothermal power and taking into account unique characteristics of the single cases. While highlighting the usefulness of case-centric studies, Blatter, Janning and Wagemann (2007) admit that such study designs hardly contribute to building theories. However, theory construction is not the overall aim of this study. Based on two cases closely scrutinized in terms of unique country characteristics, this paper rather strives to make recommendations to other DCs to overcome deployment barriers to geothermal power. While this study is to provide to other DCs stimuli on how to tackle and overcome deployment barriers, a close needs assessment of DCs is essential to apply recommendations made in this study.

Answers to the research questions have been compiled through pure desk research. Interviews with key stakeholders in Indonesia and Kenya would have been another option. However, on-site interviews in Indonesia and Kenya would have gone beyond this study's budget. Alternatively postal or e-mail inquiries to German or international country experts could have been made, but the risk of interviewees slowly responding could have delayed this study. Excluding the interview / inquiry options, desk research was considered to be the most viable method of generating data on Indonesia and Kenya and on overcoming geothermal deployment. A variety of sources was carefully examined so as to give a comprehensive picture of the cases. Although the amount of data found was limited, it was attempted to employ a great variety of sources to, ultimately, verify the reliability of information – this was not always possible. The sources carefully screened can be structured as follows: Government documents (policy papers, etc.), donor documents (project document for financing geothermal power plant construction etc.), publications resulting from geothermal conferences, newspaper articles and diverse online sources.

3.2. Case selection

The objective of this study is to demonstrate how developing countries can overcome barriers to geothermal power development. In so doing, it draws on two developing country cases (Indonesia and Kenya). While Indonesia is defined as a lower middle income country, Kenya is considered a low income country (OECD 2014). In both countries substantial parts of the population do not have access to electricity, which negatively affects people's socio-economic development (Asian Pacific Economic Cooperation (APEC) 2013; Ministry of Energy and Petroleum (MoEP) 2015; African Development Fund (ADF) 2014). Indonesia and Kenya have experienced economic growth (World Bank 2015), but in order to grow in the future, it is crucial to meet rising electricity demand. In this respect, geothermal power represents a great opportunity, which would also contribute to protecting global goods such as the climate. Moreover, the Southeast Asian country as well as the East African country (i) belong to the top-ten in terms of installed geothermal power capacity and (ii) since the 1970s and 80s have gained long-standing experience in this type of power generation technology. Thus, it can be assumed that these countries are fully aware of geothermal power deployment barriers.

Surprisingly enough, three developing countries range among the top ten in terms of total geothermal power capacity: the Philippines, Indonesia and Kenya, which are ranked second, third and eighth, respectively (see Figure 2). Each of the three countries brought geothermal power capacities online in the 1980s. As there is only a limited amount of up-to-date data available on geothermal power in the Philippines, this country has deliberately been excluded from this study. A possible reason for this lack of literature could be that the Philippines have already exploited around 50% of their estimated geothermal power potential (National Geothermal Association of the Philippines 2011). It can be assumed that the Philippines' interest in exploiting geothermal resources is inactive at present and exploration will be continued at a later date. Indonesia and Kenya, however, only utilize 4% and 3% of their respective potential,[3] so that, presumably, in these two countries, the interest of developing geothermal power and providing the respective population with green, base-load electricity is still more active than in the Philippines. Moreover, Indonesia and Kenya have experienced constant progress regarding geothermal power deployment in the previous years, while in the Philippines the amount of installed geothermal power capacity stagnated between 2000 and 2013. It can be concluded that the Philippines have not contributed much to the debate on how barriers to geothermal power can be overcome. Hence, this study focuses on recent and progressive action undertaken by governments to overcome barriers to geothermal power deployment. As developing countries, Indonesia and Kenya are frontrunners in terms of geothermal power capacity and, thus, could also be seen as role models for other countries, which also

[3] Calculations are based on data presented in the State Ministry of National Development Planning (Bappenas) (2014) for Indonesia and the Energy Regulatory Commission et al. (2011) for Kenya.

host substantial amounts of geothermal resources – above, this study already referred to the case of Peru, for instance. This study can contribute to support other developing countries to dealing with energy-related problems including social, environmental and economic issues by overcoming geothermal deployment barriers.

3.3. Limits of research

While the case selection should have the potential to offer great insight into how barriers to geothermal power deployment can be overcome in DCs, it is, at the same time a limiting factor. In particular, both cases are estimated to have a high resource potential. Hence, findings of this study are likely to be applicable to countries that are also home to a substantial amount of resources. However, as there are quite a few countries that do have a great resource potential (GEA 2014a), the research design is justified. Moreover, it is noteworthy that the analytical parts of this study clearly focus on more recent developments to overcome geothermal power deployment barriers, as identified above. The historical dimension is only touched upon. This allows the author to not go beyond the predetermined scope of this study. Moreover, given that it is essential for a study relying on desk research to preliminarily explore the range and depth of the literature available, it should be stated beforehand that little information appears to be available determining the causality of a particular measure regarding its direct effects on the geothermal power deployment. However, the analysis seeks to highlight the effects of particular measures dealing with deployment barriers using the literature already referred to in Chapter 2. In addition, recommendations made to other DCs, only focus on the deployment barriers as identified in Chapter 2 above. However, any kind of investment made is to some minor or major extent dependent on the overall performance of a political and economic system. For instance, a stable regime can attract substantial investment, whereas countries with swift regime changes could rather be perceived as unreliable locations for investment. Hence, while the author of this study acknowledges the relevance of changing factors in influencing investments made in a country, an assessment of the overall political and socio-economic performance of the cases analyzed is not intended and will not be part of the analysis.

4. Geothermal power development in Indonesia

The case study on Indonesia will, firstly, provide some background facts on the country including its history and its contemporary socio-economic and political context. After these introductory remarks, the focus is on Indonesia's power sector and the sector's challenges, before discussing the contributions of geothermal power towards meeting or mitigating the challenges. Prior to the analysis, information on the historical dimension of geothermal power in Indonesia is given. In the analytical section, it is shown how Indonesia intends to overcome barriers to geothermal power.

4.1. Country background

Europeans started to gradually explore Indonesia, located in Southeast Asia, from the 16th century onwards. Especially the Dutch through the Dutch East India Company (VOC[4]) became the dominating power in the country. VOC mercilessly controlled the local population, “aggressively using treaties and military means to establish VOC hegemony in the trade” (Frederick 2011, p. 24). In 1949 and four years after heavy fighting with the Dutch and 250,000 casualties, Indonesia gained independence.[5]

After decades of authoritarian regency (cf. Frederick 2011; Bertelsmann Stiftung’s Transformation Index 2014), Indonesia is, today, steered by a President, who is head of state and head of government, is checked and balanced by the People’s Representative Council (DPR) and the Regional Representative Council (DPD), which was was already enshrined in the 1945 constitution (King 2011, p. 234). In 2014, Joko Widodo was democratically and peacefully elected president.

Today around 253.6mn people live in Indonesia. The majority of the population (87%) is of Muslim belief. It is the fourth most populated country in the world (Central Intelligence Agency (CIA) 2015) and population growth is at around 1.2% (as of 2013; World Bank 2015). The country consists of approximately 17,000 islands. The distance from the very East to the very West of Indonesia is comparable with the distance from Dublin to New York City (Beech 2015). While roundabout 7,000 islands are inhabited, the large majority of Indonesians, approximately 80%, lives on the three main islands Java (140mn), Sumatra (51mn), and Sulawesi (17mn) (Encyclopedia Britannica 2013; 2014; 2015) and cities appear to become a focal point for larger parts of the rural population (McKinsey Global Institute 2012).

Since the 1997 crisis in Asia, positive political trends have been in tandem with strong and stable growth figures. Since 2005, Indonesia’s GDP has grown by around 6% on average (World Bank 2015).[6] It can be assumed that growth contributed to reducing the share of Indonesians living on less than USD 1.25 power purchasing parity (PPP) per day from 54% in 1990 to 16% in 2011. However, this figure still translates into close to 50mn poverty-stricken people. As stated earlier, Indonesia is still considered to be a developing country and – to be precise – according to the World Bank (2015) a lower middle income country with a gross domestic product (GDP) of USD 868bn as of 2013. GDP derives mainly from the industry sector (47%) and the services sector (40%). According to the McKinsey Global Institute (MGI 2012, p. 11), “high demand for its export commodities combined with a strong domestic market” are key drivers for economic progress. Moreover, MGI (2012)

[4] In Dutch: Vereenigde Oostindische Compagnie

[5] In the early years of the 20th century, the Dutch rule reached all corners of today’s boundaries and ended with the Japanese taking control from 1942 to 1945 seeking resources, particularly oil, and territorial expansion during WWII. Following the nuclear bombings in Japan by the U.S. in 1945, the Government of Japan surrendered and with no further claims to power in the Southeast Asian country, Japan facilitated the way for Indonesian independence. But the former Dutch colonial regime accepted the struggle for independence only in 1949 (Frederick 2011).

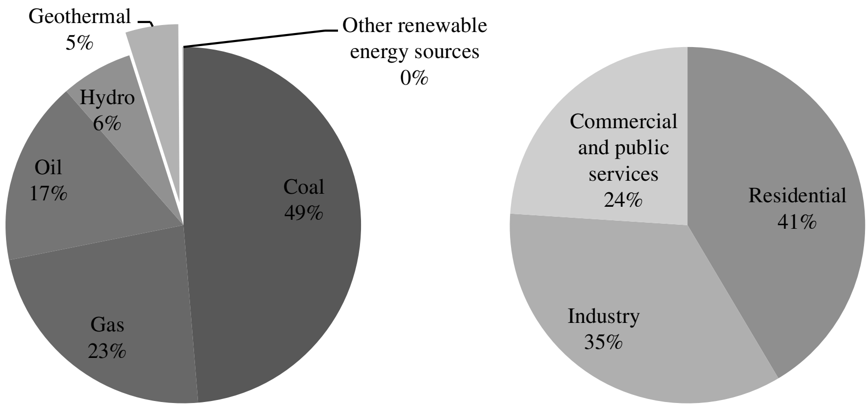
[6] MGI (2012, p. 11) notes that “Indonesia has experienced the least volatility in economic growth of any Organisation for Economic Co-operation and Development (OECD) or BRIC (Brazil, Russia, India, and China), plus South Africa economy in the world.”

estimates that the consuming class will increase from 45mn in 2010 to 135mn by 2030.[7]

4.2. Indonesia's power sector and its challenges

In Indonesia, around 40,000 MW of electricity generation capacity are online, three quarters of which are owned by the state-owned national utility PLN[8] and the remaining share being in the hands of independent power producers (IPPs) (Asia Pacific Economic Cooperation (APEC) 2013, State Ministry of National Development Planning (Bappenas) 2014; Pricewaterhouse Coopers (PwC) 2013). In 2012, Indonesia's power sector produced 195,895 GWh (IEA 2015a). The electricity mix is dominated by fossil fuel sources, particularly coal, as shown in Figure 6.

Figure 6: Electricity production per energy source (left) and final consumption per sector (right) as of 2012 in Indonesia



Based on: IEA 2015a

While both the commercial and public services sector consume only 40,000 GWh, the residential and the industrial sector require the lion's share of electricity with 73,000 GWh and 61,000 GWh, respectively (IEA 2015a). The total demand for electricity is expected to skyrocket to around 385,000 GWh by 2022 requiring a substantial expansion of power plant capacities of additional 60,000 MW (PLN 2013).

One of the major factors driving demand is, among other things, the welcomed government-set target to provide full-scale access to electricity to all Indonesian households by 2022. In particular, the East of Indonesia suffers from very low rates of electricity (APERC 2013).

Coal takes a leading role in Indonesia's power generation, also because ample reserves are domestically available in South Sumatra and Kalimantan.[9] Gas

[7] MGI (2012, p. 1) defines the consuming class as "those individuals with a net income of more than $3,600 per annum in purchasing power parity (PPP), at 2005 exchange rates."
[8] In Indonesian: Perusahaan Listrik Negara
[9] Indonesia belongs to the world's largest exporters of coal (World Energy Council (WEC) 2015).

resources are available, as well.[10] Moreover, the Southeast Asian country is also home to crude oil resources, but in contrast to coal and gas, crude oil reserves are very confined and not sufficient anymore to meet domestic demand. Between 1962 and 2008, Indonesia was the only Southeast Asian member of the Organization of the Petroleum Exporting Countries (OPEC). However, because of a rising domestic demand for oil, Indonesia became a net oil importer in 2004 and, eventually, suspended its OPEC-membership in 2008 (Pallone 2009).[11] Painting a more comprehensive picture, it should be noted that the increasing demand for oil, which has deteriorated Indonesia's resource base, has not only been driven by power needs but also by competing sectors such as transportation.

Regulated electricity tariffs set by the government generally do not cover the costs of electricity generation and, thus, the Government of Indonesia (GoI) must subsidize electricity consumption. According to the International Institute for Sustainable Development (IISD 2012), subsidies have been increasing in recent years from USD 0.9bn in 2005 to USD 3.4bn in 2006 reaching a climax in 2011 with over USD 9bn spent on subsidizing electricity production. In Indonesia, a large amount of crude oil is consumed for power consumption. Since crude oil prices are very volatile and in high-priced times, GoI must increase its subsidies in order to keep electricity prices at low levels.

The significance of fossil fuels for power production contributes to Indonesia's stock of GHG emissions driving climate change. Indonesia belongs to the top CO_2 emitters worldwide. The latest World Bank figures suggest that CO_2 emissions from the heat and electricity sector increased from 150 to 165 million metric tons between 2010 and 2011 (World Bank 2015).[12] Due to the Southeast Asian country's geographically unique situation, a rising sea level resulting from a changing climate is particularly dangerous to the archipelago. It is noteworthy that Indonesia is not only the largest island country in the world, but has also the world's second longest coastal lines, ranking only behind Canada. Some of the most important economic centers such as Jakarta and Surabaya are coastal cities (World Bank & Department for International Development 2007, p. 49).[13]

On the whole, Indonesia faces a set of interrelated challenges in the power sector. First, it must ensure that it can meet future energy demand in order to sustain economic growth and to provide the population with electricity, accordingly. Second, it is vital for Indonesia to reduce oil-based power production in order to increase the country's security of power supply and to achieve household planning security despite the subsidy regime. Third, as climate change is a serious threat to the survival of Indonesia's coastal cities, in particular, additional capacities should come from low-carbon energy sources.

[10] Indonesia is the "14th largest holder of proved natural gas reserves in the world." (WEC 2015b)

[11] As of 2013, Indonesia mainly imported crude oil from Saudi Arabia (26%), Nigeria and Azerbaijan (both 15%) (U.S. Energy Information Administration 2014).

[12] In Indonesia, GHG emissions are to great extend caused by land-use change.

[13] Moreover, food security may be compromised. Java may under certain conditions "lose approximately 113,000 – 146,000 hectares of rice fields, 16,600 – 32,000 hectares of horticultural land and 7,000 – 9,000 hectares of hard crop land in 2050" (GoI 2009, p. 84).

4.3. Geothermal resources and power production in Indonesia

The Indonesian archipelago is located between the Indian Ocean and the Pacific Ocean. Beneath the country's surface three tectonic plates led to the creation of roundabout 400 volcanoes, one fourth of which are active. Even though geothermal resources were explored under Dutch colonial rule in the 1920s, Bappenas (2014, p. 168) notes that serious activities in identifying geothermal resources revived only in 1964, when the Government of Indonesia appointed the Volcanological Survey of Indonesia (VSI), which is known today as the Center of Volcanology and Geological Hazard Mitigation (CVGHM), to compile an inventory of geothermal resources for some parts of the country. Together with scientists from New Zealand, VSI-experts systematically evaluated geothermal prospect areas with respect to geothermal power generation. In order to build the first geothermal power station in Indonesia, the state-owned oil- and gas company Pertamina, established in 1968, became involved.[14] Following a small-scale 1 MW power plant located in Kamojang in West Java, the facility was expanded to around 30 MW with financial support from the Government of New Zealand and was brought online in 1983. Today, the Kamojang power plant is still operating with a capacity of 200 MW (GeothermEx & World Bank 2010; Bappenas 2014).

In Indonesia's geothermal sector, the 1997 Asian financial crisis also marked a major cesura as noted by the Global Environmental Facility (GEF 2006, p. 6):

> During the early 1990s, eleven contracts were awarded for developing geothermal power plants with an expected total capacity of 3,147 MW. The projects were planned to be completed between 1998 and 2002, but they were all suspended or cancelled, due initially to the impact of the 1997-98 financial crisis.

In particular, the crisis affected the contracts negotiated between private sector field developers and the state-owned utility PLN – the single buyer of electricity. Contracts including electricity prices to be paid by PLN were contractually set in USD. However, as the crisis resulted in a dramatic weakening of the Indonesian currency, PLN announced that it would not be able to pay pre-crisis determined rates for electricity production, which led to project cancelation or standstill (Bappenas 2014). In 2000, instead of having more than 3,000 MW capacity online, capacities ranged around 600 MW only. As of today, GoI was able to have around 1,300 MW geothermal power capacity online representing only around 4% of Indonesia's total power capacity.

Geothermal resources used for power production could contribute immensely to meeting power sector challenges. The latest estimates suggest that Indonesia hosts 29,000 MW in geothermal resources, which is considered to be equivalent to 40% of the world's total geothermal resources (Bappenas 2014).[15] This is more than double the potential that was estimated in Indonesia in the 1990s (ADB 1995), which

[14] The exploitation process of oil and gas bears close resemblance to geothermal development. For instance, the knowledge and equipment to carry out geological studies and drilling are similar.
[15] Despite comprehensively screening the literature available, it is not clear how the share of 40% regarding global geothermal resources for power production emerged.

suggests that the quantity of resources identified may further increase in the future. Most of these resources have been identified in Sumatra (14,000 MW), in the Java-Bali region (11,000 MW) and Sulawesi (2,000 MW) (World Bank 2014a; Bappenas 2014).

Hence, as power demand is forecasted to increase substantially in Java-Bali and Sumatra, the exploration of geothermal resources in these areas could contribute to meeting rising demand. While not all resources may prove to be ideal for exploitation due to their location, the World Bank (2011, p. 2) notes that "[g]eothermal resources in Indonesia are also ideally located on islands with major population centers where electricity demand is high and continues to grow." Since such centers may pull in more people in the next decades, geothermal power could emerge as a main pillar in the cities' power mixes as it provides base load power, so that industries and services can run their businesses 24/7.

Given the large-scale resource availability, geothermal power expansion can contribute to providing much needed capacities in Indonesia, while reducing the share of fossil fuels, particularly, crude oil, used for power production and to lowering sector GHG emission. Moreover, in substituting oil-based power production, geothermal power fosters the security of power supply (due to a reduced import dependence) as well as improves the Government budgetary planning security, which is undermined through the subsidy regime in the Southeast Asian country.

4.4. Overcoming barriers to geothermal power development in Indonesia

As stated earlier, the subsequent sections provide information and an analysis on how Indonesia seeks to overcome barriers to geothermal power deployment. In the case study on Kenya, in Chapter 4, the same structure will be used. Findings from both case studies on how barriers can be overcome will, then, be merged and presented in Chapter 5.

4.4.1. Overcoming financing barriers

As has been shown earlier, the deployment of geothermal power is hampered by very high resource risks in Phases I to III and only after test drilling is completed, these investment risks are lowered towards a medium level. In order to overcome financing barriers to geothermal power deployment and to attract private sector investment, the Government of Indonesia has implemented a variety of instruments, which apply to different phases of the geothermal power development process.

In general, geothermal fields in Indonesia are preliminarily assessed by the Centre of Volcanology and Geological Hazard Mitigation, which is a research institute of the University Institute of Technology Bandung. While little information is available in the English language on the exact scope of work of CVGHM, it can be assumed that such preliminary assessments cover the preliminary survey phase and the exploration phase (Phases I and II), because of “its role to collect and promote geo-scientific data for the sustainable development of Indonesia’s resources” (Bappenas 2014, p. 180). The Ministry of Energy and Mineral Resources (MoEMR), which has overall authority for geothermal resource development, primarily assigns the CVGHM and fully finances its costs upfront. Once the CVGHM completes its duties, MoEMR approves the respective area for tendering, which is to be carried out by subnational authorities. The Ministry’s costs are recovered as soon as the geothermal site has been awarded to a developer. In particular, the winning bidder must repay the costs, which CVGHM spent on relevant data, obtained prior to continuing with Phase III.

By assigning the Centre of Volcanology and Geological Hazard Mitigation with completing Phases I and II of geothermal power development, the Ministry of Energy and Mineral Resources finances two of the three very risky project phases and compiles preliminary resource information. For the private sector, CVGHM’s involvement can be considered advantageous because private developers can circumvent seeking upfront project financing for these two phases, which may be only available on very unattractive terms. However, as CVGHM does not carry out and complete Phase III, the quality and quantity of resources is still uncertain and the project bankability is low. Hence, the winning tenderer remains in a difficult situation because of having to attract financing in a risky project phase for previous costs (for CVGHM’s work) as well as for future costs (Phase III and up).

While the literature screened is concerned with government-affiliated organizations being biased and exaggerating the amount of resources available in order to attract investors (Gehringer & Loksha 2012), it is difficult to assess whether these concerns apply to the CVGHM. As it is a University research institute, some kind of independence of direct Governmental steering can be assumed. Moreover, as has been elaborated in Chapter 4.3, the Government appointed the Volcanological Survey of Indonesia, the predecessor of CVGHM, to undertake resource assessments already in the 1960s (GeothermEx & World Bank 2010; Bappenas 2014; Smithsonian Institution 2013a).[16] Thus, because of its long-standing history and experience, CVGHM can be considered to have acquired substantial expertise in compiling and evaluating geothermal data reliably.

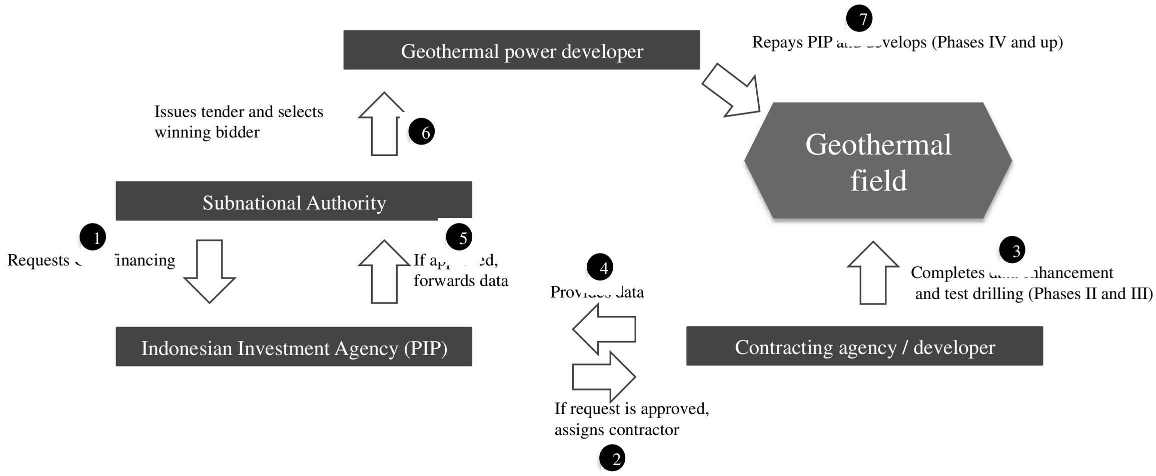
Apart from financing upfront costs for the Phases I and II of geothermal power development, the GoI through the Ministry of Finance launched the Geothermal Fund Facility (GFF) in 2013. GFF is administered by the Indonesian Investment Agency (PIP[17]) and provides soft-loans not exceeding USD 30mn, which must be used to finance data enhancement for geothermal resources and expenses should, at least, cover the costs for three resource confirmation wells. The Government initially allocated around USD 145mn, but the total volume of the Fund was ramped with another USD 105mn totaling USD 250mn. Basically, two options exist to gain access to GFF-soft loans: Option A is for public authorities (local, regional, national), which

[16] The U.S. Geologic Survey (2011) also states that “CVGHM is one of the world’s most mature volcano hazards agencies.”
[17] In Indonesian: Pusat Investasi Pemerintah

are in the driver's seat of managing the development of the resource in Indonesia, and Option B is for developers having won the tender (Bappenas 2014; Speer et al. 2014).

Option A – available to authorities – is for improving and expanding data sets that have been compiled by CVGHM but may be insufficient for authorities to attract developers for tendering.[18] Authorities apply with the GFF for funding and if the Indonesian Investment Agency approves the application, it also assigns a contractor. The contractor performs in-depth surveys *as well as* resource confirmation drilling and forwards compiled information via PIP to the respective authority. If the contractor cannot confirm resource availability „[t]he Indonesia Investment Agency will likely forgive loans to local governments for any unsuccessful exploration activities" (Speer et al. 2014, p. 32f.). If resources have been confirmed, local authorities can issue a tender for the respective geothermal field offering improved data to bidders. Interested bidders must pay a compensation charge for these enhanced data sets. However, only the winning bidder pays for the drilling of confirmation wells (Bappenas 2014; Speer et al. 2014). Figure 7 gives an overview of the GFF procedures for Option A.

Figure 7: Overview of the Geothermal Fund Facility accessed by subnational authoritie



Based on: Bappenas 2014, p. 115

In particular, repayment must cover the total costs including the expenses for dryholes. If regional governments have made use of GFF-Option A, private sector developers can be assumed to increasingly participate in the tendering of the respective field. In particular, developers have access to comprehensive data and there is higher certainty with respect to resource estimates. Developers, thus, *circumvent* Phases I to III, which bear high risks, which increases the project bankability substantially. Even though developers must repay the full costs including dryholes, it is much easier for them to do so due to risks reduced.

[18] Unreliable or insufficient information reduces the bankability of projects. Either private financing does not become available, or only at high interest rates.

Apart from public authorities, private geothermal developers after winning a tender can get access to GFF-Option B. Via GFF developers are eligible to a loan that recovers their previous costs spent on confirmation drilling – so developers must have already passed Phase III of geothermal power development. According to the Climate Investment Fund (CIF 2012, p. 22), "[t]he loan must be repaid by borrowers no later than 4 years after exploration is completed or at financial close, whichever occurs first." So these loans do not have an extraordinarily long repayment period. Unfortunately, further information on how GFF-loans disbursed to developers compare to market-based loans is not known. Hence, a qualified statement cannot be made on whether GFF's loan mechanism for developers is an alternative to the commercial banking sector. However, it must be kept in mind that after having completed Phase III, any geothermal project's bankability increases so that commercial loans should be available on more attractive terms (in contrast to their availability during Phases I to III).

In 2007, the Government through the Ministry of Finance also introduced tax and import customs rebates that apply to geothermal power investments. For instance, developers of a geothermal area have been conceded a two-year-exemption from paying import duty for machinery, goods and equipment. An extension of this arrangement is possible for the power plant construction phase (Bappenas 2014, p. 122). More specifically, this applies to equipment that is crucial for the development of geothermal power but manufactured outside the country's borders. Devices that are domestically produced but either not available in adequate quantities or in inferior quality only are eligible for the Ministry's rebate scheme (IEA 2015b). Moreover, machinery and equipment purchased for geothermal activities are exempted from value-added tax, and additional tax incentives are offered such as a reduction of the corporate income tax (Bappenas 2014; IEA 2015b).

While hardly any information is available on what types of products for geothermal drilling is produced within the Southeast Asian country's borders, it appears fair to assume that machinery and equipment (e.g. drilling rigs) is primarily manufactured in industrialized countries. Hence, tax and tariff incentives reduce some of the burden to finance the high upfront investments for geothermal power projects. As, apparently, the incentives already become effective in the risky Phase III, they, for instance, lower the costs for procuring (confirmation) drilling rigs.

Moreover, the Government through the Multi-Infrastructure Facility (MIF) and the Infrastructure Guarantee Facility (IGF) offers financial support for more mature phases of geothermal power projects. MIF was introduced in 2009 and offers long-term financing for infrastructure development in Indonesia (MIF 2012). While hardly any information is available with respect to the link between MIF and geothermal power and it is unknown whether geothermal power developers have made use of MIF-financing, it is stated on MIF's website that "[e]lectricity infrastructure, including power plants, electricity transmission and distribution" (ibid.) are eligible to receive financing. Hence, MIF, presumably, finances Phase VI (power plant construction) almost exclusively. Besides, in 2009, the IGF was launched – a state-owned company established with World Bank support. Like MIF, IGF is applicable to infrastructure investments, in general, but it "essentially functions as an insurer of any risk exposed to the private sector" (Bappenas 2014, p. 106). According to IGF's website (IGF 2015), it

> acts as the Guarantee Provider to the private sector for various infrastructure risks that may occur because of the government's actions or inactions, which may result in financial losses […], such as delays in the processing of permits and licenses, changes of rules and regulations, lack of tariff adjustment, failure to integrate the network/facilities.

Again, due to a lack of information, only vague statements on the value of MIF and IGF can be made. For geothermal power developers, the MIF can be a crucial element in geothermal power deployment as it closes the financing gap of the most costly project phase (Phase VI). Moreover, private banking market in Indonesia provides only short- and medium term financing solutions, but it is very reluctant to engage in long-term commitments (ChinaGoAbroad 2015). This justifies the establishment of MIF. IGF's guarantees are effective in the power plant construction and operation phases and for some of the preceding issues (e.g. licensing). While Bappenas (2014) notes that the guarantee is not free of charge, "premiums are available at a lower rate than those charged by traditional insurance firms" (Bappenas 2014, p. 106; PwC 2013).[19] Through guarantees, the IGF seeks to increase the bankability of projects as investment losses are secured by the Ministry of Finance, so that, for instance, developers are more inclined to invest their own capital in geothermal projects or banks become more willing to provide financing on more attractive terms (e.g. longer terms, lower interests). However, with respect to geothermal power, the stages associated with high investment risks are not covered through IGF-guarantees.

Table 2: Regional differentiation of feed-in tariffs for geothermal power in Indonesia

Location	Tariff (in USD per kWh)	
	High Voltage	Medium Voltage
Sumatra	0.100	0.115
Java, Madura, Bali	0.110	0.125
South, West and South East Sulawesi	0.120	0.135
North and Central Sulawesi and Gorontalo	0.130	0.145
West and East Nusa Tenggara	0.150	0.165
Maluku and Papua	0.170	0.185

Based on: Hasan & Wahjosudibjo 2014, p. 3

Indonesia's Government also offers feed-in tariffs (FiTs) for geothermal power. The FiT-scheme was launched in 2002 and was initially only applicable to renewable energy power plants not exceeding one MW. While hydroelectricity was not exclusively targeted, each of the twelve FIT contracts applied only to small hydro

[19] Data on the exact amount of the premium amount has not been available.

power plants (Hasan & Wahjosudibjo 2014, p. 3). Only since 2010, FiTs have become eligible for geothermal power plants and, more specifically, the scheme applies to newly developed power stations. As shown in Table 2, the premium payment for geothermal power depends (a) on the location of the power plants and (b) on the grid connection.

The prices shown above are ceiling prices and differ from region to region. Such capped prices prevent PLN from having to purchase electricity at out-of-range prices. The regional differentiation may be seen as an attempt by GoI to facilitate geothermal development in areas that are underserved from a power perspective such as West and East Nusa Tenggara, Maluku and Papua. Under the FiT-scheme, PLN is obliged to purchase power from electricity producers.

The premiums offered through the current FIT-design, generally, provide a financial incentive for investors by safeguarding increased returns, which, in turn, facilitates the bankability of a project making geothermal power projects more attractive to private financing sources. PLN, being obliged to purchase electricity from geothermal power plants creates an additional safeguard. However, it must be kept in mind that PLN was and still is in a weak financial position and is not considered to be an attractive partner for investors (Bappenas 2014).[20] Hence, the risk remains that PLN is not able to pay contractually determined prices. Moreover, as FiTs are only for power producers that have entered the market since 2010, the scheme “perversely translated into a ‘last mover’ advantage for private sector developers” (Clean Technology Fund 2012, p. 10), beneficial to those actors that enter the market at a later date. On the one hand, this could result in an increasing interest of new power developers seeking investments in the Indonesian geothermal market. However, such activities may also have a negative effect because developers rather “wait and see” whether the incentives for geothermal power investments will become more attractive.[21]

In order to reduce the above-mentioned “PLN-risk,” the Ministry of Finance has launched the so-called Business Viability Fund, which guarantees the offtake of electricity through PLN to the private sector. Hence, it should ease the search for commercial financing for geothermal power projects because returns generated through the selling of electricity are *de facto* insured.[22] The Business Viability Fund is only applicable to projects that started between 2010 and 2014 (Norton Rose Fulbright 2013a)[23] and it is unknown whether the scheme has been pursued beyond 2014.

[20] Since there is no change in the subsidy regime on the horizon, requiring that PLN forwards electricity to final consumers below the costs of production, PLN’s financial situation is likely to remain as it is for the mid-term future. For information on the subsidy scheme in Indonesia, see IISD (2012).

[21] Hasan and Wahjosdibjo (2014) as well as CIF (2012) refer to GoI-plans to link the FIT-price to both, the size of the geothermal power plant as well as to the geothermal resource composition (high-enthalpy resources and low- or medium-enthalpy resources).

[22] Information on Business Viability Guarantee is relatively scarce. The following sources may complement the idea of the Guarantee scheme: Baker & McKenzie (2014), Norton Rose Fulbright (2013)

[23] In 2010, GoI announced the so-called second Fast-Track Program (FTP-2) set for the period from 2010 to 2014. Foremost, under FTP-2, GoI announced the plan to bring online 10,000 MW of additional power capacities,

The Government of Indonesia has installed various types of financing support measures, which could comprehensively provide support to developers for overcoming financing barriers to geothermal power deployment. Through the Government's financing Phases I and II (through CVGHM), private sector developers can avoid covering these phases at their own expense. However, the private sector, which is eligible to develop a geothermal field after having won the respective tender, must repay the costs of these phases. Moreover, since Phase III is not covered by CVGHM, but must be carried out by the developer, the project bankability is still low (see, once more, Figure 5), so that the chance of finding attractive commercial financing sources is still limited. Thus, this financing support measure is useful to a limited extent only, which is why GoI has established the Geothermal Fund Facility. However, if subnational actors gain access to GFF, loans are made available to enhance resource data and carry out test drilling. Once these tasks are completed, subnational authorities can tender the field for developers, which are supposed to show great interest in the tenders because of reduced resource risks and increased project bankability. For Phase III and up, developers also have the opportunity to reduce investment costs for purchasing equipment through tax and tariff incentives. Additionally, for the later phases of geothermal power development, developers can gain access to further financing instruments. This appears to be vital because the Indonesian banking market is not inclined to engage in long-term commitments. While the Multi-Infrastructure Facility offers loans, the Infrastructure Guarantee Fund and the Business Viability Fund *de facto* insure developers against financial loses. This may not only make banks more willing to provide financing at more attractive rates, but also to increase the likelihood that investors bring in their own capital into the geothermal project. Last but not least, FiT-premiums are paid to the developer as contractually negotiated with PLN, and the FiT scheme guarantees the grid-connection of the power plant increasing overall project planning security as well as showing the Government's long-term commitment to the geothermal power sector.

4.4.2. Overcoming institutional barriers and unreliability

In order to reduce institutional uncertainties, which may be perceived by developers regarding the overall geothermal framework, Indonesia has introduced a set of measures on both, the national level and the subnational level.

In Indonesia, the Ministry of Energy and Mineral Resources has overall authority over the energy sector and is, among other things, in charge of (i) designing guidance for future power sector investments and (ii) establishing a positive investment environment, so that future power sector needs are met. In order to guide power sector investments, MoEMR publishes the National Electricity Plan, "which sets out, amongst other things, a 10 year estimate of electricity demand and supply, the investment and funding policy, and the approach to the utilization of new and renewable energy resources" (PwC 2013, p. 13). In 2010 only, the MoEMR created

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primarily through the private sector. In particular, 49% or 4,965 MW were determined to be provided through geothermal power (Bappenas 2014).

the Directorate General for New and Renewable Energy and Energy Conservation (DG NREEC). According to APEC (2013), DG NREEC is assigned with “preparing and implementing the policies in the fields of new, renewable energy and energy conservation, preparing the standards, norms, guidelines, criteria, and procedures in the fields of new, renewable energy and energy conservation.” DG NREEC consists of four supplementary Directorates in order to perform its duties, namely:

- Directorate of Geothermal
- Directorate of Bioenergy
- Directorate of Various New and Renewable Energy Sources
- Directorate of Energy Conservation.

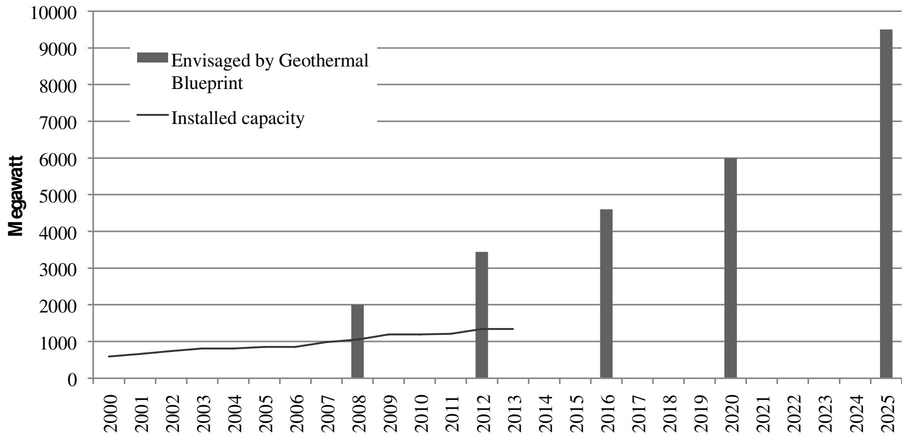
With hardly any further concrete information available showing whether DG NREEC is adequately staffed and funded to carry out its work, its structure suggests that geothermal resources are of particular concern to them. Among all renewable energy sources, only geothermal energy (and bioenergy), have stand-alone Directorates so that special attention can be paid to the characteristics of geothermal energy and, thus, a more attractive and uniquely framework can be developed. Moreover, several policies targeting exclusively geothermal power investors and developers were not implemented before 2010, DG NREEC’s founding year. For instance, the Geothermal Fund Facility was launched in 2013 and the GeoPortal, which serves as an information tool to developers, was brought online in 2014.[24] Other policies applying to geothermal power such as the Multi-Infrastructure Facility or the Infrastructure Guarantee Fund had already been launched in 2009. However, MIF and IGF, as was shown, are rather a catch-all measure targeting different types of large-scale infrastructure projects not specifically taking into account the unique characteristics of geothermal power development.

The Ministry of Energy and Mineral Resources as well as other Government stakeholders endorse and participate in conferences, that are particularly designed for the geothermal power sector. On the one hand, this is the Indonesia International Geothermal Convention and Exhibition, which has annually been hosted by the Indonesian Geothermal Association (API[25]) since 2013 and endorsed by the MoEMR (API 2015). On the other hand, at the Geothermal Power Conference (GPC) Government stakeholders actively provide information on the latest policy development in the field of geothermal power. For instance, the agenda of the 2014 GPC conference shows that the Ministry of Finance attended the conference in order to inform stakeholders on new policies and measures affecting the geothermal sector. Moreover, according to the agenda, information on globally good geothermal policy practices was exchanged, through which GoI may receive input for enhancing the investment framework in Indonesia (GPC 2014). Such conferences can be seen as one of many channels, through which governments can foster the exchange between policy-makers and business community stakeholders. This may also increase confidence with investors showing them that decision-makers are receptive to their concerns and suggestions and willing to remove barriers.

[24] The GeoPortal is discussed further below in Chapter 0.
[25] In Indonesian: Asosiasi Panasbumi Indonesia

Apart from the institutionalization of designated actors engaging in the geothermal power business community, GoI has issued the National Energy Policy (KEN[26]), which functions as an overall vision for Indonesia's energy future and includes ambitious geothermal expansion targets. Among other things, it determines the total primary energy mix of the country of 2025. With respect to geothermal power, the KEN of 2006 specified that geothermal power would contribute 5% of the future energy mix, which represents 9,500 MW (APEC 2013). A new draft version of KEN has been published in the meantime. While literature suggests that the share of renewable energy will be increased to 23% by 2025, it is unknown whether the new draft will affect the share of geothermal power to be installed (PwC 2014). In addition to KEN, MoEMR published the Blueprint for Geothermal Development in Indonesia in 2006. The Blueprint echoing the geothermal targets set for 2025 serves as a roadmap, particularly designed for geothermal power including intermediate expansion goals as shown in Figure 8.

Figure 8: Planned step-wise increase in geothermal power until 2025 and achievements so far



Based on: APEC 2013 and BP 2014

The target set through KEN and the Blueprint are highly ambitious. For instance, Indonesia required more than twenty years to develop only 852 MW as of 2006. Moreover, from a global perspective, geothermal power of 9,500 MW would exceed the total amount of geothermal power installed in 2006 worldwide (GEA 2014b). As UNEP FI (2012, p. 13) notes "[t]argets are considered key as they provide the backbone of any country's overall renewable energy strategy and the framework within which incentive mechanisms […] are placed." However, as can also be seen from Figure 8, roadmap targets have turned out to be unrealistic so far. One reason could be that the Government has not approached other barriers to geothermal power investments. For instance, instruments such as the Business Viability Fund came into being only in 2010. The retarding effect has compromised the usefulness of the Government's geothermal expansion objectives.

[26] In Indonesian: Kebijakan Energi Nasional

Apart from actors and the geothermal expansion targets, which can be assumed to provide certainty for the institutional framework, the Geothermal Law of 2003 deserves attention. Until 2014, it defined geothermal activities as "mining activities" similar to coal-, gas- and oil-exploration activities. In Indonesia, however, under Forestry Law 41/1999 mining activities are prohibited from being performed in certain forestry areas. According to Bappenas, around 21% (or 6,000 MW) of geothermal resources can be found in such forest areas, which has restricted developers from gaining access to a relatively large part of attractive geothermal resources in Indonesia (Bappenas 2014, p. 148). According to an interview of the Jakarta Post (2014a) with Chevron Geothermal & Power President, Javier A. La Rosa, the Geothermal Law was perceived as one of the most important barriers to geothermal developers. Only in 2014, the Parliament revised the Geothermal Law. Since then, the Law has ceased to define geothermal activities as mining activities (Jakarta Post 2014b), which opens up new opportunities for geothermal developers as well as for communities that seek to benefit from those "newly" available resources. The Indonesian Geothermal Association forecasts that the revision of the Geothermal Law could boost geothermal development by 2,000 MW by 2020 (Republika Online 2014). The fact that the long envisaged change in the Geothermal Law was finally implemented, reinstates the Government's commitment to geothermal power production.

Substantial efforts have also been made on the subnational level. According to the Geothermal Law, the subnational level is primarily in charge of managing the development of geothermal resources for power production. A such a geothermal area

> is located within one district/regency, the bidding will be conducted by the district/regency government. If the working area crosses district/regency boundaries but is within one province, the bidding will be conducted by the provincial government. If the working area is located in multiple provinces, the bidding will be conducted by the M[o]EMR (Bappenas 2014, p. 64).

One of the core problems with subnational authorities managing geothermal resource deployment was associated with the tendering process of geothermal areas. As noted by Gehringern and Loksha (2012, p. 72),

> most subnational institutions lacked the capacity and experience to carry out multimillion dollar international tenders. Equally important, many public institutions faced capacity constraints in planning and managing geothermal developments. The result was a number of poorly structured geothermal development opportunities being tendered and none achieving financial closure. With a lack of preliminary information regarding the field and the credibility of the information offered being questioned (despite Indonesia having a vast database of mapped geothermal fields and related information), many top geothermal developers did not participate in the tenders.

According to the literature screened, the Ministry of Energy and Mineral Resources seeks to overcome this problem by involving geothermal experts of the Geothermal Business Association (API) in tender committees (Bappenas 2014). Unfortunately, sources do not offer any further information on API-involvement and whether it has proven to be successful or not in accelerating the tender process. However, this *ad-*

hoc solution of dragging in expertise as soon as a field is tendered appears to be quite innovative – particularly, given that only few geothermal resource areas are available in each community or region, which is also why the employment of a full-time expert would be unnecessarily costly.[27] Hence, the API could contribute to accelerating the tendering process and make tender documents more comprehensible. This could increase the confidence among investors that subnational authorities are able to carry out multi-million dollar deals for geothermal power.

After the tender, a winning bidder must apply for an environmental license issued by subnational authorities. In particular, geothermal power plant developers have to provide comprehensive environmental impact assessment (EIA) reports, the so-called Analisa Mengenai Dampak Lingkungan (AMDAL).[28] However, similar to the tender process the procedures for the AMDAL have put local authorities in a difficult position, because the reviewing process is sophisticated and requires in-depth knowledge with respect to geothermal power. The World Bank (2006, p. vii) notes that

> [t]he AMDAL System changed with the introduction of regional autonomy laws. Critically speaking, authority for AMDAL review and approval was transferred de facto to Indonesia's 400-plus local governments while the role of the provinces was significantly weakened. This had the effect of placing the bulk of the responsibility for EIA – Indonesia's only widely recognized environmental management tool – where there is least capacity.

This critique of shifting responsibility onto inadequate authorities is underlined by Bappenas (2014, p. 46) stating that the processing of an AMDAL study may “take anywhere between six months to three years.” This, again, represents a problem to private sector developers, for whom delays in obtaining clearances may cause further delays in carrying out other undertakings. In order to tackle this problem, GoI has established a service standard, which demands from local authorities to review the AMDAL reports within six months. Apparently, GoI seeks to enable local authorities to enforce the service standard by providing “training and human resources to units processing the applications” (Bappenas 2014, p. 46). Unfortunately, literature does not offer any into the success of such capacity building measures.

In order to overcome institutional barriers and unreliability in the geothermal power framework and, thus, barriers to attract investment, the Government established DG NREEC, which includes the Directorate for Geothermal. Based on the limited information available, it can be cautiously assumed that through the DG NREEC within the MoEMR an actor was established in 2010 that is fully aware of the unique characteristics of geothermal power and pays attention to creating and maintaining a investor friendly framework. Having such a actors “whose functions include explicit planning for geothermal energy development” (Gehringer & Loksha 2012, p. 77)

[27] In Indonesia, only up to two geothermal resource areas are estimated to be within the authority of any subnational body of government (Bappenas 2014, p. 56)

[28] In fact, there are different types of environmental documentation, which must be delivered to subnational authorities. For more information, please consult Bappenas (2014).

could provide confidence among investors. Moreover, it is important to point out that the Government of Indonesia, apparently, actively engages in dialogs with the business community through special business community conferences. Among other things, this could convey the conviction to developers and investors that the Government is open to suggestions regarding framework improvements. The recent change of the Geothermal Law, which prohibited developers to obtain access to a substantial amount of geothermal areas, can be seen as evidence that decision-makers are susceptible to business community concerns. MoEMR also announced expressive expansion targets in the National Energy Policy and in the Geothermal Blueprint. Expansion targets, according to UNEP FI (2012), represent an important pillar to generate confidence among investors regarding the long-term government commitment. Likewise the long-envisaged change in the Geothermal Law through which developers now have access to more geothermal areas can also contribute to reinstating the Government's commitment to geothermal power development. Moreover, in order to overcome institutional barriers, GoI supports subnational authorities in administering geothermal development. While subnational authorities manage the development of geothermal areas, they are challenged due to their incapacity of carrying out tenders or reviewing environmental impact assessments. First, tendering is supported through the integration of experts of the Geothermal Business Association. Such experts are supposed to make tender documents more comprehensible and evaluation of bits can be made in due course. The support could increase the confidence among investors that local authorities are capable to deal with multi-million dollar investments. Training measures have been carried out to enhance the ability of subnational authorities to review environmental impact assessments, so that the issuance of the environmental license is accelerated.

4.4.3. Overcoming the lack of human resources

Human resource development (HRD) for geothermal power development in Indonesia is, primarily, carried out by the University Institute of Technology Bandung (ITB), the University of Gadjah Mada (UGM) as well as the University of Manado (UoM), and to some extent through foreign assistance. In particular, New Zealand Aid and some renowned research institutions in New Zealand, for example, the University of Auckland (UoA), promote human resource development in Indonesia. The UoA's Geothermal Institute, for example, trained 160 Indonesian experts until 2011 (New Zealand Ministry of Foreign Affairs & Trade (MFAT) 2011a; MFAT 2011b). Moreover, UoA and UGM cooperated "to deliver specialist geothermal courses in Yogyakarta in 2011" (MFAT 2011a, p. 27). Apart from bilateral support from GoNZ, the Geothermal Training Program offered by the United Nation University (UNU-GTP) in Reykjavik, Iceland, supported GoI by training 29 experts between 1979 and 2014. The UNU-GTP offers training to post graduates from developing countries, where sufficient geothermal resources are available (UNU-GTP 2015).

However, given the impressive geothermal expansion targets of 9,500 MW by 2025, MFAT (2011, p. 12) argues that it is absolutely impossible for domestic research institutions to meet the demand for geothermal experts: MFAT estimated that Indonesia lacked 4,800 engineers, earth scientists and further support staff in order to meet even its geothermal expansion target of 5,000 MW by 2014 (MFAT 2011a).[29] Due to the huge amounts of capital required in order to bring geothermal power plants online, the lack of sufficient expertise in Indonesia can be seen as a tremendous bottleneck to achieve set targets as it disincentivizes investors to become active in the Southeast Asian country.

Moreover, MFAT criticizes that GoI has neither created a central institution setting "a navigational HRD course for RI's [Republic of Indonesia's] Geothermal industry as to how the MW [Megawatt electrical] production targets set by GoI will be achieved," nor a "strategic plan for managing the human resources […] growth of the industry to achieve these targets" (MFAT 2011a, p. viii). In the wake of such harsh criticism, the State Ministry of National Development Planning (Bappenas) issued a draft for a National Geothermal Capacity Building Program (NGCBP), in which, among other things, the NGCBP plans to pursue the following undertakings:

- Increase the number of universities with curricula on geothermal resources and respective graduates, particularly, given that "15 universities located in the same province with geothermal working areas" (Bappenas 2012, p. 13)
- Seek increasing international support and foreign-based training (e.g. in Germany, Iceland, Japan, New Zealand) (ibid., p. 15)
- Seek close cooperation between research institutions, trade associations and the private sector and establish on-the-job training (ibid., p. 17)
- Promote research on future development of geothermal technology such as enhanced geothermal systems
- Analyze best-practices for capacity building activities in the geothermal industry (ibid., p. 39).

The first suggestion appears to be quite reasonable, since universities located close to geothermal fields have three advantages. First, they can contribute to overall HRD in Indonesia. Second, students can easily gain hands-on experience within their region or community. Third, university staff and students may support local governments, which are in charge of managing geothermal fields but often have limited capacity and inadequate knowledge of geothermal resources and its development.

The initial fruits of the NGCBP appear to emerge. For instance, ITB opened a Magister Program for Geothermal Exploration in 2012. Moreover, since 2014 the Indonesian-Dutch bilateral program apparently has linked its support to the NGCBP with the Geothermal Capacity Building Programme (van der Meer et al. 2015).[30]

In Indonesia, human resources in the field of geothermal power development are educated and trained in domestic research institutions, while international support also has a prominent role to play. Following New Zealand's assessment of the HR's needs to achieve geothermal power expansion targets, GoI designed a plan on how

[29] In fact, MFAT (2011a, p. 12) argues that even combining the efforts of ITB and UGM with those of the University of Auckland would not be sufficient to meet the human resources needs of Indonesia.
[30] See van der Meer et al. (2015)

to increase the HR capacity in Indonesia. The plan takes into consideration the expansion of domestic HR efforts, while acknowledging the significance of international support in training HR.

4.4.4. Overcoming information barriers

In 2014, with support from the German KfW development bank, the State Ministry for Development Planning (Bappenas), which is in charge of Indonesia's overall development planning, launched the GeoPortal. The GeoPortal is an online-database hosting a variety of information regarding geothermal power in the Southeast Asian country. Access can be gained free of charge after a brief registration process.

The database includes a "library" function and a resource inventory. The former offers policy papers, newspaper articles and reports available on geothermal power in Indonesia. The cornerstone of the online library, the Geothermal Handbook for Indonesia, has also been used for this study as a major source (Bappenas 2014). According to the comprehensive 300-pages report (ibid. 2014, p. 1)

> this Handbook is intended to assist key stakeholders, such as private sector renewable energy developers investing in Indonesia, the central and regional government policy makers, and those national and international stakeholders who aim to promote geothermal developments in Indonesia. The Handbook covers the legal, policy, regulatory, financial and economic frameworks of the geothermal sector in the country and describes how the government aims to foster geothermal economic growth in the energy sector.

It should be taken into account that the local or regional administration, assumes duties with respect to geothermal power development such as publishing tender documents. However, respective staff does not have sufficient expertise regarding the resource and its development (Bappenas 2014). Hence, the "library" of the GeoPortal may be an important source to get access to information on geothermal power. Apart from the library, the GeoPortal offers an online map showing an overview of geothermal resource spots. Indonesia has a "comprehensive inventory of geothermal resources with high quality data" (Wang et al. 2012, p. xi). Some of this data has been made publicly available through the GeoPortal. Interested geothermal power developers can gain access to information on geothermal areas for general geothermal resource areas and areas, which are to be offered for tendering. Among other things, information includes:

- Resource location
- Current phase of field development (e.g. preliminary survey)
- Types of surveys conducted (e.g. surveys on geology, geochemistry, geoelectrics)
- Amount of resources estimated based on Indonesia's geothermal reporting system

Again, it appears as if international support plays a major role in overcoming geothermal power barriers. Regarding the information gap, the Government, together with the KfW development bank, established the GeoPortal, which is supposed to deliver easy-access information on the current framework for geothermal power including regulation, policies and procedures. Apart from that, information on the individual geothermal resource areas and resource potential is provided. Through the GeoPortal, geothermal power investors can reduce transaction costs for search relevant information. The portal can also reduce the risk of delays because through the GeoPortal the staff of subnational authorities can familiarize themselves with the technology and implementation procedures.

4.4.5. Overcoming social opposition

Social opposition may increase the likelihood of project delays. However, the GoI seeks to reduce opposition through two factors. First, as noted earlier, private geothermal developers are required to carry out an environmental impact assessment in order to mitigate negative impacts of the designated power station, and they must also procure land. In Indonesia, it is clearly stated that the "private implementor holds no right to expropriate land owners from their lands. The land acquisition has to be done based on negotiation and agreed price with the land owners" (Supreme Energy 2014, p. 39). Regulation determines that local authorities ensure that forced expropriation is prohibited. In that respect, subnational authorities carry out a very important function as a mediator between the different interests. Even though corruption is a dramatic issue in Indonesia, authorities can be assumed to be best-suited to mediate between the interests of local communities and private sector developers. In particular, they are supposed to have the closest connection to the local communities, while being responsible for the sustainable development of the whole community or region. Through support from subnational authorities, geothermal developers are actively assisted in overcoming local opposition, which may result in costly delays.

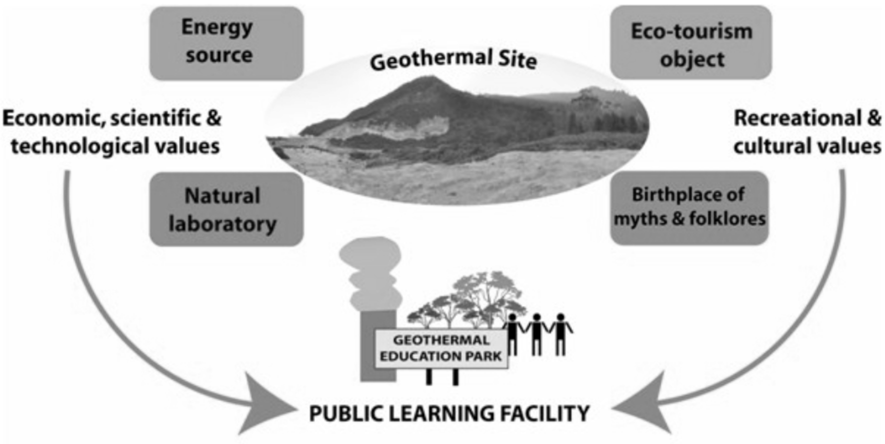
Apart from that, researchers and practitioners in Indonesia have considered using selected plants more holistically as public learning centers and not only as power generation facilities (cf. Utami et al. 2011; Petrus et al. 2015). So apart from being a source of power generation, the geothermal site can also represent a natural laboratory, a touristic point of interest and a place to preserve and memorize the heritage of the indigenous peoples living in the surrounding area (see Figure 9).

The different roles of the site serve various purposes. Preserving their heritage may have a positive effect on native peoples, who may be more willing to accept a power plant construction and regard it as a positive contribution to the community. Moreover, a plant, that is at the same time a magnet for (eco-)tourists, may not only function as a source of income for the local people of the area[31] but also increase the awareness of the general public for power generation through geothermal resources. Prejudices, that geothermal power plants are unsafe, could be minimized. Moreover, in particular for younger target groups, such sites may also be an opportunity to familiarize themselves with the technology increasing their interest in seeking a

[31] It should be ensured that the local communities really benefit from such an innovative project, instead of a single investors gaining all the revenues.

professional career in the geothermal sector. Preserving their heritage may be crucial to increase the acceptance of the people with regard to power plants and required infrastructure. Even though such public learning centers have not been implemented yet, the University of Gadjah Mada in cooperation with New Zealand Aid provides technical advice to some subnational governments to realize such a learning center (Petrus et al. 2015).

Figure 9: Illustration of the different values of a geothermal site



Source: Petrus 2015, p. 6

In order to mitigate social opposition, which, in turn, may cause delays in project execution, GoI has institutionalized subnational authorities as a watchdog to avoid forced expropriation and to review environmental impact assessments. With regard to the latter, it has already been shown that GoI has initiated capacity enhancement projects. While being a watchdog for avoiding involuntary resettlement, subnational authorities must also take the role as a mediator between the interests of both, developers and local communities. Although it is unknown whether public learning facilities have been implemented yet, the realization of such platforms may not only mitigate local opposition of communities living on or close to a geothermal field, but they can also contribute to improving the overall image in the country as people can familiarize themselves with geothermal power and its advantages.

5. Geothermal power development in Kenya

The case study on Kenya is structured in line with the preceding analysis on Indonesia. In the introduction, country background facts including this country's history and its contemporary socio-economic and political context are provided. Subsequent to these introductory remarks, the focus is on the power sector in Kenya and its specific sectoral challenges, before discussing the contributions of geothermal power towards meeting or mitigating the challenges. Prior to the analysis, information on the historical dimension of geothermal power in Kenya is offered. In the analytical section, it is shown how Kenya seeks to overcome to barriers to deploying geothermal power.

5.1. Country background

Due to findings by archeologists, East Africa, in general, and Kenya, in particular, are well-known for having "provided the setting for the earliest development of the human species" (Library of Congress (LoC) 2007, p. 1) and labeled the "cradle of humanity" (British Broadcast Corporation 2014). Following a long period of Arab dominance on Kenya's coasts from 600 onwards with trading hubs being established, the Portuguese arriving in 1498 claimed power. However, increasing military opposition of local tribes and Omani Arabs made the Portuguese leave the region by the late 17th century. From the 19th century onwards, "British influence superseded that of the Arabs. Unlike their Arab predecessors, the British showed interest in controlling land beyond the coastal region and encouraged European explorers to map the interior" (LoC 2007, p. 2). Kenya formally became a colony of the British Empire in 1920 with a White ruling class and large-scale discrimination against the local population. Violent protests by Africans peaked in the 1950s and, in the end, resulted in the British paving the way for Kenyan independence, which was achieved in 1963 (LoC 2007). In the aftermath of becoming independent, an "initial period of de facto, and later of de jure one-party rule (1967 – 1991)" (BTI 2014, p. 3) followed. From 1991 onwards, multiparty elections were allowed, but ethno-political conflicts always surrounded elections as in the decades before.

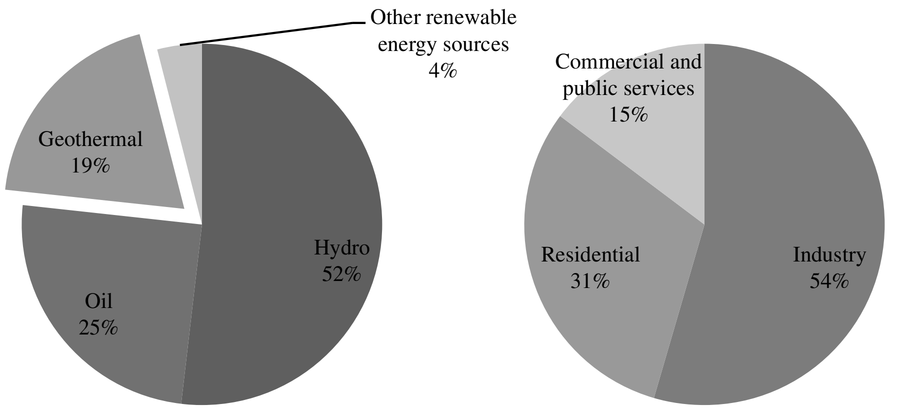
Today, around 45mn people live in Kenya (CIA 2015) and the annual population growth rate was constantly at around 2.7% between 2000 and 2012 (World Bank 2015). The largest cities are Nairobi, the capital and industrial hub, and Mombasa with its large sea port (LoC 2007). Solid economic growth has taken place in the East African country. Between 2005 and 2013, Kenya's GDP grew by over 5% on average and was at USD 55bn in 2013 (World Bank 2015). In that respect, "[a]bout 55 percent of Kenya's GDP comes from services, transport, finance, tourism, information and communications technology (ICT) and trade" (World Bank 2012). The agriculture sector contributes 29% and the industry sector around 15% to the GDP (CIA 2015). According to the World Bank (2014, p. 1), "sustained growth has been attributed to a stable macroeocnomic environment, investments in infrastructure and education, structural reforms in key sectors of the economy, which have created the foundation for Kenya's future."

For 2030, the Government has established the clear target to become a middle income country. In 2007, GoK published the so-called "Vision 2030," which, among other things, strives for a stable economic growth rate of 10% annually (GoK 2007).[1] The World Bank (2012, p. 1) even assumes that Kenya could already become a middle-income country by 2019. The energy sector, in general, and the power sector, in particular, are considered to be integral elements of the "Vision 2030." In order to really become a middle-income country, Kenya must succeed in overcoming challenges in the power sector.

5.2. Kenya's power sector and its challenges

Kenya's power plants have a total capacity of around 1,600 MW producing 7,800 GWh of electricity (as of 2013; Ministry of Energy and Petroleum (MoEP) 2015). Most of the power generating assets are owned by the partly state-owned Kenya Electricity Generating Company (KenGen).[32] As shown in Figure 10, water resources provide the largest amount of electricity and most of the power generated is consumed by the industrial sector.

Figure 10: Electricity production per energy source (left) and final electricity consumption (right) as of 2012 in Kenya



Based on: IEA 2015

The power system in Kenya faces several challenges. First, electricity demand is expected to increase to 23,000 GWh in 2018 and 104,000 GWh in 2031 (Energy Regulatory Commission (ERC) et al. 2011). While the goal to sustain economic growth is one of the driving forces for demand increases, another major issue is that only 32% of Kenyans have access to electricity. This represents a major bottleneck for human development affecting the overall process of the country, as a whole. Due to the relevance of electricity, GoK seeks to provide 100% of Kenyan households with electricity by 2020. This is an ambitious project because it results in an increasing annual electricity connection rate (MoEP 2015; ADF 2014).[33]

Second, the security of electricity supply is a major concern in Kenya because of the country's dependence on hydroelectricity. In particular, 2009-droughts in the East African country resulted in dam flows significantly below expectations (ERC et al. 2011) and, hence, limited the power generation through water. The reliance on hydropower has, among other things, been caused by the fact that Kenya has hardly any fossil energy resources available. Moreover, for a long time the low share of oil-

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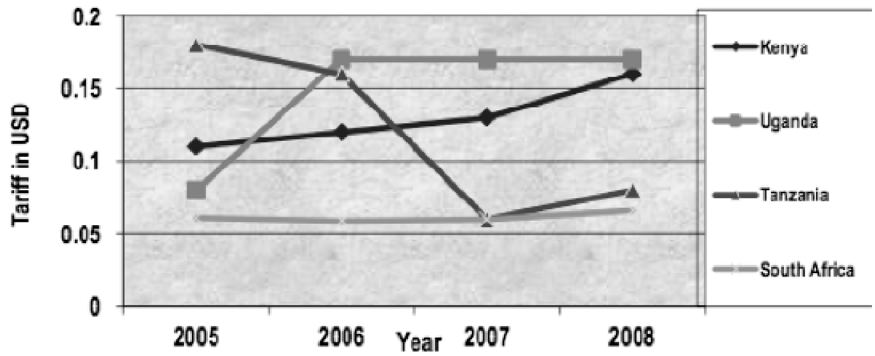
[32] According to KenGen's website, it manages almost 800 MW (KenGen 2015).

[33] According to ADF (2014), the number of people newly provided with electricity is between 300,000 and 400,000 per year. In order to achieve universal access, the annual number must increase to around 700,000 new electricity users. If this is achieved, the demand for electricity will rise more rapidly than in the previous years and, hence, stresses the demand for additional power generation capacities.

based power production required imports, most of which (75% of total oil imports) came from Abu Dhabi suggesting a relatively high dependence on a single oil-supplier (ibid.). However, the dependence on crude oil imports should gradually be reduced due to oil discoveries in Kenya (Tullow Oil plc 2013). A reliable supply of electricity is vital for sustaining Kenya's economy, which – as stated above – depends on sectors such as services, finance, tourism and ICT. In order to maintain the services performed by those sectors, the electricity system must be stabilized (World Bank 2012).

Apart from that, high electricity prices appear to be a bottleneck for Kenya's overall development project by disincentivizing (i) lower income groups to seek access to the grid as well as (ii) business that seeks investments requiring substantial amounts of electricity. According to the African Development Fund (ADF 2011, p. 1) "energy costs are currently higher than the average costs in other competing African economies" and the World Bank (2012, p. 5) notes that the average electricity retail tariff in Kenya, which is at USD 0.17 per kWh, is close to six times higher than in Ethiopia. Figure 11 below shows that electricity tariffs in Kenya have experienced growing rates reducing regional competitiveness (ERC et al. 2011).

Figure 11: Electricity tariff in selected East African countries



Source: ERC et al. 2011, p. 35

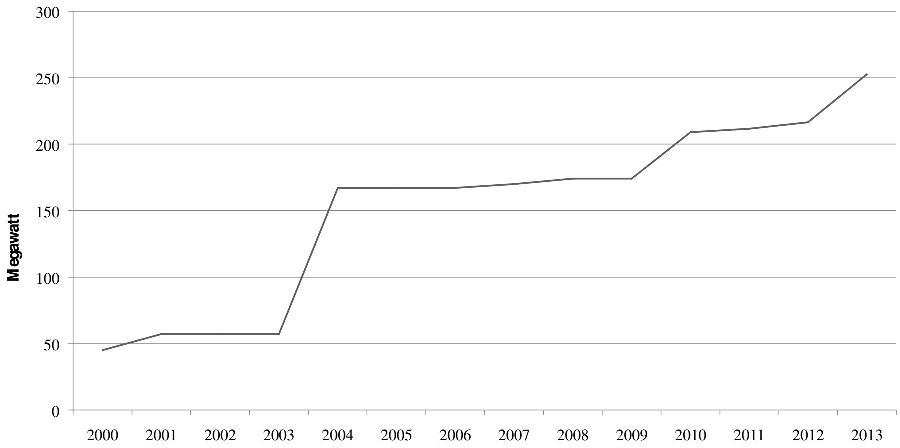
Moreover, while Kenya has relatively low CO_2 emissions emanating from the electricity sector due to a hydroelectricity-dominated power mix, the country is and will be challenged in keeping related emissions low in the future (WEC 2014c). Most recent World Bank figures suggest a slight upwards trends of emissions from the electricity and heat sector between 2010 and 2011 (World Bank 2015).

Hence, against the backdrop of expected power demand, GoK will have to find a way of increasing electricity generating capacities to reliably provide the residential and non-residential sector with power, while improving the security of electricity supply, reducing or at least stabilizing electricity tariffs and maintaining low levels of CO_2 emissions.

5.3. Geothermal resources and power production in Kenya

While under British colonial rule the existence of geothermal resources had been recognized, resource exploration did not start before the 1970s with GoK and UNDP teaming up. In 1972, the project partners initiated exploration drilling and found a successful well in Olkaria (GeothermEx & World Bank 2010). Due to high dependence on oil imports and dramatically increasing world market prices for oil in 1973 and 1980, GoK was required to push for alternative energy sources (World Bank 1990, p. 1). GoK with support from the World Bank brought online the first geothermal power plant in Africa in 1981. The power station had an initial capacity of 15 MW. Successful operations resulted in adding another 30 MW by 1985 (Sinclair Knight Consulting Engineers 1994). Meanwhile, during the 1980s, donors such as Japanese International Cooporation Agency carried out several surface studies increasing the knowledge regarding available geothermal resources. The United States Agency for International Development forecasted the stock of resource to be at around 4,000 MW (GeothermEx 2010 & World Bank). In 1996, a U.S.-Israel-based private investor jumped on the geothermal bandwagon and started exploration activities in the Western Olkaria area realizing an eight MW power plant. Then, the German development bank KfW development bank financed capacity additions, so that a 48 MW facility was realized (ibid.). With further support from the World Bank, the facility was gradually expanded into a 110 MW plant in February 2014 (Ormat Technologies 2014). Figure 12 shows the development of geothermal power capacity since 2000.

Figure 12: Evolution of geothermal power capacity in Kenya since 2000



Based on: BP 2014

Given the vast resource potential, GoK has only utilized a minor share of its resources. According to the GEA (2014a), Kenya already has around 20 geothermal sites in the project pipeline, all of which have an accumulated geothermal power capacity of around 1,000 MW.

Kenya is located in a benign location form a geothermal resource perspective. The so-called East African Rift Valley, which passes through Kenya, "has been associated with intense volcanism and faulting" (ERC et al. 2011, p. 52). The Rift "has produced the continent's highest and lowest volcanoes, ranging from massive Kilimanjaro to vents in Ethiopia's Danakil Depression that lie below sea level" (Smithsonian Institution 2013).

In total, the East African region is currently estimated to host 15,000 MW that can be used for geothermal power production. Up to 10,000 MW of these resources are available in Kenya, stretching from the country's Northwest to its Southwest (ERC et al. 2011). Given that Kenya has only utilized 3% of its geothermal resources available, geothermal-based power production can contribute to meeting rising electricity demand from various sides such as the residential sector. Moreover, geothermal power can increase the security of power supply. Most importantly, it is not dependent on weather conditions or seasonal variations, which should have a positive effect on providing electricity to the GDP-generating sectors. Apart from that, as the World Bank (2014b, p. 2) points out, "Kenya's average tariffs are expected to decline over time as cheaper generation from wind, geothermal and regional hydro make up a greater share of the energy mix and as the relative share of oil-based thermal generation dispatched declines." Also, by providing low-carbon base-load power, geothermal resource may assist GoK in maintaining an electricity mix that is climate friendly.

5.4. Overcoming barriers to geothermal power development in Kenya

The subsequent sections show how Kenya seeks to overcome geothermal power deployment barriers. Afterwards results from this case study as well as findings derived from the section on Indonesia are merged, so as to conclude how other developing countries could leash their geothermal power potential.

5.4.1. Overcoming financing barriers

Financing has been identified as a substantial barrier in every geothermal power project because of risks in Phases I to III of geothermal power deployment. As has been shown for the Indonesian case, there are methods to reduce the risks. In Kenya, four mechanisms have been identified that seek to overcome the financing barrier to geothermal power deployment.

In order to actively deploy geothermal power, the Government of Kenya established the state-owned Geothermal Development Company (GDC) in 2009. As its name suggests, it is especially designed to "fast track the development of geothermal resources in the country" (GDC 2014).[34] The GDC is, primarily, in charge of conducting preliminary surveys (Phase I), exploring geothermal resources (Phase II)

[34] Note that GDC is also actively involved in increasing the direct use of geothermal resources, that is heat production. For example, geothermal heat is used for green houses.

and drilling resource confirmation wells (Phase III). Having completed Phases I to III and evaluated resource data, GDC is entitled to tender the field to the private sector.[35] GDC's activities are financed by the Government as well as by donor countries (Ngugi 2012). For 2014, the Oxford Business Group (2014) notes:

> The National Treasury allocated KES [Kenyan Shilling] 12.5bn ($142m) in the budget for the fiscal year ending June 2014 to GDC to develop and drill for steam. GDC has also secured $120m from the African Development Bank and a $25m grant from Nairobi's Scaling-up Renewable Energy Programme for the Menengai geothermal project, which is designed to produce electricity for 500,000 households.

The financing of GDC through the Government and donors is quite advantageous to private sector developers that wish to take over and advance the geothermal development process. In fact, together, GoK and donors absorb the very risky Phases I to III of geothermal power development. Since after completing these phases the resource knowledge of the respective site is more profound due to successful test drilling, the project's bankability is more benevolent, which is the reason why commercial financing can be obtained on more attractive terms (CIF 2011). Unfortunately, recent charges against GDC damage the organization's reputation. The consequence of suspecting GDC to overestimate the quantity and quality of resources may be that developers as well as financing institutions back away from geothermal areas explored by GDC (Gehringer & Loksha 2012).

Apart from the Government's and donor's financing Phases I to III for geothermal power deployment in Kenya, the African Rift Geothermal Development Facility (ARGDF) was launched in 2010 (UNEP & GEF 2006; Mwangi 2010). It is managed by the UNEP and the World Bank and funded by the GEF. As its name suggests ARGDF does not focus on Kenya only but on the East African geothermal arena as a whole.[36] In particular, ARGDF partially seeks to absorb the risks associated with test drilling (Phase III) by providing both, guarantees of up to 70% of the costs for a test drilling and grants of up to 25% of the expenses for exploration drilling. Public as well as private developers have access to guarantees and grants, but for the former, they must pay a premium (UNEP & GEF 2006).

For sector developers, the grant-option reduces the need to find additional financing sources as only 75% of the total costs need to be covered. Through the guarantee-option, parties can reduce the risks of incurring financial losses, which are very likely during the initial geothermal development phases. This, in turn, increases the project's bankability. The guarantee scheme and the grant scheme complement each other as, in case of unsuccessful drilling, 95% of the eligible costs are covered by ARGDF and only 5% of the losses are passed on to developers. Unfortunately, information on the utilization of funds is not covered by the literature screened. It should be kept in mind, that, as the state-owned GDC takes a decisive role in

[35] GDC is legally also able to carry out geothermal development on its own. However, tendering is, generally, first offered to KenGen, which has the first right to refuse. If a geothermal field is refused by KenGen, private sector parties can offer bids. If neither KenGen nor private parties show interest, GDC can advance the field (GeothermEx & World Bank 2010).
[36] ARGDF has six member countries: Eritrea, Ethiopia, Kenya, Rwanda, Tanzania, Uganda.

carrying out Phases I to III in geothermal power development in Kenya, it can be considered a main beneficiary of ARGDF funding.

In 2012, the African Union Commission (AUC), Germany's Ministry for Cooperation and Development (BMZ[37]) and the European Union Africa Infrastructure Trust Fund (ITF) launched the Geothermal Risk Mitigation Facility, which facilitates geothermal power deployment in East Africa.[38] GRMF is a fund equipped with EUR 20mn and EUR 30mn provided by the BMZ and the ITF, respectively, through the German KfW development bank. Plans to increase the financial capacity of the fund have been announced (AUC 2014a) and, apart from that, other donors are eligible to enhance the financing volume of GRMF. GRMF, in turn, has been integrated into AUC's Directorate of Infrastructure and Energy supervising the Fund (Bloomquist et al. 2012). GRMF provides grants for:

- Surface studies
- Exploration wells to confirm preliminary resource findings
- Project continuation beyond the drilling of exploration wells ("contingent grant")
- Infrastructure works.

Surface studies are financed by up to 80% of the expenses and must lead to "the siting of wells for confirmation drilling" (Bloomquist et al. 2012, p. 78). Hence, the surface studies grant covers Phases I and II of the geothermal development process. Grants for test drilling of up to two exploration wells do not exceed 40% of eligible costs. If a project developer seeks to move a project beyond Phase III, a contingent grant (or project continuation premium) can be accessed financing up to 30% of the expenses for the drilling of production or injection wells, resource reservoir studies or power plant design studies (Phase IV and V). Moreover, applicants can also apply for grants covering 20% of the expenses spent on infrastructure works including road construction and water or power access.[39]

For the private sector, grants provided by the fund reduce the need for financing the initial project phases. In particular, by spreading the grant disbursement on various phases, the GRMF's financing scheme tackles the risky phases of geothermal power development and it may incentivize developers to gradually advance the geothermal area from one phase to the next. The share of covered costs decreases as the knowledge of geothermal resources becomes more reliable and private sector developers are gradually able to attract financing through other channels.

Apart from ARGDF and GRMF, the Government has also offered feed-in tariffs for geothermal power since 2010. Actually, the Kenyan FiT scheme was launched in 2008 following a four-year dialog with the World Bank, but did not include geothermal

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[37] In German: Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung

[38] Initially, only Kenya, Rwanda, Uganda, Ethiopia and Tanzania participated in the pilot scheme but the Facility was extended addressing resource risks in Burundi, Comoros, Democratic Republic of Congo, Djibouti, Eritrea and Zambia, as well.

[39] AUC (2014b, p. 6), the consultant assigned with establishing GRMF, notes for the continuation grant that it is "depending on the availability of funds."

power before 2010.[40] Kenya's current feed-in tariff can be divided into two FiT-schemes as shown in Table 3.

Table 3: Feed-in tariff scheme in Kenya

	Installed capacity in MW	Standard FIT in USD / kWh	Max. cumulative capacity in MW
Feed-in tariff for small projects			
Wind	0.5 – 10	0.11	-
Hydro	0.5 – 10	0.0825 – 0.105	-
Biomass	0.5 – 10	0.10	-
Biogas	0.2 – 10	0.10	-
Solar (on-grid)	0.5 – 10	0.12	-
Solar (off-grid)	0.5 – 10	0.20	-
Feed-in tariff for projects above 10 MW			
Geothermal	35 – 70	0.088	500
Wind	10.1 – 50	0.11	500
Hydro	10.1 – 20	0.0825	200
Biomass	10.1 – 40	0.10	200
Solar (on-grid)	10.1 – 40	0.12	100

Based on: MoEP 2012, p. 16

While 30% of these schemes are financed by the grid operator and 70% of the costs are passed on to electricity consumers, one of the schemes targets small-scale renewable energy power plants of up to ten MW only. Geothermal power is excluded from this scheme. The second FIT-scheme is devised for larger renewable energy power stations, which also applies to geothermal power plants. This latter scheme differs from the former in that it has capped the total amount of power capacity eligible for FiTs. This creates a first-mover advantage for investors that seek to undertake geothermal power development rather sooner than later. Under the current feed-in tariff scheme of 2012, geothermal power plants with a capacity between 35 MW and 70 MW will receive a premium price on produced electricity for "20 years from the date of the first commissioning of the geothermal power plant" (MoEP 2012, p. 12). For renewable energy plants the scheme guarantees grid-access, increasing the planning security for investors. The prices represent maximum values and must be negotiated with Kenya Power.

[40] GoK's original intention was to (i) facilitate the promotion of renewable energy while raising the overall power generation capacity, (ii) incentivize smaller projects and (iii) create a more benign private investment climate in order to relieve the government from undertaking intensive capital investment in the power sector. The original FiT was only applicable to small hydro, wind and biomass projects as a WBG-study found these particularly promising for decentralized and off-grid power production (Nganga et al. 2013). In contrast, geothermal power is, generally, rather considered to be ideal for on-grid power generation. Moreover, the WB-study excluded geothermal power because Kenya has successfully launched geothermal power projects since 1981 without a premium payment for geothermal electricity. However, the narrow technology focus on small hydro, wind and biomass raised critique from the several private renewable energy investors (ibid.). Apparently, as a result of harsh criticism massive FiT was revised only two years after its actual launch in 2010. From then on, FiT has become eligible for biogas, solar and geothermal power generation, as well.

As a stand-alone policy FiTs for geothermal electricity would not be very attractive to private parties to engage in geothermal deployment because they only provide increasing returns after the completion of the power plant, when risks are very low. However, in Kenya developers obtain fields, where the initial risk is mitigated, and the resource knowledge is relatively high. Hence, with that in mind, FiTs offering increased returns, the project bankability improves and enabling developers to achieve better financial arrangements with commercial financing sources.

Unlike in Indonesia, financial support in Kenya clearly targets the initial phases of geothermal power development and absorbs risks for private sector investment. Investors can enter the geothermal development process subsequent to the completion of Phase III and continue with Phases IV to VII, which are associated with fewer risks and, thus, higher project bankability, which is why the private investors can finance the final project phases on more attractive terms. Moreover, investors have access to FiT's generating increasing returns, which should enhance the project bankability. GRMF's financing support could increase the interest of investors because it offers support through grants disbursed on a continuing basis once Phase III is completed. However, with the exception of FiTs, Kenya's financing support scheme appears to be only feasible due to donor financing.

5.4.2. Overcoming institutional barriers and unreliability

While little information is available on the exact institutional barriers disincentivizing investment in geothermal power in Kenya, the examination of the institutional set-up offers some conclusions to draw on through which the GoK seeks to enhance the reliability of the institutional set-up and provide confidence among investors.

Kenya's Ministry of Energy and Petroleum (MoEP) is assigned with safeguarding an "enabling environment" (Norton Rose Fulbright 2013b, p. 2) for power sector stakeholders. In particular, the Geo-Exploration Department is in charge of geothermal power, even though a Renewable Energy Department exists (Gamma Systems Ltd. 2012). The Geo-Exploration Department

> formulates fiscal, legal and regulatory frameworks and policies, including setting the feed-in tariff for geothermal projects, and conducts geological mapping, acquisition, analysis and exploratory drilling. Licences for exploration and drilling in relation to geothermal IPPs would have to be negotiated and obtained through the Ministry (Norton Rose Fulbright 2013b, p. 3).

Even though literature does not offer information on the founding of the Geo-Exploration Department, its existence and special assignments allocated for the exploration of geothermal resources show that the Ministry of Energy and Petroleum is aware of the unique characteristics of geothermal power deployment and its importance for Kenya. Hence, given the MoEP's task to provide an investment friendly environment for the power sector, in general, it can be assumed that regarding the geothermal power framework it does so through the Geo-Exploration Department, in particular.

With respect to regulatory procedures, the MoEP is supported by the Energy Regulatory Commission, established in 2006 and funded through regulatory levies (ERC 2012a).[41] According to a report published by the International Finance Corporation (2011), licensing procedures are burdensome to investors in renewable energy, in general, but for geothermal power, in particular, because more licenses or clearances are to be obtained than for any other type of renewable energy investment. Hence, it can be assumed that such regulatory procedures are relatively challenging for the geothermal sector. Moreover, as shown in Table 4, which gives an overview of the licenses and clearances necessary to advance a geothermal power project, the licensing process triggers several actors including the national Government (e.g. MoEP) and county governments, of which Kenya has 47 (MoEP 2015).

Table 4: Clearances required by geothermal power developers in Kenya

	Clearance	Agency
1.	Geothermal Exploration Authorization	Ministry of Energy and Petroleum
2.	Approval for Expression of Interest and Detailed Feasibility Study	Ministry of Energy and Petroleum
3.	Geothermal Resource License	Ministry of Energy and Petroleum
4.	Environment Impact Assessment	National Environment Management Authority
5.	Approval for Change of User	County Government
6.	Development Permit	County Government
7.	Special Use License	Kenya Forestry Service
8.	Way Leave Authorization	Kenya Forestry Service
9.	Negotiate FIT based on Power Purchasing Agreement	Kenya Power
10.	Approval of Power Purchasing Agreement	Energy Regulatory Commission
11.	Electricity Generation License	Energy Regulatory Commission

Table based on: ERC 2012b

According to the literature screened, ERC supervises, enforces and reviews regulatory procedures affecting renewable energy investments including geothermal energy (Gamma Systems Ltd 2012; Norton Rose Fulbright 2013). Hence, through the ERC, the Government has established an actor that *de jure* is eligible to ease the burden for investors emanating from those procedures. And, apparently, it takes its work seriously. For example, ERC has established service standards requiring the processing of licenses to be carried out within a given timeframe. Moreover, in 2012, ERC launched the Internet-based Renewable Energy Portal, which transparently

[41] For instance, the Electricity Regulatory Levy is paid by electricity consumers to the Kenya Power and Lighting Company (KPLC), which distributes electricity to consumers. KPLC, in turn, must forward the collected levy to ERC on a monthly basis (ERC 2012a).

provides information on how the different types of clearances and licenses are to be obtained.[42]

Regarding the capacity of the individual agencies (including county governments) to perform their duties reliably and in line with service standards established by ERC, as mentioned in the table above, literature is hardly available. However, a few years ago concerns were voiced that, especially, the National Environmental Management Authority (NEMA), which was established in 2003 (Ogola 2008), does not have comprehensive capacity to review and approve environmental impact assessments. Mwangi (2009, p. 2) points out that

> [t]he institution of NEMA is still in its formative stage. It still requires critical mass of expertise not only to cover its vast array of functions, but also to build up credibility and blaze the trail in the enforcement of the law for sound environmental management in Kenya.

And more concretely, Ogola (2008, p. 5) states that “NEMA officers who are charged with the issuance of licenses and review of environmental audit reports are usually bogged down with documentation of several other permits without necessarily looking into the details of the EIA or audit reports.” Since this critique was voiced, NEMA has had time to improve its processes and, indeed, has issued licenses for geothermal power (CIF 2012). But on whether the Authority was supported by, for example, donors in enhancing its capacities, the literature does not offer any clues. However, a special agency such as the NEMA, which is almost exclusively in charge of environmental issues, would allow for well-targeted capacity enhancement measures with the Authority.

While county governments are relieved from the burden to carry out environmental impact assessments, they are not in charge of tendering fields either. This task is carried out by the state-owned Geothermal Development Company (GDC) established in 2008, which also completes Phases I to III in the geothermal power development process in Kenya. As noted by the African Development Fund (ADF 2011, p. 13) the “GDC has developed tremendous expertise in the geothermal sector over the past couple of years and is aggressively training staff in all the activities of geothermal development.” For 2011, GDC was considered to employ 520 employees, most of which have had hands-on experience due to being involved in former geothermal projects. International donors support the Company in training activities through e.g. workshops and enable the GDC to acquire equipment such as drilling rigs (CIF 2011; ADF 2011).[43] Hence, with regard to the tendering process, the GDC can be considered an organization that is able to publish tender documents that private sector developers seeking to advance a geothermal field from Phase IV onwards can understand. While, apparently, GDC can be seen as a reliable partner for geothermal activities and strategic planning, recent corruption charges may compromise the positive image of the company. Since 2014, GDC has been

[42] The Renewable Energy Portal is discussed in detail in Chapter 0.

[43] For example, capacity building measures as well as equipment purchases have been financed regarding the site-development of the Menengai field. International donor support for the project started in 2011 (ADF 2011; CIF 2011). From a geothermal power perspective, the Menengai field is a huge project that seeks to install a 400 MW power plant in the first phase by 2016. The area is estimated to host a total of 1,600 MW.

interrogated by the Kenyan Criminal Investigations Department on the purchase of three drilling rigs, whereas original tender documents envisaged buying two rigs only from a Chinese contractor. Moreover, charges also revolve around deliberately exaggerating the quantity of geothermal resources estimated in the Menengai area (The Star as found with AllAfrica.com 2015).

Apart from the above-mentioned institutions including the Geo-Exploration Department, the Energy Regulatory Commission and the Geothermal Development Company, Kenya has also established geothermal power expansion targets, which can contribute to establishing a trustworthy framework for geothermal power developers (UNEP FI 2012, p. 13). Kenya does not have a specific roadmap document for geothermal power expansion. Instead, the Government publishes the Least Cost Power Development Plan (LCPDP) every few years.[44] The LCPDP is supposed to guide “stakeholders with respect to how the sub-sector plans to meet the energy needs of the nation for subsistence and development at least cost to the economy and the environment” (ERC et al. 2011, p. 12). Hence, the LCPDP is cross-cutting from an energy technology perspective and covers a period of 20 years neatly depicting the expansion schedule for each year. The LCPDP of 2011 suggests that the power mix will be dominated by geothermal power from 2015 onwards (ibid., p. 133).

Even though not legally binding, the envisaged shares of energy resources used for power production forecast a substantial increase in geothermal capacity from 198 MW (as installed in 2011, when the LCPDP was published) to 5,530 MW by 2031. It is noteworthy that compared to the 2001 and 2006 version of the LCPDP, geothermal targets have been substantially scaled upwards. In particular, the LCPDP 2001 stipulated geothermal power to amount to 512 MW by 2020, while the 2011 version recommends geothermal power to be at around 1,728 MW in the same year (Mariita 2007; Mwangi 2008).

While the expansion target may be perceived as unrealistic, it must be pointed out that, among others, the Geothermal Development Company contributes to formulating the LCPDP.[45] Due to the expertise the Company has accumulated with regard to geothermal power development in Kenya, GDC can be assumed to be qualified to realistically forecast geothermal power expansion.

It is also noteworthy to mention that the Ministry of Energy and Petroleum reinstated the geothermal power expansion goal when publishing a new draft version of the National Energy Policy in 2014. Through this document “the Government will encourage investment in the geothermal subsector so as to achieve at least 1,900MW of geothermal electric power generation by 2017 and 5,500MW by 2030” (MoEP 2015, p. 13). As geothermal power expansion appears to be a cornerstone of

[44] Unfortunately, previously published documents of the 2001 and 2006 LCPDP have not been available for this study. However, reference is made in Mariita (2007) and Mwangi (2008).

[45] Apart form the above-mentioned GDC, the following organizations participate in LCPDP formation: Ministry of Energy and Petroleum, Energy Regulatory Commission, Kenya Electricity Generating Company, Kenya Power and Lighting Company, Rural Electrification Authority, Kenya National Bureau of Statistics, the Ministry of State for Planning, National Development and Vision 2030, Kenya Electricity Transmission Company Limited, Kenya Vision 2030 Board, Kenya Investment Authority and the Kenya Private Sector Alliance (ERC et al. 2011).

Kenya's energy policy, it has become a matter of higher-level politics, which should also reaffirm private sector parties of the relevance of geothermal power in Kenya.

In order to encourage investors to participate in geothermal power production in Kenya, the Government through the Geo-Exploration Department and the Energy Regulatory Commission has established actors that are supposed to design and maintain an investor friendly institutional set-up. Potential procedural bottlenecks, which could disincentivize geothermal power investors from engagement, have been overcome by delegating important assignments such as tendering and the review of environmental impact assessments to specialized actors (that is GDC and NEMA). Further increasing confidence is supposed to be achieved through geothermal expansion targets. The Government provides ambitious geothermal expansion targets in the LCPDP. Geothermal expansion targets are meticulously defined for each year until 2031. The feasibility of achieving geothermal power expansion targets, is safeguarded by the GDC that has long been considered to be a reliable actor in the sector. However, recent corruption charges may undermine this positive image. The LCPDP can be regarded as the foundation of MoEP's National Energy Policy reinstating geothermal power expansion. In particular, with respect to the expansion targets stipulated in the LCPDP, the document provides planning security, which is not only important for domestic players, but also for foreign actors including private sector investors as well as donors.

5.4.3. Overcoming the lack of human resources

It has to be kept in mind that the development of a geothermal power project requires experts from various fields. Thus, the lack of human resources regarding both, quantity and quality, may prevent private companies from engaging in geothermal power development. While expertise can be "imported," it increases the development costs. Hence, expertise domestically available is vital.

Unlike Indonesia, which, at least, offers three major universities with HRD programs for geothermal power development, Kenya does not provide similar facilities. Hence, GoK has mainly been dependent on foreign assistance to enhance human resources in the sector. A substantial number of Kenyan geothermal experts have been trained abroad since the 1970s (Mariita 2012). The UNU-GTP has been playing an important role in enhancing geothermal human capacities in the East African country. For example, 100 Kenyans have been trained between 1979 and 2014 at UNU-GTP. This is the highest figure of participants from any single country by far followed by participants from China, El Salvador and the Philippines (UNU-GTP 2015).

Apart from that, UNU-GTP has launched the so-called "UN Millennium Short Course Series" in East Africa. The series, which is "Iceland's official contribution to the UN Millennium Development Goals" (Georgsson et al. 2015, p. 7), offers introductory courses as well as highly specialized courses in the field of geothermal power development to a broader audience than expensive courses in Iceland.[46] Such

[46] Georgsson et al. (2015) note that between 2005 and 2014 short courses reached more than 400 participants from African countries. During the same time, only around 130 participants were trained in Iceland.

training has enabled experts in Kenya to carry out a wide range of geothermal activities on their own (e.g. surface geothermal exploration, drilling, reservoir monitoring) (Mariita 2012, p. 2). Apparently, Kenya has immensely benefited from UNU-GTP and has turned into some kind of focal point for human resources in Africa. As Georgsson et al. (2015, p. 7f.) point out, “Kenyans have, to a large extent, been in the role of the donor, while countries like Rwanda, Comoros, Zambia and most recently Sudan have utilized Kenya’s knowledge and contracted Kenyan experts for local exploration projects.” In the near future, this kind of South-South cooperation will lead to the establishment of a regional geothermal training center that will develop human resources on its own[47] and will reduce the lack of experts in the region.[48] Plans for a geothermal training center have been in the discussion since, at least, 2001 (Malin 2001 as found in Wambugu 2010, p. 475). However, the respective feasibility study financed by ICEIDA has not been commenced yet (ICEIDA 2014).[49]

Apparently, especially Kenya benefited from international and regional capacity building activities, through which the East African country has transformed into an exporter of expertise helping the whole region to meet its power needs through geothermal resources. The geothermal training center is likely to help the region with institutionalizing and steering capacity enhancement programs. These developments should increase the confidence of private sector actors to participate in geothermal power development in Kenya and reduce the costs of importing expertise.

5.4.4. Overcoming information barriers

The lack of information on the legislative and institutional framework may also disincentivize geothermal power developers, which is why, in 2012, the Energy Regulatory Commission (ERC) launched the Renewable Energy Portal (REP) with support from the World Bank. Among other things, the online platform includes (ERC 2012c):

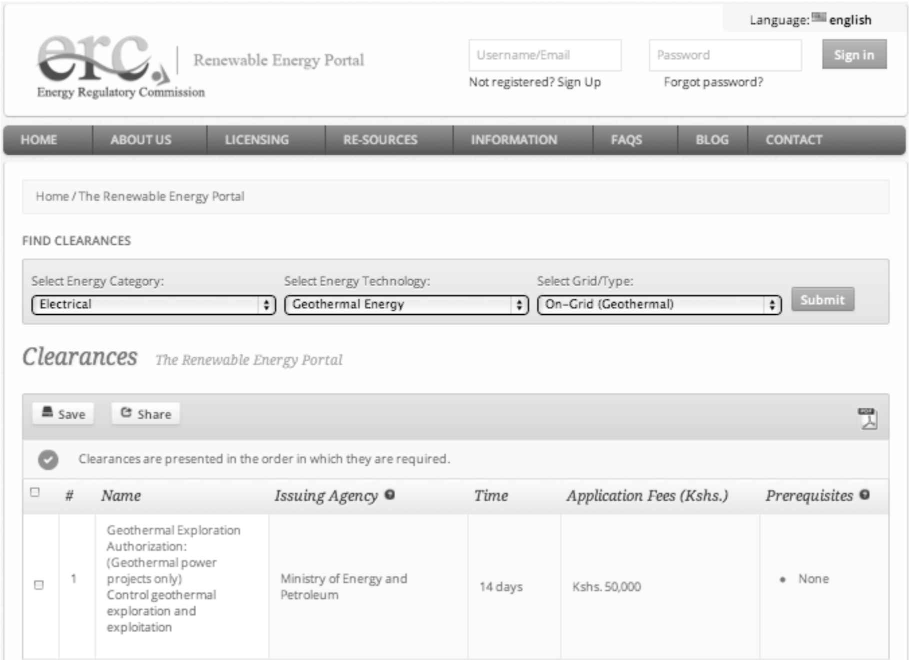
- Information on the endowment with renewable resources
- Lists of renewable energy projects and their current status
- Policy, legal and regulatory documents such as the LCPDP or the National Energy Policy
- Lists of licensed renewable energy practitioners.[50]

Most importantly, however, the REP gives “relevant information about administrative entry requirements and procedures for operating a power plant based on renewable energy” (ERC 2012d). As can be seen from Figure 13, the resulting information includes the agency in charge of issuing the license, the time it takes for processing

[47] Presumably, donors will be continuing to provide financial and technical support once the Facility is completed.
[48] According to the literature available, East Africa lacks up to 500 additional experts in order to achieve geothermal near-term expansion objectives (Teklemarian 2010 as found in Omenda & Simiyu 2010, p. 461). Unfortunately, Omenda and Simiyu (2010) only refer to the *regional* needs for geothermal experts and do not give a breakdown for the individual countries in that area.
[49] In fact, the expression of interest in carrying out the „Feasibility study and Preparation of a Concept Note for African Geothermal Centre of Excellence“ was due only in December 2014 (ICEIDA 2014).
[50] The list does not include any information on practitioners with respect to geothermal power.

the license application as well as charges imposed and prerequisites for obtaining the license.

Figure 13: Screenshot of the Renewable Energy Portal's website showing easy-access information regarding licenses and clearances in Kenya



Source: ERC 2012b

Apart from that, more in-depth information is provided by the REP showing, for example, the application procedure for an environmental impact assessment.

In 2011, the International Financing Corporation (IFC) published a report called "Inventory of Regulatory Requirements to Start and Operate a Renewable Energy Project in Kenya" (IFC 2011). As already stated earlier, with regard to regulations for geothermal power investors, the report found that investors in geothermal power must apply for eleven licenses and clearances – more than investors of other renewable energy sources (ibid., p. 7f.).[51] The study recommended establishing a one-stop shop facility that guides investors through the complete bureaucratic procedure. In particular, the IFC (2011) concluded:

> In a first phase, an option could be to create a digital One-Stop-Shop for the provision of relevant information to investors. This would be a website containing the described information on regulatory procedures for starting an investment project, tenders of sites, regulatory and policy decisions, and any information relevant to RE investors. Tender documents and application forms could be made downloadable. In addition, the GoK should consider publishing all signed PPAs to improve transparency in the sector as it is done in other countries.

The rationale for establishing the Portal is clearly to have an easy-to-use information access point or a "one-stop shop information counter offering guidance on the licensing and regulatory requirements for renewable energy projects in Kenya"

[51] Given that investors plan to make use of the feed-in tariffs provided by GoK.

(Mwirichia 2013). Even though the portal itself does not ease licensing and regulatory arrangements, it enhances transparency and, hence, reduces transaction costs or, more specifically, information search costs for geothermal developers. It remains to be seen whether GoK will be able to establish a one-stop shop in the near future.

Apart from the REP, there are more information databases: the Geothermal Database (AUC 2015a), the Web Geographic Information System (AUC 2015b) and the African Geothermal Inventory Database (UNEP 2014). The former two have been implemented as complements of the Geothermal Risk Mitigation Facility, which provides various types of grants to developers in Kenya and Eastern Africa, in general. The Geothermal Database includes publicly available literature on geothermal power development reducing the search costs for such relevant literature (AUC 2015a). Apart from that, GRMF provides the Web Geographic Information System (Web GIS). Web GIS displays a map, on which users can identify geothermal power plants as well as surface studies and drilling activities, funded by the facility. Additionally, as exemplified by the screenshot below for the Bogoria field, information on the resource potential and the resource type is provided. Hence, the Web GIS is a handy and easy-to-use tool for interested parties to gain access information on geothermal areas (ibid. 2015b).

Figure 14: Screenshot of the publicly available Web Geographic Information System

Source: AUC 2015b

For some investors, the Database may serve as a crucial instrument to gain access to country reports. However, the last update of the database was made in 2012 (as of January 2015), so either there are no new reports generated for the last three years or the “library” is not properly managed, which compromises the value of the database.

Last but not least, in 2014, the Icelandic International Development Agency and UNEP developed the so-called African Geothermal Inventory Database (AGID) “[t]o counter the lack of reliable and accurate data and information” (UNEP 2014). The Database does not only include information on Kenya but also on other East African countries, hence, it is a regional database. End-users of the database include public and private sector stakeholders interested in developing geothermal power in the region (UNEP). Since AGID was launched in late 2014 access is restricted to official and authorized personnel (in ARGeo countries), few details have been published.

According to UNEP (2014), the AGID includes information on:

- Previous, on-going and future projects
- Geothermal prospect areas and maps
- Stakeholders (companies, institutions, authorities, etc.)
- Laboratories
- Existing power plants
- Equipment available or needed
- Human resources.

Despite the lack of information, several advantages of such a regional database can be assumed. First, the database can contribute to exchanging and more efficiently allocating experts and equipment from different countries to geothermal power projects developed in the region. For instance, developers through AGID are supposed to better plan their projects with regard to experts and machinery as they can check the Database regarding availability. This also increases the developers’ capacity to design financial plans because they have a broad idea what kind of machinery or expertise has to be procured and even imported. However, as AGID was only introduced in late-2014, the advantages have a weak literature basis. Moreover, much depends on the systematic management of the database. However, it is indispensable that the data must be kept up-to-date by special staff in charge. Apart from AGID, in particular, the Renewable Energy Portal appears to be relevant as it helps investors to find their way through the procedural “jungle”, while information offered via the Geothermal Database (AUC 2015a) and the Web GIS (ibid. 2015b) may contribute to further reducing transaction or search costs.

5.4.5. Overcoming social opposition

The Government takes into account the site-specific socio-environmental trade-offs that may be triggered by geothermal power plants. First, as shown above, the national legislation requires developers to carry out environmental impact assessments and to obtain approval for land-use change. Moreover, the Geothermal Development Company annually hosts a running event, which has become more and more popular.

Environmental Impact Assessments are to identify “both negative and positive impacts of any development activity or project, how it affects people, their property and the environment. EIA also identifies measures to mitigate the negative impacts, while maximizing on the positive ones” (ERC 2012b).

Another safeguard is the clearance for land-use change to be obtained from county governments. The safeguards require that investors publish the requested land-use change in daily newspapers and put “a sign on the [targeted] land indicating [their] intention to change its use” (ERC 2012e). The county government, in turn, assesses public comments and approves or disapproves the land-use change requested. Apparently, according to information provided by ERC (2012f), regulatory procedures on environmental impact assessments and land-use changes do not require direct negotiations with local communities.[52] However, since international donors assisted geothermal projects developed, safeguards from those international organizations are applied. Generally, these safeguards, among other things, require compensation payments in case of involuntary resettlement.[53] [54]

Since 2012, the Geothermal Development Company has carried out the so-called Menengai Half-Marathon annually. By also offering ten-kilometer races, school and corporate races as well as family and wheelchair races, GDC addresses large target groups in a country, where running can be considered a national sport.[55] A prize-money provided to winners creates an additional incentive, especially for relatively well-known and popular runners, who, in turn, increase the popularity of the event. The number of participants has increased in recent years from 400 athletes in 2012 to 1,000 in 2013 and to 3,500 in 2014 (GCD 2014; AllAfrica.com 2014). According to GDC’s event brochure “[t]he Menengai Geothermal Half-marathon is GDC’s way of giving back to the community” (GDC 2014, p. 2) and “[s]ince initiating the Marathon in 2012, GDC has undertaken several health initiatives” (ibid.) including the rehabilitation of a hospital in the Menengai area.

As such, GDC performs to what literature may refer to as corporate social responsibility. Moreover, such activities raise the public’s awareness of geothermal-based electricity, which is amplified through media coverage. In doing so, GDC may reduce the fears of people that are not acquainted with the technology.

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[52] Please note that land ownership is a problematic issue in Kenya. For more information, please consult, for instance, FoodFirst Informations- und Aktionsnetzwerk (2010).

[53] For instance, World Bank (n.d.) points out that due to World Bank-supported projects “[i]n some cases, people are relocated or lose income and assets. We speak of “involuntary resettlement” when the affected people do not have the right to refuse land acquisition or restrictions on land use that result in physical or economic displacement. In Bank-financed projects, if such displacement occurs, affected people will get compensation and resettlement assistance.”

[54] However, despite applicable safeguards of donor organizations, donor-financed projects are criticized because evictions apparently do take place. The U.S.-based civil society organization Cultural Survival (2013) states “the discoveries of massive potential for geothermal energy made their land [that is the land of the Maasai] and home an international point of interest for both local and international power generating companies. The community has now sought redress by appealing to the High Court, where as previous court rulings favoring the Maasai as the legitimate owners of the land, a recent high court ruling went against previous rulings and deprived the Maasai of their right to own the land.”

[55] Several of the top long-distance runners in the world are from Kenya.

6. Merging results – towards a framework for overcoming geothermal deployment barriers in developing countries

In the preceding parts, measures were identified through desk research that are contributions to overcoming barriers to geothermal power deployment in Indonesia and Kenya through desk research. The hurdles spotted in Chapter 2 by carefully reviewing the existing literature, are financing barriers, institutional barriers and unreliability, the lack of human resources, information barriers and social opposition.

6.1. Measures to overcome financing barriers

The examination of both cases has shown, that Indonesia and Kenya make use of special organizations to overcome the early-stage risks associated with geothermal power development and, then, seek to transfer the further project development phases to developers. In Indonesia, CVGHM has been assigned with exploring geothermal resources since the 1960s and, thus, can be considered to have developed substantial expertise in carrying out this assignment reliably. The Kenyan example shows, that it is possible to develop, within a few years, a highly reputable company, the state-owned Geothermal Development Company, which is engaged in completing the initial stages of geothermal power development. Donors have substantially supported GDC in training personnel and procuring relevant machinery. However, recent charges brought up against GDC may undermine not only the reputation of the company but also GoK's geothermal expansion targets. With respect to its performance, the Indonesian CVGHM, apparently, is only engaged in completing Phases I and II, while Kenya's GDC is also responsible for completing the test drilling phase (Phase III) through which a higher degree of certainty regarding both the quantity and quality of the resource is ensured for developers in Kenya. Moreover, in Indonesia the costs for preliminary surveys and early-stage exploration are only temporarily financed by the state. A winning bidder of a geothermal field must repay the costs for the data compiled by CVGHM. In Kenya, the costs for Phases I to III are covered by both, state budget and donor funding, and, as the literature screened suggests, need not be repaid by developers. The differences in tackling the initial exploration risks already show that the Government of Indonesia is reluctant to absorb the risks associated with geothermal power development. For Kenya, in turn, the fact that donors contribute to financing Phases I to III and to absorbing risks proves to be a clear advantage from the investor perspective (Speer et al. 2014). This, probably, is an effect of Kenya's lower development status (in contrast to the lower middle-income country Indonesia), which facilitates GoK's better access to donor financing.

In order to incentivize private sector investments in Indonesia, the Government has launched the Geothermal Fund Facility, which provides loans for data enhancement and exploration drilling. GFF funding must be requested by local authorities and if approved by the managing authority of the GFF, a contractor is assigned. Once the contractor has completed his duties and has found reliable resources, the geothermal area is tendered. Private sector parties participating in the tendering of GFF-supported areas have the advantage of entering the field development at a later stage (Phase IV) of the geothermal project cycle, when the project bankability is better due to lower resource risks. Nevertheless, costs covered by GFF-loans must be repaid including the costs for unsuccessfully drilled wells. It has been also found that banks in Indonesia are less inclined to engage in long-term commitments necessary for infrastructure financing. In that respect, GoI also offers further financing options through the GFF (loans), the Multi-Infrastructure Facility (loans) and the Infrastructure Guarantee Facility (guarantees). Apart from that, the Government offers tax and tariff incentives reducing the costs for, for instance, machinery. Moreover, since the state-owned utility PLN is considered to be an unreliable financing partner, GoI introduced the Business Viability Fund, which guarantees that power purchasing agreements between the power plant developer and the utility are fulfilled, even if PLN goes bankrupt. Last but not least, developers can obtain a feed-in tariff, which may increase the bankability due to increased returns.

The close examination of the Kenyan system reveals that in contrast to Indonesia fewer institutionalized financing arrangements are available. However, those which are available, which are the African Rift Geothermal Development Facility and the Geothermal Risk Mitigation Facility, focus on the initial and, thus, very risky phases of geothermal power development. While ARGDF offers guarantees and grants, GRMF offers an innovative grants system for surface studies, test drilling, project continuation for works beyond Phase III as well as for infrastructure works, which also drives geothermal power development from one phase to the next. Like in Indonesia, a FiT-scheme is available but only for medium-scale power stations (35-70 MW) and it is capped at a cumulative geothermal power capacity of 500 MW. So as long as the total capacity of geothermal power plants does not exceed 500 MW, electricity producers are eligible for the FiT in Kenya. This creates a first-mover advantage and incentive for investors and may help to kick-start geothermal power deployment in the country.

Based on the case examinations, recommendations for other DCs regarding measures to overcome financing barriers can be made:

- Identify or establish an actor capable of reliably identifying and assessing geothermal resources, particularly, if geothermal power is to be explored on a large scale
- Seek to obtain donor funding for establishing an actor from scratch, for training personnel and for financing equipment
- Assess which Phases of geothermal power development the actor completes, but consider assigning the actor with carrying out Phases I to III
- Assess financing options for the actor as well as the willingness of donors to make contributions
- Consider the institutionalization of financing options (loans, grants, guarantees and / or feed-in tariffs) in different phases of geothermal power development

- Create first-mover/-investor advantage(s) to kick-start geothermal power development
- Consider the relevance of utilities, how they are perceived by financing institutions and, if necessary, provide guarantees for power purchase agreements.

6.2. Measures to overcome institutional barriers and unreliability

Based on the cases examined it appears crucial to have one or more Government bodies that take into account the unique characteristics of geothermal power development. While Kenya has entrusted the Geo-Exploration Department and the Energy Regulatory Commission with this task, Indonesia has created the Directorate General for New and Renewable Energy and Energy Conservation with its Directorate for Geothermal Energy, which offers special insight, because DG NREEC's date of establishment, 2010, correlates with the emergence of several measures taken to overcome financing or information barriers. Moreover, it is noteworthy that Indonesia's MoEMR appears to actively engage in stakeholder dialog through participating in business conferences. This contributes to fostering the exchange of information between policy-makers and investors and may help the Government to review and adjust its overall framework for geothermal power.

Moreover, the cases are revealing in that both countries have established geothermal power expansion targets, which have been interwoven with the respective national energy policies. Indonesia's expansion targets launched in 2006 for 2025, however, appear to be largely unrealistic as the Southeast Asian country is already behind schedule by more than 2,000 MW. From the perspective of the author of this paper, it is justifiable to point to the fact that Indonesia has only very slowly initiated measures that could have contributed to achieving the target. For instance, DG NREEC was only established in 2010, FiTs became eligible to the geothermal sector in 2010, the Geothermal Fund Facility became effective in 2013, the GeoPortal was launched only in 2014. Likewise, the Geothermal Law, which was considered to be a huge barrier to geothermal deployment, was revised only in 2014. However, recent developments in Indonesia can be positively interpreted as increasing Government commitment to geothermal power. In Kenya, policy support (e.g. the Renewable Energy Portal, Geothermal Risk Mitigation Facility) was provided directly after the publication of the latest version of the Least Cost Power Development Plan, which can be considered as a roadmap for power expansion including geothermal deployment. Moreover, the latest publication of LCPDP was published with support from the Geothermal Development Company, which has long been perceived as a reliable actor, even though recent corruption charges undermine this image and may scare off private sector parties.

Both cases suggest the importance of enhancing the capacity of authorities to execute their assignments appropriately and in due course. The literature screened on Indonesia refers to improvements underway in the field of tenders for geothermal areas as well as with respect to the evaluation of environmental impact assessments, both of which are performed by subnational authorities in the Southeast Asian country. For tendering, experts from the Geothermal Business Association are integrated in order to generate comprehensible tender documents and to evaluate bids, which is supposed to significantly affect the participation rate of developers. These were massively discouraged because of not perceiving subnational authorities to be able to carry out multi-million dollar deals (Gehringer & Loksha 2012). Moreover, subnational governments, which apparently have little expertise in geothermal power, are trained in evaluating environmental impact assessments. Since in Indonesia, subnational authorities assume more responsibility with respect to geothermal power development (Bappenas 2014), decentralized capacity enhancement measures are essential in order to meet service standards set by the Government. In the case of licensing delays, the Infrastructure Guarantee Fund may protect developers from financial losses. Kenya has also set specific service standards requiring that clearances and licenses should be reviewed or issued in due course. However, in Kenya tendering and the review of EIAs is carried out by specialized agencies, namely the GDC and the National Environment Management Authority (NEMA). Through this arrangement of having central actors assigned with relevant tasks to promote geothermal power development, capacity training can be more precisely targeted at these institutions, if necessary.

Through the case analyses, recommendations for other DCs regarding measures to overcome institutional barriers and provide reliability regarding the geothermal power framework can be made as follows:

- Entrust one or more government bodies with safeguarding an investment friendly environment for geothermal power
- Foster the stakeholder dialog between decision makers and the geothermal business community
- Establish ambitious and feasible geothermal expansion targets
- Integrate expansion targets into the national energy policy
- Establish flanking policies that support expansion targets
- Recruit qualified staff working on the expansion targets
- Identify laws (such as the Geothermal Law in Indonesia) prohibiting geothermal development in certain areas
- Assess the degree of expertise regarding geothermal power in relevant authorities
- Set adequate service standards for relevant assignments
- Initiate capacity enhancement for unqualified personnel
- Protect investors from financial losses due to institutional incapacity.

6.3. Measures to develop human resources

Enhanced human resources can contribute to attracting geothermal power developers in two ways. First, well-trained government staff can more easily exercise and accomplish assignments regarding geothermal power, which reduces the likelihood of unnecessary and capital-consuming delays. Second, if expertise is domestically available in sufficient quality and quantity, developers need not import their qualified personnel from abroad, which may increase development costs. While

HRD is crucial, it is at the same time a serious challenge because developing countries can, generally, be assumed to have limited structures (e.g. Universities) in that respect. The examination of Indonesia and Kenya has revealed several important points, which other DCs may keep in mind for overcoming this important bottleneck.

First, the case of Indonesia suggests that it is crucial to have an overall plan guiding HRD for the geothermal sector. Such a plan should take into account geothermal expansion goals, identify the demand for expertise to realize these goals and assess opportunities on how to foster and speed up HRD. With respect to the latter, it is, obviously, reasonable to first identify domestic research institutions that are able to develop expertise. Indonesia is blessed with having, at least, three Universities for such purposes. Apart from that, the United Nation University Geothermal Training Programme appears to be a cornerstone of international HRD efforts, but there are also other countries such as New Zealand offering support in that respect. The analysis for Kenya shows, that the East African country has benefited more than any other country from UNU-GTP and, according to the literature screened, has *de facto* become a regional exporter of qualified staff supporting neighboring countries to deploy geothermal power. Additionally, East African countries, in a collaborative effort with the Icelandic International Development Agency, strive to establish a regional training center, which is supposed to give these countries some kind of independence of the agendas of international donor organizations, which, for example, could easily withdraw such support due to financial constraints (Wambugu 2010).

Based on the case examinations, the following recommendations for other DCs regarding measures regarding HRD can be given:

- Develop a strategy to build up human resources for geothermal power development
- Assess HR-needs for achieving geothermal expansion targets, if applicable, and assess the landscape of domestic research institutes that can assist in HRD, if applicable
- Seek to improve the domestic HRD landscape and if research institutes are non-existent, seek to establish domestic HRD structures
- Alternatively, seek regional cooperation with neighboring countries in establishing HRD structures
- Take into account international HRD-programs (e.g. UNU-GTP).

6.4. Measures to overcome information barriers

Easily-accessible information is crucial to geothermal power developers to reduce the time spent on searching for information. The examination of the two cases, Indonesia and Kenya, has shown that both provide information systematically through the Internet.

In Indonesia, GoI has developed, with support from the German KfW development bank, the GeoPortal, which provides up-to-date reports, newspaper articles and policy papers regarding geothermal power in Indonesia (Bappenas 2015). The Geothermal Handbook (Bappenas 2014), available online on the GeoPortal, can be considered as one of the most valuable sources of gaining information on relevant legislation, policies, stakeholders etc. Unfortunately, it is unknown whether this source is really exhaustive. For example, regarding licenses and clearances, it mainly refers to environmental impact assessments, while in other sources (e.g. Supreme Energy 2013) land-permits are discussed as an issue for developers, too. Apart from these important documents, the GeoPortal also includes a map with geothermal areas in Indonesia, including information on resource estimates and much more. The fact that all these types of data and sources are available on a single website increases the value of the GeoPortal. It could be an interesting platform to be transferred to other DCs. In contrast, information in Kenya is a bit more diffusely stored with the Geothermal Database (AUC 2015a), which offers reports and studies on geothermal power development in Kenya, and with the Renewable Energy Portal providing information on the legislative procedures (ERC 2012b). Especially the REP should be really helpful for investors and developers in getting a full picture of the licenses and clearances necessary for geothermal power production. Very little literature is available on the African Geothermal Information Database, launched in 2014 and supported by ICEIDA. In fact, this database is supposed to host information on human resources and equipment available in East African states for geothermal power production. If private sector developers gain access to this information directly or indirectly (through an authority), the planning process may be eased.

Based on the case examinations, recommendations made for other DCs regarding measures to overcome information barriers are as follows:

- Provide an “online library” for reports, newspaper articles, policy papers and other documents that relate to geothermal power and make them available online
- Provide information on regulatory procedures
- Provide an “online map” for geothermal areas and include as much additional information as is available for respective areas
- Provide information on available human resources and machinery
- Seek to bundle all the information on as few websites as possible
- Ensure the proper management of the system(s) so that information can be kept up-to-date
- If necessary, seek to obtain support from donor organizations.

6.5. Measures to overcome social opposition

Social opposition towards investments can delay projects, for example, through fierce legal disputes. For geothermal power development, this is particularly worrisome because of the long lead-time until a power station can be deployed. Hence, it is crucial to reduce factors that may trigger social opposition.

The examination of Indonesia and Kenya shows that both countries require investors to carry out projects with socio-environmental assessments regarding the impact of geothermal power development and power plant operation on the environment. However, in both cases the literature raises doubts whether government authorities are qualified to appropriately evaluate such impact assessments. Hence, while safeguards are important, it must be ensured that safeguards are adequately evaluated. With respect to land procurement, the national Government of Indonesia requires local authorities to not only monitor negotiations between investors and communities living on the site, where geothermal resources have been found, but also to function as mediators to settle potential disputes between the investors and the community. This may help developers, who may not necessarily be familiar with local peculiarities, to achieve an agreement. Apart from that, there appears to be a trend to more holistically use geothermal power stations in Indonesia (Petrus et al. 2015). In particular, memorizing the heritage of local people could reduce their fears of losing their identity. Moreover, plans also include making use of geothermal fields as sights for eco-tourists, which may also enhance the image of the technology, in general, as people can become familiar with geothermal power in an unconventional way. In addition, if this creates living-wage jobs for local people, this may reduce opposition. However, it is unknown whether the more holistic use of geothermal sites will be mandatory for private sector parties and whether GoI provides incentives. The running events hosted by the Kenyan Geothermal Development Company are also quite innovative. In a nation, where running is a national sport and, most probably, gains lots of media coverage, a running event may create a very positive image of the technology within the population.

Based on the case examinations, recommendations made for other DCs regarding measures for mitigating social opposition are as follows:

- Establish safeguards mitigating the negative effects of geothermal power
- Ensure that competent authorities are assigned with monitoring safeguards and issuing clearances
- Support developers (e.g. through local government authorities) in seeking common ground with local communities
- Assess opportunities to familiarize the population with geothermal power.

6.6. Summarizing measures to overcome barriers to geothermal power deployment in developing countries

The following Figure 15 presents an overview of the findings above.

Overcome financing barriers

- Identify or establish an actor capable of reliably identifying and assessing geothermal resources, particularly, if geothermal power is to be explored on a large scale
- Seek to obtain donor funding for establishing an actor from scratch, for training personnel and for financing equipment
- Assess which Phases of geothermal power development the actor completes, but consider assigning the actor with carrying out Phases I to III
- Assess financing options for the actor as well as the willingness of donors to make contributions
- Consider the institutionalization of financing options (loans, grants, guarantees and / or feed-in tariffs) in different phases of geothermal power development
- Create first-mover/-investor advantage(s) to kick-start geothermal power development
- Consider the relevance of utilities, how they are perceived by financing institutions and, if necessary, provide guarantees for power purchase agreements.

Overcome institutional barriers and unreliability

- Entrust one or more government bodies with safeguarding an investment friendly environment for geothermal power
- Foster the stakeholder dialog between decision makers and the geothermal business community
- Establish ambitious and feasible geothermal expansion targets
- Integrate expansion targets into the national energy policy
- Establish flanking policies that support expansion targets
- Recruit qualified staff working on the expansion targets
- Identify laws (such as the Geothermal Law in Indonesia) prohibiting geothermal development in certain areas
- Assess the degree of expertise regarding geothermal power in relevant authorities
- Set adequate service standards for relevant assignments
- Initiate capacity enhancement for unqualified personnel
- Protect investors from financial losses due to institutional incapacity.

Overcome the lack of human resources

- Develop a strategy to build up human resources for geothermal power development
- Assess HR-needs for achieving geothermal expansion targets, if applicable, and assess the landscape of domestic research institutes that can assist in HRD, if applicable
- Seek to improve the domestic HRD landscape and if research institutes are non-existent, seek to establish domestic HRD structures
- Alternatively, seek regional cooperation with neighboring countries in establishing HRD structures
- Take into account international HRD-programs (e.g. UNU-GTP).

Overcome information barriers

- Provide an "online library" for reports, newspaper articles, policy papers and other documents that relate to geothermal power and make them available online
- Provide information on regulatory procedures
- Provide an "online map" for geothermal areas and include as much additional information as is available for respective areas
- Provide information on available human resources and machinery
- Seek to bundle all the information on as few websites as possible
- Ensure the proper management of the system(s) so that information can be kept up-to-date
- If necessary, seek to obtain support from donor organizations.

Overcome social opposition

- Establish safeguards mitigating the negative effects of geothermal power
- Ensure that competent authorities are assigned with monitoring safeguards and issuing clearances
- Support developers (e.g. through local government authorities) in seeking common ground with local communities
- Assess opportunities to familiarize the population with geothermal power.

Figure 15: Measures to overcome geothermal power deployment barriers in developing countries

7. Summary and final remarks

The objective of this study is to contribute to paving the way for developing countries in overcoming investment barriers to geothermal power deployment. Geothermal power represents a unique source of electricity given its low-carbon and base-load characters. Moreover, it is hardly affected by weather or seasonal variations. Some developing countries have a great potential for deploying geothermal power, but in order to reap its benefits, substantial barriers must be overcome, which particularly affect developing countries.

After having comprehensively screened the literature available, important hurdles to geothermal power deployment could be structured into five barriers: financing barriers, institutional barriers and uncertainty, lack of human resources, information barriers and social opposition.

In order to answer the central research question on how developing countries can overcome barriers to geothermal power deployment, this study deliberately carries out two case studies on Indonesia and Kenya. The major reason for selecting these countries is that both, quite surprisingly, belong to the global top-ten countries in terms of installed geothermal power capacity. Moreover, both cases have a high resource potential and, thus, can be assumed to have an active interest in deploying geothermal power. This may reduce the target group of this paper to those countries with high resource estimates. However, since there are several DCs with substantial resource estimates (GEA 2014a), a study concentrating on Indonesia and Kenya is justified.

The results from the case studies are merged and a framework is conceptualized including barrier-specific recommendations made to facilitate investment in the geothermal power sector. Financing barriers, which especially apply to the early stages of geothermal power development (Phases I to III) can be overcome by assigning a capable and reliable agency that completes these initial Phases. Since developing countries have little financial capacity to cover the expenses necessary within these Phases, donor financing could substitute the government’s budget or blend it to increase the financial lever. Apart from financing the agency directly, instruments that facilitate loans, grants or guarantees could also prove useful in one or various phases of geothermal power development. First-mover advantages facilitated through, for instance, FiTs, could kick-start investment.

In order to mitigate institutional barriers discouraging investors, government bodies should be designated to create and maintain an investment friendly framework with respect to policies as well as regulatory procedures. Moreover, an active information exchange with stakeholders could not only contribute to identifying flaws in the overall (policy, institutional, legal) framework but also to assuring business community stakeholders that the government is open to and takes seriously suggestions for improving the investment framework. This may help to identify and remove both, legal misconception or underperformance of authorities that are, for instance, in charge of tendering geothermal fields. Geothermal expansions targets, which are, ideally, integrated into the national energy policy, reinstate government commitment and serve as a “backbone to any country’s renewable energy strategy” (UNEP FI 2012, p. 13). However, qualified staff should be working on the expansion targets in order to create ambitious as well as feasible targets.

The lack of human resources can also be a limiting factor for geothermal power investment as, for example, developers cannot draw on a pool of domestic experts. For large-scale expansion of geothermal power, it appears relevant to build a strategy for human resource development, to assess human resource needs and the institutions available that could contribute to enhancing human resources. If the institutional HRD structure is weak, which can easily be the case in DCs, international capacity building programs can be adopted. However, in the long-run domestic HRD institutions should established.

In geothermal power development, different kinds of information are crucial. The examination of the cases found that online platforms could be used to provide data and reports on geothermal resource areas, on the regulatory procedures as well as on the availability of expertise and machinery in a country. Such a package of information can reduce transaction or information search costs and enhance the ability to plan a project. While donors could assist in establishing such databases, it appears crucial to maintain these databases and to keep them up-to-date.

Despite the clear advantages of geothermal power, despite the little space needed for power plant construction (compared to other technologies) and its sound environmental performance (Gehringer & Loksha 2012; IFC 2007; Goldstein et al. 2011), geothermal power stations are site-bound and, thus, can be considered disadvantageous to people living on the site of where the geothermal resource is located. Hence, it is crucial to establish safeguards that mitigate the effects of geothermal power plants on people and the environment. Apart from applying these safeguards, it has to be ensured that safeguards are effectively monitored. In particular, the support of developers through local actors appears helpful to negotiate a mutually beneficial agreement between developers and communities. In addition, measures to familiarize the population with geothermal power could help to yield an overall positive image of the technology within the population.

Having made use of two case studies helped to explore approaches of governments in DCs to facilitate geothermal power deployment despite substantial technology-specific barriers to investment. Even though expert interviews could have given further insights into technology-specific barriers applying in DCs, the conceptual framework of barriers, which was developed in this study, should be relatively comprehensive since the most recent available literature was systematically assessed.

Given this study’s findings, it is legitimate to state that both Indonesia and Kenya address these five barriers to geothermal power investment by implementing specific instruments. Hence, other DCs should also factor in these barriers when they seek to increase power production from this unique source of energy.

However, the individual policy instruments should not be regarded as passe-partout but it is necessary to take into account the country-context. For instance, while in Indonesia a state-owned oil and gas exploration company was able to also take over geothermal energy projects, Kenya had to go another pathway in gradually developing capacities for such projects. Moreover, making use of policy instruments identified in the case studies does not automatically mean, that these instruments are effective in overcoming barriers and achieve their goal(s). For each and every policy instrument, ex-ante as well as ex-post assessments on the effectiveness should become the rule. For example, with respect to policies aiming at capacity building, governments should monitor how many people have been trained to what degree. Having this done for each and every policy is, of course, a laborious task, but it is essential to have policies perform well and, ultimately, contribute to the overall aim (which in this study is the deployment of geothermal power). This request also applies to donor agencies that become active in foreign countries through development cooperation. Respective interventions must also be monitored neatly.

Apart from making use of policy assessments and evaluations, it appears crucial to analyze more DCs on their strategies to increase geothermal power generation. This is true for comprehensive country strategies for the five barriers studied. However, cross-country comparisons regarding specific barriers could also be helpful.

Even though this study’s recommendations are based on the close examination of two countries, Indonesia and Kenya, results are nevertheless helpful and can provide stimuli for other developing countries that intend to exploit their geothermal power resource. Admittedly, though, such countries must still carry out a tailor-made feasibility study, which identifies the exact geothermal power deployment barriers and their effects on investment.

Since more and more developing countries appear to become interested in utilizing geothermal power, future research should focus attention on the technology-specific barriers. For instance, a close examination of measures taken by both, other DCs or even industrialized countries to overcome barriers could be effective. Research on industrialized countries such as the U.S., Iceland or New Zealand could prove to be useful analyzing how they seek to overcome barriers and whether lessons can be learned from these cases for developing country cases. Moreover, it may also be interesting to assess what countries with little experience in geothermal power, such as Peru, can learn from cases such as Indonesia or Kenya, in particular. This could support DCs in achieving a sustainable, reliable power system for the future decades. Apparently, a lot can be done to enhance the global community’s knowledge on how geothermal deployment barriers can be overcome and how investment can be attracted.

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Editor of this issue:
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Contact: inef-editor@uamr-graduate-centre.org
Cover-Design: Jan Schablitzki, Simon Rohde
Cover-Photos: Wolff | John Isaac | Jean Pierre Laffont (UN Photos)

ISSN: 2195-1659 (Print)

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