TRANSITIONS PATHWAYS AND RISK ANALYSIS FOR CLIMATE CHANGE MITIGATION AND ADAPTATION STRATEGIES

D3.2 Context of 15 case studies:

Kenya: Charcoal and Geothermal Sector

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Like many countries in sub-Saharan Africa, Kenya has high development ambitions, aiming to become a middle-income country by 2030. In particular, these ambitions are based upon a low-carbon, climate resilient development pathway, as set out by Kenya's Intended Nationally Determined Contributions (INDC). These development ambitions depend on the rapid expansion of the energy sector to increase the access, security and affordability of energy service provision. Geothermal seems poised to play an important catalysing role in this expansion. At the same time, a narrow focus on power sector development overlooks the important role of biomass energy for cooking, particularly charcoal, which is the preferred cooking fuel for a rapidly expanding urban population and has significant impact on land use emissions. With this in mind, this case study explores the energy sector in Kenya, with particular focus on the geothermal and charcoal sub-sectors.

1.1 Research questions for the Kenya case study

As with many sub-Saharan African (SSA) countries, Kenya's greenhouse gas (GHG) emissions are dominated by land use sectors due to clearing for commercial agriculture, slash and burn practices of small farmers, increasing charcoal use and inadequate land use policies. The business-as-usual (BAU) projection is a near-doubling of GHG emissions by 2030 to 143 $MtCO_2eq$, compared to the 2010 baseline of 73 $MtCO_2eq$. As with other SSA countries, rising population and increasing demand for land, food and energy has led to forest encroachment and unsustainable growth. According to Kenya's Intended National Development Commitments (INDC), the goal is a 30% reduction of GHG emissions by 2030 compared to the BAU scenario. The Kenyan government has generally embraced the notion of a green economy and is often seen as a leader among African countries on renewable energy while at the same time facing significant vulnerability to the impacts of climate change.

Considering the importance of land use emissions, a special focus in Kenya will be the charcoal sector. The analysis of the charcoal sector in African countries is notoriously complex due to the interactions between key actors in the supply chain and the incentives they have for change and innovation.

In the power sector, geothermal seems poised to play an important role and thus a second research focus in Kenya is the question of how, when and where this sector can be scaled up. There is also a key regional linkage because of the potential for geothermal power along the Rift Valley that runs through the region.

Research Questions:

1. What are possible future(s) for geothermal power and the charcoal sector in Kenya?

a. Can the charcoal sector be made sustainable in Kenya?
b. Can geothermal power play a significant role in Kenya by 2030?
c. What are the societal costs, benefits, risks and opportunities of reliance on these two sectors (geothermal and charcoal) as significant energy sources in Kenya?
d. How does development of these two sectors affect energy access, livelihoods and equity?

2. Which key actors, networks and sector/system management approaches are needed in these sectors?
    a. Who are the key actors and how do they impact these two sectors in the context of external pressures (socio-technical perspective)?
    b. What are the incentives for change among the actors involved and what key linkages, synergies and conflicts can be identified?
    c. How and to what extent can these actors and networks support innovation towards low carbon transition pathways in Kenya?

3. What are the key enabling policies and institutions to support sustainable geothermal and charcoal sectors (or substitution) in Kenya?
    a. What policies and institutions, including regulation and financing, can help mitigate identified risks in these two sectors and accelerate implementation of the most sustainable options and pathways?
    b. Who are the key actors in driving such policies and institutions (socio-technical perspective) and what external events are these policies and institutions dependent on?
    c. Are there important linkages, synergies and/or conflicts between the aforementioned policies and institutions with existing policies, institutions and sector development processes?
    d. What are the uncertainties, risks, barriers & opportunities associated with implementing the aforementioned policies and institutions for these two sectors?
    e. How and to what extent can the implementation of the policies and institutions for these two sectors support low carbon transition pathways in Kenya?

1.2 Introduction to the general context

Kenya is situated in East Africa, between 5ºN and 5ºS latitude and 34ºE and 42ºE longitude. With a total area of 582,646km^2,[2] the country hosts a population of approximately 41 million (KNBS, 2010). Arid and semi-arid conditions account for over 85% of the land mass. In 2015, the Gross Domestic Product stood at roughly 62.2 billion USD which is a growth of 5.46% compared to 2011 figures (KNBS, 2016). The country's high dependence on natural resources makes its GDP very sensitive to any impacts of climate change on the natural environment. As population has increased, demand for resources and industrial expansion has taken an upward trend. Overexploitation of available natural resources increases the country's vulnerability and exposure to the threats of climate change. Development of the energy sector is recognised as a key driver towards achieving Vision 2030, the country's blueprint for becoming a newly industrialising, middle-income country providing a high quality life for all its citizens by the year 2030. It is anticipated that total energy demand will surpass the current installed capacity hence the need to explore alternative cost effective sources of energy.

Responding to the decisions adopted during the 19th and 20th sessions of the conference of parties, Kenya submitted its INDC towards achieving Article 2 of the convention in UNFCCC. The INDC notes that land use, land use change, forestry and the agriculture sectors contributed 75% of the total GHG emissions in year 2010. Although the country is a relatively low emitter, there is commitment to continue making investments to adapt to climate change and constrain the expected emissions increases.

By the year 2030, Kenya's GHG emissions under a business-as-usual scenario – excluding future exploitation in the extractive industry – are estimated at 143MtCO_2eq, based on the per capita emissions of about 1.26 MtCO_2eq. Therefore, the country has set mitigation and adaptation actions to abate its GHG emissions by 30%. To achieve a low carbon, climate resilient development pathway, some of the mitigation activities relate to promoting clean energy technologies to reduce overreliance on wood fuels; achieving a tree cover of at least 10% of the land area and expansion of renewable sources of energy including solar, wind and geothermal resources. As part of this effort, Kenya submitted its first National Appropriate Mitigation Action (NAMA) for accelerating geothermal power development in 2014. Supported by ECN Policy Studies and Ecofys Germany through the Mitigation Momentum project, the geothermal NAMA was the product of a 16-month multi-stakeholder dialogue. Since then, the Government of Kenya – with support from UNDP – has embarked on developing a NAMA for the charcoal sector. Meanwhile, adaptation measures include climate proofing infrastructure as well as supporting innovation and development of appropriate technologies that promote climate resilient development. These measures have come out of Kenya's consecutive strategies and plans for addressing climate change, starting with the National Climate Change Response Strategy (NCCRS) developed in 2010, followed by the National Climate Change Action Plan (NCCAP) launched in 2013 and most recently the country's National Adaptation Plan (NAP), which was finalised in 2016.

1.2.1 Policy overview

The environment, energy and climate change sectors are driven by international, regional and national processes. As a signatory to Paris Agreement 2015, the country is committed to contributing to the objective of holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. Prior to the Paris Agreement, Kenya was a signatory to UNFCCC and Kyoto Protocol to which it had aligned its national policies and legislative framework. On the energy front, Kenya has subscribed to the UN Sustainable Energy for All agenda, which aims to ensuring universal access to modern energy services, doubling the rate of improvement in energy efficiency and doubling the share of renewable energy in the global energy mix. As a requirement under this commitment, the country undertook a stock taking in 2013 to identify the gaps and barriers to energy access with a view of developing an appropriate national action plan to address them (Ministry of Energy and Petroleum, 2013). The subsequent Action Agenda and Investment

Prospectus outlines Kenya's plan to invest in renewable energy programmes on biomass and geothermal.

At the regional level, the Africa Strategy on Climate Change under the leadership of the African Union focuses on fiscal policy measures, such as environmental taxes, subsidy reform and carbon pricing, to minimise the environmental impacts of energy use, diversify the energy system and integrate renewable energy options into the energy mix (African Union, 2014). Agenda 2063 – a strategic framework for the socio-economic transformation of the continent over the next 50 years – seeks to accelerate the implementation of past and existing continental initiatives for growth and sustainable development. It recognises that while Africa at the present contributes less than 5% of global emissions, it bears the brunt of the impact of climate change (African Union, 2015). Hence, there is a need to prioritise mitigation and adaptation in all actions, drawing upon skills of diverse disciplines with adequate support, such as affordable technology development and transfer, capacity building, financial and technical resources, to ensure implementation of actions for the survival of the most vulnerable populations, including islands states, and for sustainable development and shared prosperity.

At a national level, the National Climate Change Response Strategy (NCCRS) and the Climate Change Act aim to promote technological innovations for low carbon development. These policy instruments recognise that the energy sector is vulnerable to climate change and hence the need to strengthen research in energy technologies, like geothermal, and promote the sustainable harvesting and consumption of biomass.

Kenya's Medium Term Plan 3 (2018-2022) – anchored within the Vision 2030 – is now in the design phase and gives great priority to the renewable energy sector. By mid-2015, Kenya's installed electricity capacity was 2298.9MW, with 35.7% hydro, 26% geothermal, 37.2% thermal and 1.1% wind (see Figure 1). However, actual electricity consumption (based on electricity purchases) in mid-2015 was 2228.4MW, with 35.7% coming from hydro, 43.7% coming from geothermal, 19.3% coming from thermal, 0.4% coming from wind and 0.9% coming from imports (see Figure 2). The reason for consumption pattern differing from the capacity mix was largely due to limited operational availability of some thermal plants compared to their installed 'nameplate' capacity, and cheaper geothermal power being dispatched before more expensive thermal power. The country's Least Cost Power Development Plan (2011-2033) projects that geothermal resources will contribute 26% of national electricity supply by 2033. As such, one might assume this indicates a clear step towards a lower carbon energy system. However, the fact that one third of electricity supply will continue to come from fossil fuels (13% coal, 11% gas and 9% diesel) suggests there is need to explore some of the trade-offs in national energy planning. The current dependence on traditional biomass resources has led to exploitation beyond the rate of forest regeneration. Kenya's national energy policy recognises that investment in sustainable harvesting of fuelwood, sustainable charcoal production and clean cooking fuels and stoves can reduce GHG emissions associated with land use change and inefficient cookstoves.

Hence, the charcoal and geothermal sectors remain of great interest in shaping the future of Kenya's energy system. The different policy contexts, investment needs, perceptions and trends in both sectors, and their potential to contribute to GHG emissions reduction is a key driver for undertaking the Kenyan case study.

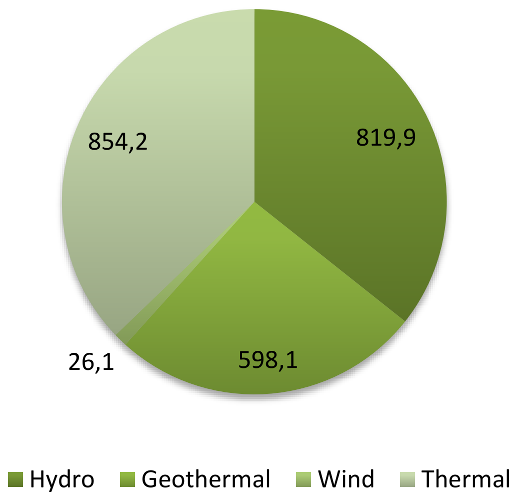


Figure 1 Installed electricity capacity in Kenya as of mid-2015 (MW)

ERC (2015)

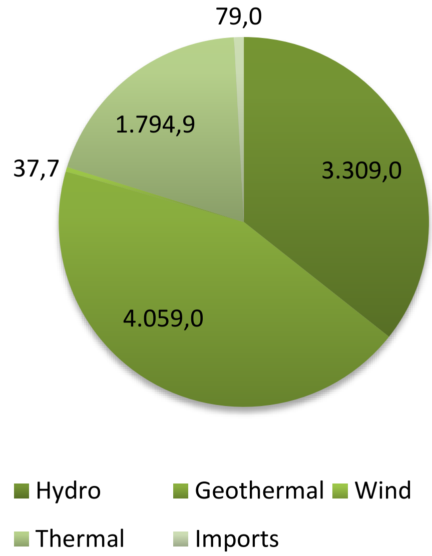


Figure 2 Electricity consumption (purchased) in Kenya, 2015 (GWh)

ERC (2015)

1.2.2 Natural resources and environmental priorities

The quest for economic development along with rapid population increase, has led to increased energy demand in Kenya. As shown in Figures 3 and 4, the country's energy mix is dominated by biomass resource use in the residential sector: IEA figures suggest that, in 2014, biofuels and waste – which includes charcoal and woodfuel – accounted for 71.8% of total final energy consumption in Kenya, with coal, oil and electricity accounting for 21.4%, 2.2% and 4.5% respectively (IEA, 2016). Meanwhile, the residential sector – which typically consumes biofuels and waste for cooking – accounts for 75.6% of total final energy consumption, whilst transport accounts for 14.8% and industry for 8.3%. The remaining 1.1% is accounted for by commercial, agriculture/forestry and non-specified sectors. Biomass resources are derived from public natural forests, farmlands and community rangelands and forests. As population rises and demand for biomass resources subsequently grows, increasing pressure is exerted on these resources, hence the need to ensure sustainable production and harvesting. In particular, charcoal – produced by carbonising of wood by pyrolysis – is the preferred source of energy for urban households and institutions, supplying energy needs to over 80% of the urban population with current per capita demand of $0.3915m^3$. There is a growing gap between supply and demand of the commodity, with current demand, estimated at 16.3 million m^3, far above the current supply of 7.4million m^3 (Wanleys Consultancy Services, 2013). By 2032, forecasted demand is estimated to increase by 17.8% while supply will increase by only 16.8%. In such a scenario, the supply-demand gap is 8.9 million m^3 and will grow to 10.6 million m^3. This calls for innovative approaches to producing charcoal to close the gap as well as improving efficiency during conversion and consumption. Yet doing so is not easy: despite the importance of charcoal in Kenya, the sector remains informal, with little recognition in formal annual national economic reporting. As such, there is still limited attention given to addressing the challenges faced in managing the sector so it is sustainable. Section 1.4.2 provides a more detailed overview of the charcoal sector in Kenya.

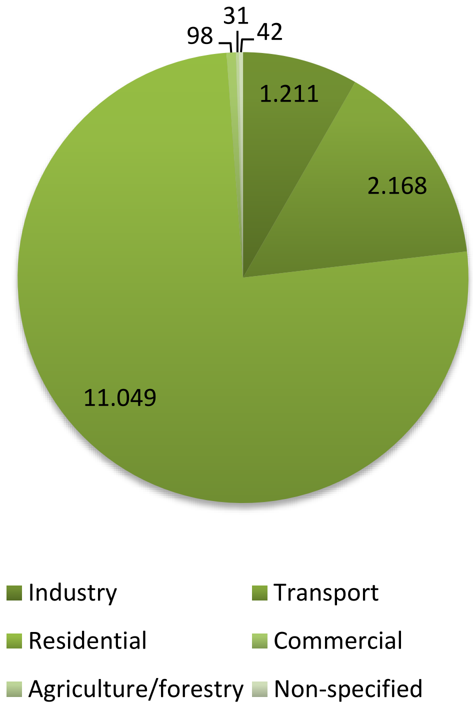


Figure 3 Total final energy consumption in Kenya in 2014, by sector (ktoe)

IEA (2016)

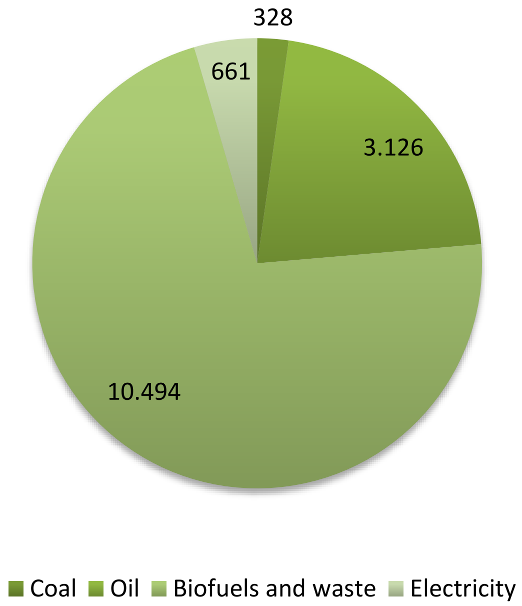


Figure 4 Total final energy consumption in Kenya in 2014, by fuel type (ktoe)

IEA (2016)

Kenya aims to transition to a middle-income nation by 2030, and development of energy infrastructure is one of the main pillars towards the realisation of the vision. Long-term and mid-term national energy development strategies including 5000+MWe prospectus (2013 – 2016) and the Least Cost Power Development Plan (LCPDP, 2011-2031) – the main blueprint for Kenyan energy development – indicates significant reduction in renewable energy contribution to the national electricity mix, in the ratios of 63% as at 2013, 45% in 2016 (projection) and 40% by 2031 (see Figure 1). In spite of such changes, the plan is to achieve the nationally determined contribution to GHG reduction of 30% in 2030. Geothermal is poised to be the most attractive option, supplying the country with up-to 26% of national energy demand by 2030. Guided by Vision 2030, the peak demand is projected to reach 11,318MW under the low reference scenario (Government of Kenya, 2011) by 2030. The installed generation capacity is also projected to reach 14,676 MW based on the reference scenario. Yet even with increased generation, capacity utilisation continues to be an issue: between 1998-2008, annual capacity utilisation in Kenya's power sector ranged from 40 to 60% (Vagliasindi and Besant-Jones, 2013).

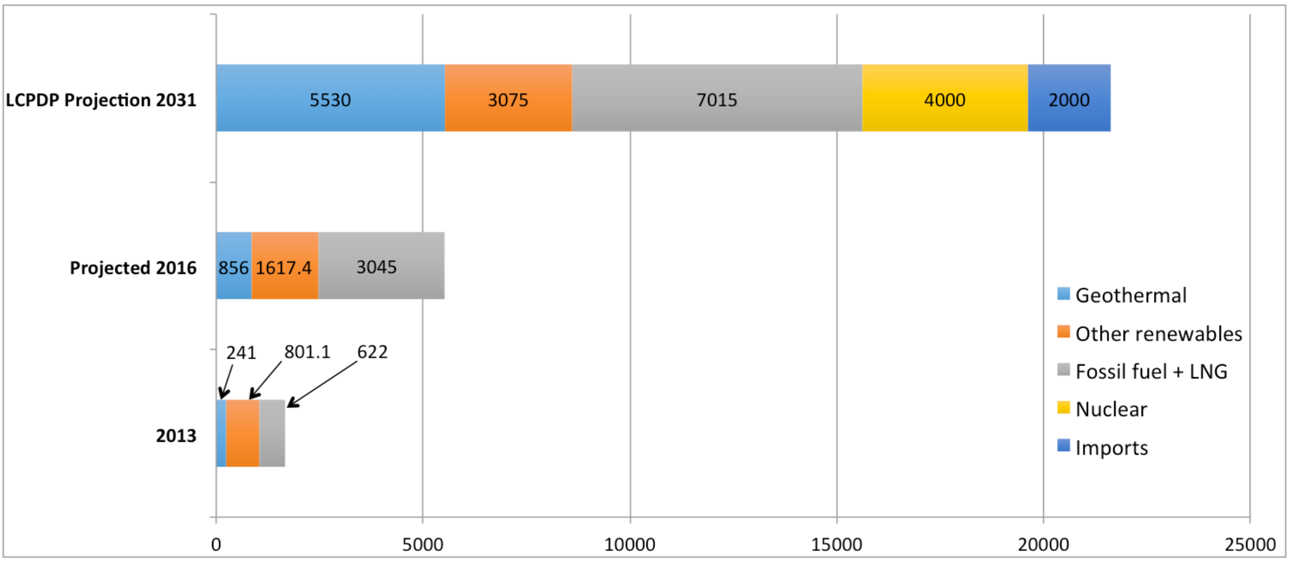


Figure 5 Projected power sector mix (MW)

Sources: Government of Kenya (2011)

Fossil fuel exploration started in 1960 when the first oil well was drilled. Although evidence of oil and gas deposits were found, none of the drilled wells were deemed viable for commercial production. Over the years there have been numerous efforts to conduct studies in different regions to determine oil potential: by January 2015 a total of 70 exploratory wells had been drilled, and roughly 90,000 line km of two dimensional (2D) and over 6,300km^2 of three dimensional (3D) seismic data acquired. The estimated recoverable reserves stand at 750 million barrels of crude oil and it is anticipated that, by 2017, 2000 barrels of crude oil will be exported per day, possibly increasing to 4000 barrels per day over time (Daily Nation, 2016; Odhiambo, 2016; Uganda Oil, 2016).

In 2007, the Kenyan government identified two zones with possible commercially viable coal resources: Mui Basin in Kitui County and Taru basin in Kwale and Kilifi counties. By 2010, 400 million tonnes of sub-bituminous to lignite with approximately 16-27 MJ/kg calorific value was confirmed. Exploration was then extended to other parts of the country, with 31 additional coal blocks established for the purpose of ascertaining coal potential and delineating the blocks for concession. Plans are also underway to build a coal power plant, with an initial capacity of 960MW and expected commissioning in 2017. By 2030, coal is projected to provide at least 2420MW (Government of Kenya, 2011). Kenya's cement industry in particular is expected to also utilise domestic coal. Coal imports for use in the cement industry have increased in recent years, with an average of 172,000 metric tonnes being imported as of December 2014.

In 2010, GHG emission levels in Kenya were recorded as 55MtCO_2e, with the energy sector accounting for 17.7%, the agriculture sector responsible for 41%, land use, land-use change and forestry contributing 37%, waste making up 2% and the industrial sector accounting for 1.5% (see Table 1).

Table 1 GHG emission by sector

Sector	2010 Emissions (CO_2e - Gg)				Total	Total as %
	CO_2	CH_4	N_20	HFCs		
Energy	7,227	1,932	601		9,760	17.76
Industrial processing	694			118	812	1.48
Solvent and other product use					-	-
Agriculture	-	13,041	9,498		22,539	41.01
Land use, land-use change and forestry	20,571	57	9		20,637	37.55
Waste	7	697	502		1,205	2.19
TOTAL	*28,499*	*15,726*	*10,611*	*118*	*54,955*	*100*

Source: Government of Kenya (2013)

With population increase and economic development, GHG emissions are projected to increase to 102 MtCO_2e by 2030, when agriculture, land-use, land use change and forestry and energy sectors will contribute 27 MtCO_2e, 13MtCO_2e and 33 MtCO_2e respectively (Government of Kenya, 2013). In exploring low carbon options, the electricity sector was noted to have the highest abatement potential of close to 14 MtCO_2e per year by 2030, mainly attributed to development of the geothermal sector. Introduction of efficient kilns for wood conversion to charcoal has the potential to reduce emissions by 1.6 MtCO_2e per year, while use of improved cook stoves in households could cut emissions by 5.6 Mt CO_2e per year. In the agriculture sector, sustainable agroforestry has the potential to reduce emissions by around 4 MtCO_2e per year (Government of Kenya, 2015a).

The Kenyan government aims to support different sectors that can help the country achieve its Vision 2030 agenda, at the same time as reducing GHG emissions. Though the country is a low emitter of GHG emissions, the impacts of climate change that increase vulnerability and affect livelihoods are felt widely, particularly since Kenya's GDP greatly depends upon activities based around climate-sensitive natural resources.

1.2.3 Economic priorities

Kenya economic priorities are entrenched within the national long-term development agenda, Vision 2030. Vision 2030 was launched in 2008, with the aim of transforming Kenya into a middle-income country by 2030 while ensuring high quality of life of all citizens in a clean and secure environment. This blueprint is centred around economic, social and political pillars. The political pillar aims to realise an issue-based, people-centred, result-oriented and accountable democracy. The social pillar seeks to foster just, cohesive and equitable social development, in a clean and secure environment. The economic pillar seeks to improve the prosperity of all regions of the country and all Kenyans by achieving an average annual GDP growth rate of 10 per cent.

In the 1990's, Kenya experienced unstable economic growth until the government launched the Economic Recovery Strategy for Wealth and Employment Creation (ERS), which helped GDP growth to rise from 0.6% in 2002 to 6.1% in 2006. Vision 2030 set out a strategy to ensure this economic growth was sustained (Government of Kenya, 2007). Vision 2030 is implemented through 5-year Medium Term Plans (MTPs): the first phase ran from 2008-2012; the second (and current) phase runs from 2013-2017; and the third phase will run from 2018-2022. The third phase (MTP3) is currently being developed and is focused on the following areas:

- Macroeconomic stability
- Continuity in governance reforms
- Enhanced equity and wealth creation opportunities for the poor
- Infrastructure
- Energy
- Science, technology and innovation (STI)
- Land reform
- Human resources development
- Security
- Public sector reform

Over the last five years, Kenya's economic growth has remained relatively stable, typically attributed to investments in infrastructure, continued low international oil prices and political stability. In 2013, the country recorded GDP growth of 5.7%. In 2014 and 2015, this growth was maintained at 5.3% 5.5% respectively, despite currency depreciation of 10 per cent (AfDB/OECD/UNDP, 2016). In 2015, 22% of the country's GDP came from the agriculture, forestry and fishing sectors, while the manufacturing sector accounted for 11% (Trading Economics, 2016). Other major sectors include real estate, wholesale and retail trade, transport and storage, education, financial and insurance activity and construction (KNBS, 2015).

Low commodity prices had a net positive impact in Kenya in 2015. The gains from low oil prices and rising earnings from tea have offset the loss in earnings from other exports (e.g. coffee and horticulture). As a result, the current account deficit contracted from 10.4% to 7.1% of GDP. The projections for 2016 and 2017 show an economic expansion of 6.0 and 6.4% respectively (World Bank, 2015). This positive outlook is predicated on a number of planned infrastructure investments, particularly in the power sector and in roads. Fiscal consolidation is expected to ease pressure on domestic interest rates and increase credit uptake by the private sector. It is also expected that contraction in the current account deficit will continue to be supported by declining commodity prices and rising exports of tea.

Kenya was noted as one of the top ten improvers in the World Bank's ranking on the ease of doing business 2014/2015. Out of the 189 economies ranked, Kenya rose from number 129 in 2014 to 108 (World Bank, 2016). This was attributed to improving procedures associated with accessing finance, issuing permits, paying stamp duty and the ease of getting electricity, especially enforcing service delivery timelines.

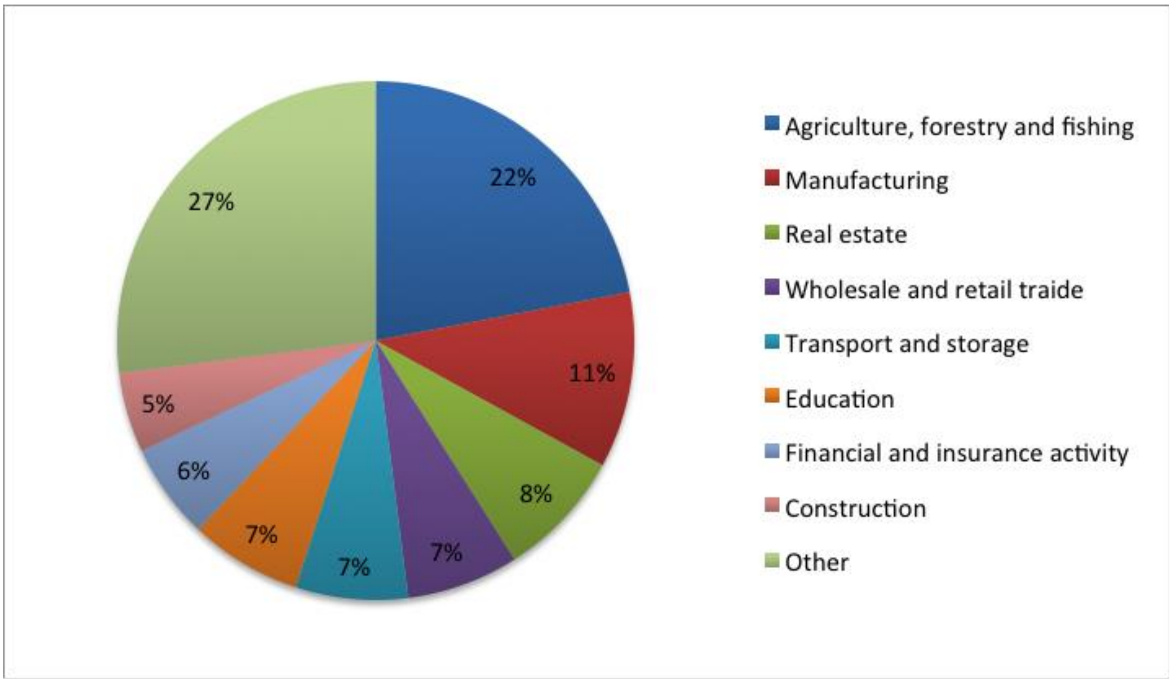


Figure 6 Sectoral contribution to GDP in Kenya

Source: KNBS (2016)

The Green Economy Strategy and Implementation Plan (GESIP) for Kenya was developed to guide the country's transition towards a green economy as well as consolidate efforts still required for the country to meet the 10% economic growth target stipulated in Vision 2030 (Government of Kenya, 2015b). The GESIP has three main scenarios:

- **Business as usual (BAU) baseline scenario:** assumes no fundamental changes in policy or external conditions up to 2030
- **BAU 2% scenario:** assumes additional investment above the baseline scenario of 2 per cent of GDP per annum
- **GE 2% scenario:** assumes additional green investment above the baseline scenario of 2 per cent of GDP per annum.

These 2% additional investments are well within the green investment allocation recommended within the GESIP of 1-2.5% of the Gross Domestic Product (GDP) per year between 2010 to 2050 (United Nations Environment Programme, 2011).

As shown in Figure 7, positive economic returns are expected approximately 7 to 10 years after a number of green economy policy interventions are put in place. The national real GDP is projected to exceed the BAU2% by about 12 per cent by 2030, to reach KES 3.6 trillion (US$45 billion). Average annual real GDP growth rates with green economy and BAU interventions are 5.2 per cent and 4.6 per cent, respectively, in the 2012-2030 period.

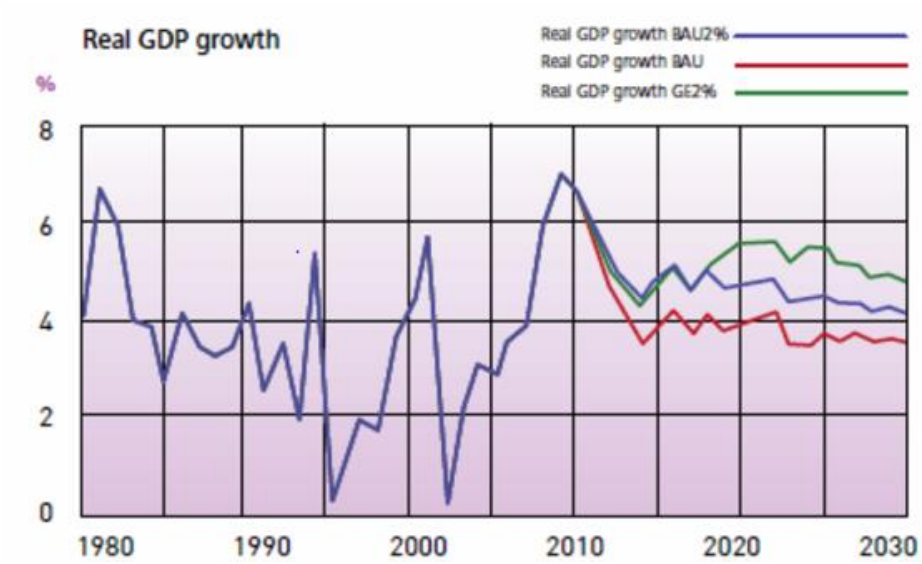


Figure 7 Potential GDP increase

Source: Government of Kenya (2015b, p. 5)

1.2.4 Societal priorities perspective on climate change:

Climate change presents significant challenges in the context of development and growth priorities in Africa due to poor infrastructure and the vulnerability of many segments of the population, requiring renewed efforts based in both the natural and social sciences. While there has been progress in natural science understanding of climate change, social science research on the issue has not been as fully developed. Climate change is expected to affect virtually every sector of the economy, including water resources, food production, energy use, transportation and commerce, recreation and even national security. In Kenya, the economy is dependent on many climate-sensitive sectors, such as forestry, agriculture and tourism; negative impacts of climate events on these sectors could lead to economic instability affecting the wider community (Government of Kenya, 2002).

Kenya's population, having grown from 37.7 million in 2009 to 41.8 million in 2013, is projected to reach 46.7 in 2017 (KNBS, 2015). In 2015, roughly 67.7 per cent of the country's population resided in the rural areas and relied predominantly on an ever degrading environment and scarce natural resources for their livelihoods. However, this situation is changing with an increase in rural to urban migration. The urban population increased from 5.4 million in 1999 to 12.2 million in 2009 and is projected to reach 17.64 million in 2017. Equally the country has a high population density that increased from 66.4 to 71.2 persons per km^2 between 2009 and 2012, and is projected to reach 80.3 persons per km^2 by 2017.

Despite government efforts to alleviate poverty in the country, by 2012, 49.8 per cent of the total population was living below the poverty line (below 1 USD a day), with urban and rural levels at 35.5 and 55 per cent respectively. The poor continue to lack critical services such as access to modern energy services, quality healthcare, clean water supply and adequate education. Economic gains have largely benefited the wealthiest quantile contributing to increasing social and economic inequality with great disparities between the rural and urban areas. The bulk of those living below poverty line are more vulnerable to climate change (Government of Kenya, 2010a).

1.2.5 Politics of energy and development priorities

Vision 2030 aims to achieve a people-centred and politically-engaged open society. To do so, the government is seeking to enact and operationalise necessary reforms in policy, legal and institutional frameworks in order to enhance public service delivery in an open and accountable manner, as is expected in a democracy. In 2010, establishment of a new constitution paved the way for a devolved government system. In 2012, the government started implementing the devolved system which is now entering its fourth year. Politics and development are centred on this system, where the national government and 47 county governments are supposed to complement each other. As stipulated in the constitution, the national government was supposed to devolve the responsibilities of national ministries to the county level, and if possible deploy expertise and build capacity in the decentralised county governments. The majority of sectors have now been devolved like health, education, agriculture, tourism and energy; however, some sectors like security and defence still remain a function of the national government.

Kenya's new constitution requires that revenue raised nationally be shared equitably among the national and county governments. County governments may be given additional allocations from the national government's share of the revenue, either conditionally or unconditionally. The Fourth Schedule of the Constitution (Government of Kenya, 2010b) allocates to the national government the functions of energy policy, including electricity and gas reticulation and energy regulation, and allocates to the county governments the functions of county planning and development.

With energy planning and development mandates, county governments have a substantial role to play with regard to shaping energy development priorities and politics. It is evident that each county would like to have control over energy resources in their territory as much as possible with the aim of generating revenue for the county and improving livelihoods of its citizens through enhanced access to energy. For instance, in northern Kenya, Turkana County is the heart of oil exploration and the county is advocating for control over their own resources regardless of national or international debates on fossil fuels. Similarly, Kitui County is the heart of coal exploration, and the county government is clearly supporting further development of coal resources. With regard to biomass resources, especially charcoal, Tharaka-Nithi, Kitui, Narok, Kajiado and Kwale counties are known as production hotspots and some of these counties have already development regulations to manage their resources. For geothermal power generation, most development is being pursued at a national level.

At the county level, energy is mostly categorised under infrastructure, water or natural resources. If under infrastructure, there is a high tendency for energy to receive limited funding, as infrastructure budgets tend to be spent on roads or other infrastructure rather than energy provision. This may be the result of large-scale energy infrastructure being outside the purview of county governments, and little attention being given to smaller-scale solutions or household use of biomass energy as a result. As such, where county funds are spent on energy development, street lighting is always the priority. Energy development is also influenced by regional or even international arenas. For instance, apart from national investments, the geothermal sector in Kenya has received a lot of support from the African Union, the African Development Bank and other development partners (AfDB/OECD/UNDP, 2016).

Political decrees and ruling party aspirations have also seen development agendas being pushed upon different sectors of the economy. Although there exists good policies and legislation to promote energy sector, Kenya has no clearly specified mechanisms for monitoring and evaluating the progress toward the achievement of its various energy ambitions, nor is there any system of rewards or penalties to incentivise their achievement.

1.2.6 Conflicts and synergies of priorities

The energy sector in Kenya is characterised by a range of tensions between different priorities. For example, despite Kenya's well-established commitment to a low-carbon, climate resilient development pathway, exploitation of indigenous fossil fuel resources (coal and oil) for power production and export suggest a tension between future development pathways. Of course, it is understandable that Kenya might want to use its indigenous resources to power economic development and bring in foreign exchange, especially given the limited contribution to already low levels of GHG emissions. At the same time, there is real concern that a fossil fuel-intensive development pathway – particularly given the range of cleaner energy options, such as geothermal, solar, wind and hydro – will lock-in Kenya to a high-carbon pathway, contrary to the commitments made in its INDC. And indeed, such an economic growth and industrial development pathway may concentrate benefits in urban areas, with rural areas losing out in economic and ecological terms.

Parallel to the tension between low- and high-carbon energy development pathways are a number of other tensions: large-scale solutions versus small-scale solutions; centralised versus decentralised solutions; and electrification versus household cooking. Solar power development in Kenya has a long and impressive history. However, most of this development has been within solar home systems and solar portable lanterns niche (Byrne et al., 2014). In this sense, its development has been quite separate from electrification efforts through the national grid. Larger-scale grid-connected solar would be one way to overcome the perceived divide between large-scale and small-scale solutions, but it is yet to be realised; currently the only instance of grid-connected solar in Kenya is the rooftop solar power plant at Strathmore University. Meanwhile, electricity provision continues to dominate the energy policy agenda at the expense of cooking, despite the hugely inefficient biomass energy use in Kenya. Even in homes that are electrified, charcoal and woodfuel are often used for cooking due to economic and cultural reasons.

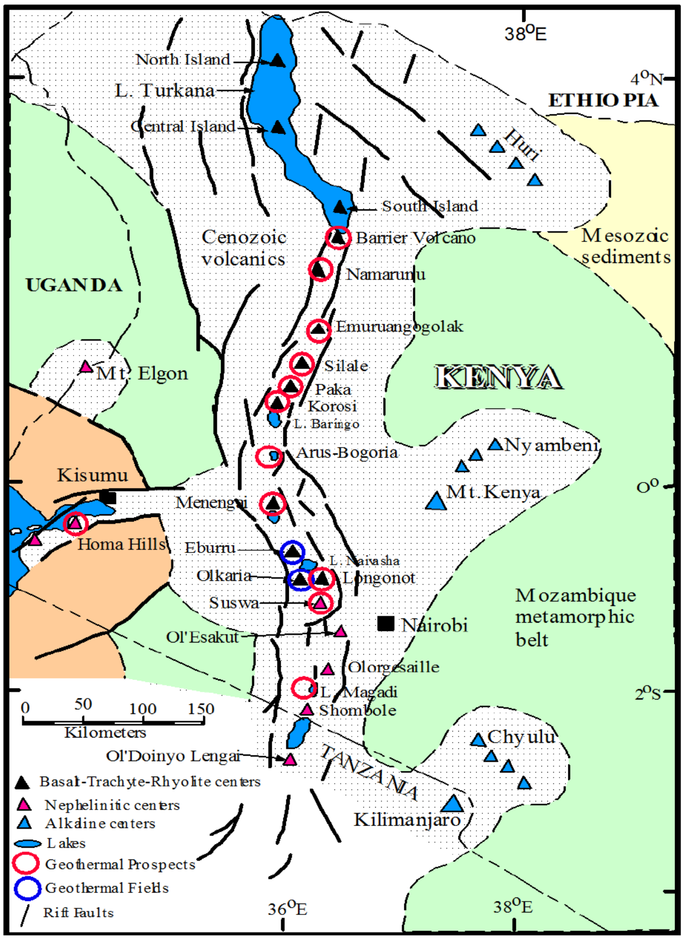
These tensions are exacerbated by the ongoing devolution of energy sector planning in Kenya from central government to county governments. Research has shown that political decentralisation does not automatically lead to calls for decentralised energy solutions (Brown and wa Gathui, 2015). Rather, county level governments have called for more control over the centralised energy systems, in particular control over electricity generation resources, such as hydro, coal, wind and geothermal. There is a continued lack of clarity over division of responsibilities between the central and county governments: the Energy Bill 2015 seeks to clarify responsibilities, but it was recently returned to Parliament by the President due to concerns over the ability of counties to absorb additional revenue accruing from exploitation of local resources (Ngirachu, 2016).

Yet there are a number of synergies that might be capitalised upon. For instance, there appear to be a number of opportunities for harnessing synergies between geothermal power generation and local industrial development. Where small and large scale industries are situated close to geothermal resources, geothermal steam can be used directly for industrial heating purposes, as well as indirectly for industry power generation. This presents a number of opportunities for developing geothermal resources and local industry in tandem. Meanwhile, there are increasing synergies between the forestry, environment and energy sectors, all of whom have a stake in seeking to improve the sustainability of charcoal production and consumption. Managing illegal logging and forest degradation from charcoal production requires effective intervention on both the supply and demand side and thus requires coordination between a range of actors with similar goals. Such a 'coalition of the willing' could serve to provide the critical mass needed to achieve real progress in improving sustainability of the charcoal sector.

1.3 The Human Innovation System Narrative (geothermal in Kenya)

1.3.1 Overview of the development of geothermal power generation in Kenya

Geothermal resource is located within the great rift valley of Kenya and extends to Ethiopia, Tanzania and Rwanda. The country's high temperature geothermal resource is spread across 14 sites and is estimated to have an electricity generation potential of between 7000MW to 10,000MW (Ngugi, 2012). It is a reliable source of energy less affected by climate variability. Currently it is the least cost source of energy generation in Kenya costing cents US$7 per kWh against cents US$ 11 per kWh of cumulative other sources of energy. It is a suitable baseload energy source with a lifespan of 30 years until decommissioning.



Rift Region		Potential (MW)
Central Rift		
• Menengai		1,600MW
• Eburru		250MW
• Arus Bogoria	400MW	
		2,250MW
South Rift		
• Olkaria		2,000MW
• Longonot		750MW
• Suswa		600MW
• Lake Magadi		100MW
		3,450MW
North Rift		
• Lake Baringo	200MW	
• Korosi		450MW
• Paka	500MW	
• Silali	1,200MW	
• Emuruangogolak		650MW
• Namarunu		400MW
• Barrier		450MW
		3,850MW
Nyanza		
Homa hills	100MV	
Akira		350MW
		450MW
Total Potential		**10,000MW**

Figure 8 Geothermal Potential in Kenya

Source: Government of Kenya (2011)

Geothermal development in Kenya started in the 1950s. Between 1956 and 1958, the Kenya Power Company Limited first attempted to drill in the Olkaria area without success. A period of fallow years followed with no substantial activities. The government then entered into an agreement with the United Nations Development Programme (UNDP) in 1967 to concentrate efforts in geothermal exploration in Olkaria area with a boundary of 80km^2 area. This was followed with a series of explorations with six wells drilled between 1968 and 1976, and an additional twenty wells were drilled up to 1985. The first geothermal power plant in Olkaria I was commissioned in 1981 (15MW capacity); two similar capacities were commissioned in 1982 and 1985 respectively running one Mitsubishi turbine.

Table 2 Kenya geothermal status

Geothermal Projects installed and effective			
	Plant	**Installed capacity (MW)**	**Effective capacity (MW)**
1	Olkaria 1 units (1,2 & 3)	45	44
2	Olkaria II	105	101
3	Eburru Hill	2.5	2.2
4	OW37 Olkaria Mobile Wellheads	5	2.2
5	OW43 Olkaria Mobile Wellheads	12.8	12.8
6	OW914 and OW915 Olkaria Wellheads	37.8	37.8
7	Olkaria IV	140	140
8	Olkaria I Units 4 & 5	140	140
9	OrPower 4 - Geothermal I, II, III	110	110
	Total	**598.1**	**590**

Geothermal Projects in the pipeline			
	Plant	**Capacity (MW)**	**Expected commissioning**
1	Wellhead unit	25	2016
2	Marine Power - Akira	70	2016
3	OrPower4 Plant IV	50	2017
4	Quantum (Menengai)	35	2017
5	Sosian (Menengai)	35	2017
6	Ormat (Menengai)	35	2017
7	Olkaria 1 rehabilitation	-45	2018
8	Olkaria 1 rehabilitation	50.7	2018
9	Wellhead leasing	50	2018
10	Olkaria 1 - (Unit 6)	70	2018
11	Africa Geothermal International (AGIL)	70	2018
	Total	**445.7**	

Source: Kenya Power (2015)

Structural adjustments were subsequently made in the power sector to facilitate private participation in the energy sector. Kenya Power Company Limited was split into two entities: Kenya Power and Lighting Company (KPLC) – later rebranded as KenyaPower – responsible for transmission and distribution, and Kenya Energy Generation Company (KenGen) responsible for generation. Although considered private entities, the government remained the major shareholder in both KenyaPower and KenGen. This single-buyer model was expected to catalyse competition in power generation between KenGen and independent power producers, all of whom could and would sell their power to KenyaPower.

In its new form, KenGen remained in control of Olkaria I and began drilling of Olkaria II. In the meantime, the first private sector concession was issued in 1998 to explore and develop Olkaria III. Olkaria II units 1 and 2 were commissioned in 2003 and unit 3 commissioned in 2007. From the beginning of the process, it took about 40 years for Kenya to install a capacity of 150MW from geothermal. In 2006, the government established the Geothermal Development Cooperation (GDC) with the mandate to carry out rapid exploration and development of geothermal over the next 20 years, encouraging further private sector-led expansion in geothermal power generation and removing the high risks associated with expensive exploratory drilling. To-date around 590 MW of geothermal power generation capacity has been commissioned with a projected capacity of 5530

MW expected by 2030. Private sector involvement is considered to be one of the major drivers for the development of the geothermal sector in Kenya. Figure 9 below summarises the development of geothermal sector in Kenya.

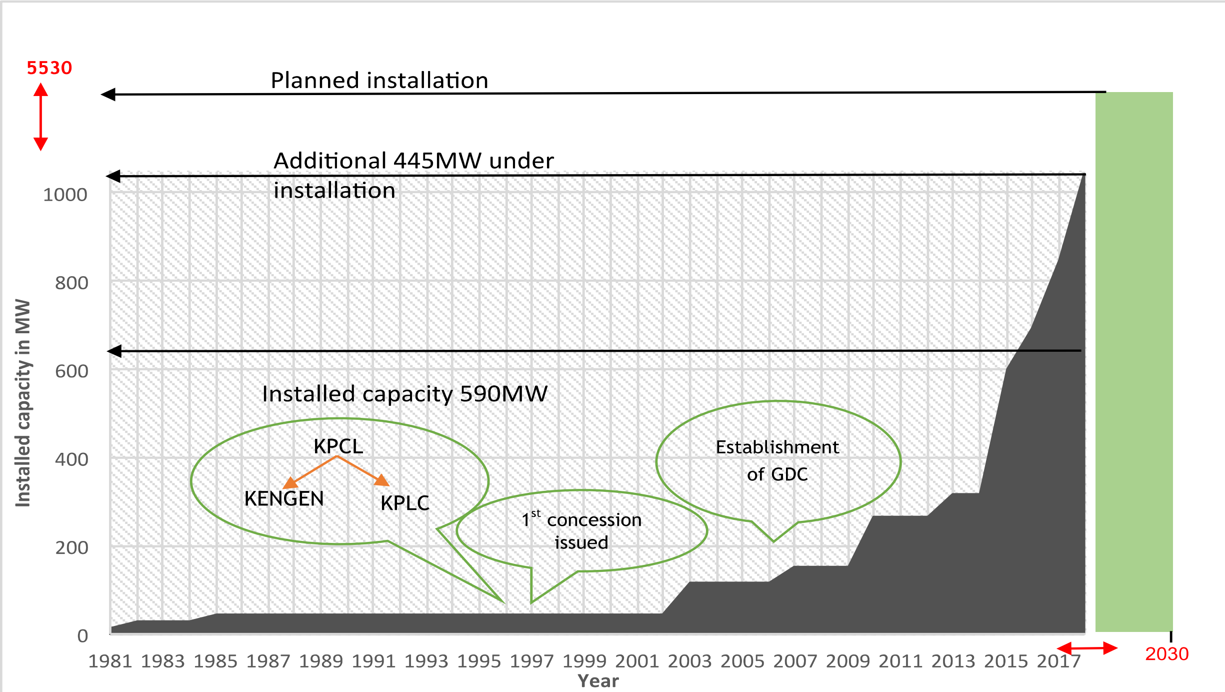


Figure 9 Geothermal development trend line

Sources: Heya (2002), Karingithi (2012), TransCentury (n.d.)

1.3.2 TIS life cycle value chain: a cradle to grave analysis

Geothermal generation typically follows a defined process and a typical schematic of a condensing geothermal power plant in Kenya is illustrated in Figure 10.

The technological innovation system life cycle for geothermal can be broadly defined in the following six steps (shown in Figure 11):

a) Energy resource extraction/exploration:

Geothermal development in Kenya starts with geo-exploration. The objective is to determine the viability of the resource including: energy source, fluid recharge and pathways, and reservoir condition (permeability, density, heat capacity, fluid chemistry, phase and gases).

b) Exploratory drilling and appraisal drilling:

The practice involves drilling three to six wells, narrow and to about 2000 – 3000 meters. The objective is to determine the size of the resource, a more accurate hydrological model, volume, geometry and pressure, temperature and overall fluid chemistry. This is one of the costliest, riskiest and most time consuming processes in geothermal development, hence once of the factors limiting geothermal exploration in Kenya. GDC was set up precisely for the purposes of taking on the risk and cost of establishing wells, capacity and characteristics, which can then be tendered out to private developers. To reduce costs further, GDC has begun to procure its own drilling rigs, leading to savings of US$ 3.5 million per well and thereby reducing the exploration cost by 46% (Ngugi, 2012). To date GDC has 7 rigs and KenGen has 2 rigs (GDC, 2016; Standard Digital, 2011).

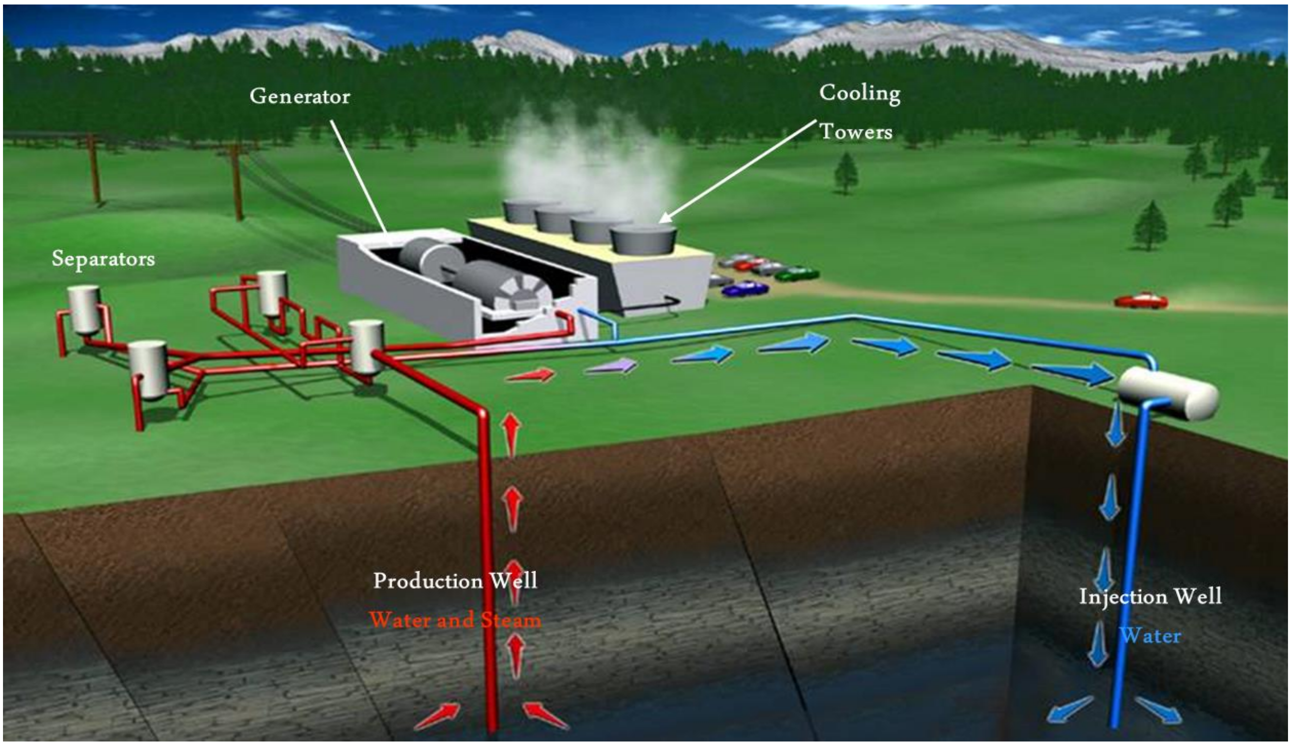


Figure 10 Schematic of geothermal power plant

Source: Simiyu (2010)

c) Production drilling and power plant construction:

This involves drilling around sixteen wells for steam generation as well as constructing steam gathering system and power plant. This task is mainly carried out by the developer/IPP and is depended on the technology type. In Kenya, four main types of technologies are used: -

I. Condensing dry steam
II. Condensing flash steam and
III. Non condensing flash steam power plants and
IV. Binary cycle power plant

Today the direct application of heat is used in agriculture (notably (in a 100ha flower farm in Naivasha) and in manufacturing etc. There are seven generation companies in Kenya: six private developers and one state-owned utility (KenGen). However, the share of current generation capacity by IPP and KenGen is 18% and 81% respectively.

d) Geothermal power transmission:

The geothermal power generated is transmitted through the national grid by Kenya Power and Kenya Electricity Transmission company (KETRACO). In 2008 KETRACO was established to facility grid access, allow for grid connection with new generation power plants and to enable regional power trade. It plans, construct, owns, operates and maintains new high voltage grid lines. All new power generation are transmitted through KETRACO. It is 100% owned by government of Kenya.

e) End-use:

End users include, household, industrial and commercial applications. Nairobi County Government depends mainly on the geothermal power.

f) Decommissioning of geothermal power plants:

Geothermal power uses steam turbines; since the commission of the first geothermal power plant in 1981 there have not been any shut down. Frequent and regular maintenance of the turbines and compressors is required to avoid breakdowns. If maintained well, the standard geothermal lifespan is 30 years. Given this lifespace, some plants in Kenya are due to be decommissioned. However, the three Olkaria 1 plants are scheduled for rehabilitation in 2018.

1.3.3 Enabling environment: policy mixes in the socio-economic system

Geothermal is regarded highly in the Kenyan power sector and investment is channelled towards the development of the sector. This shall include, human resources, exploration equipment and funds for research and development. The roadmap to vision 2030 envisages a 5000+MW by 2030 with further projected growth to 17,764MW. Furthermore, expansion of geothermal to increase resilience of current and future energy systems is considered as both a mitigation and adaptation action in Kenya's INDC. In Table 3 we set out some of the key policies shaping development of the geothermal sector. Given the challenges around land access (from a conservation and a human land rights perspective), the sector is guided by policies on, amongst others, energy generation, land acquisition and use, environmental management and water consumption.

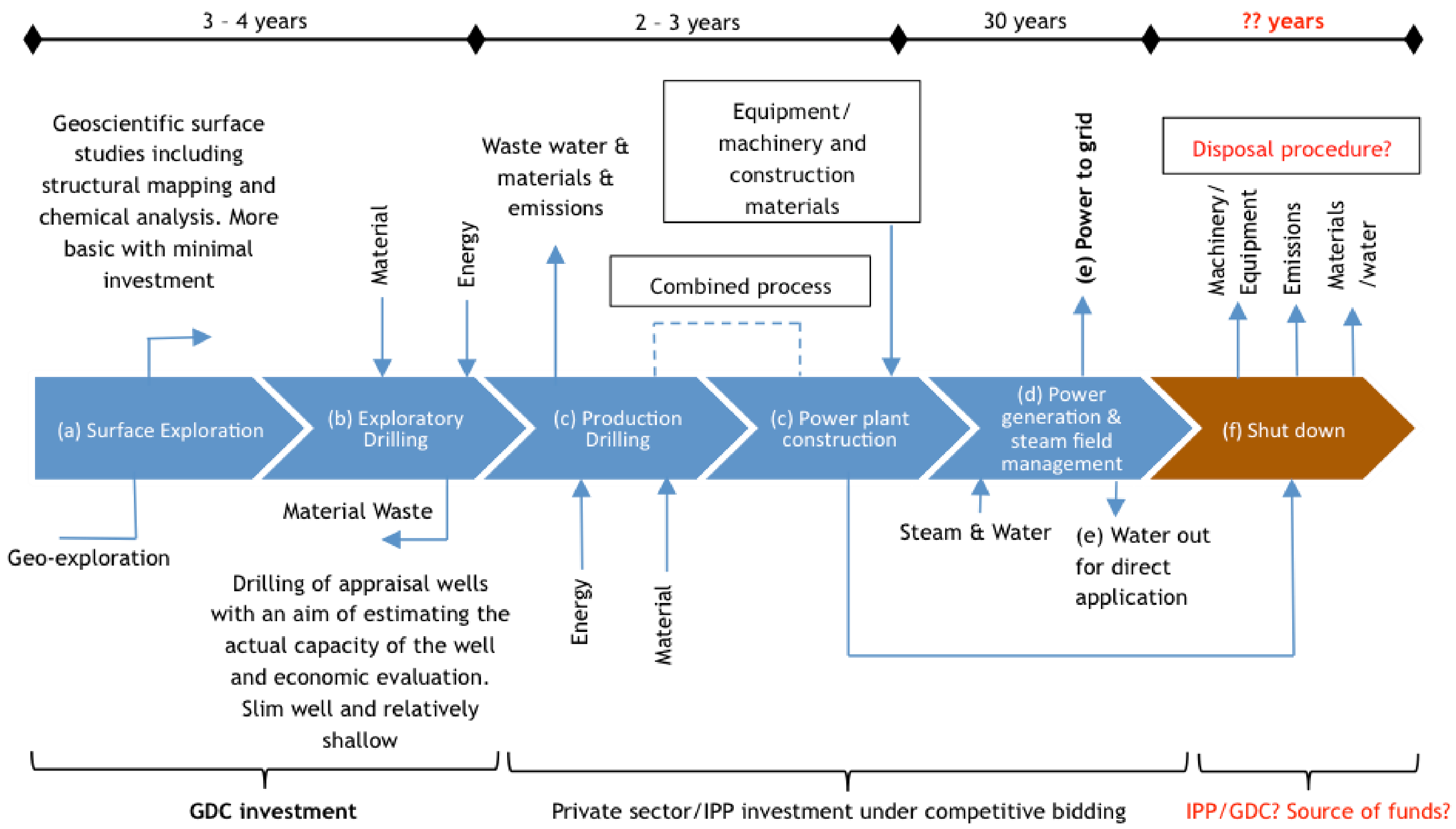


Figure 11 Geothermal lifecycle in Kenya

Source: Author's own

Table 3 Policies guiding the geothermal sector in Kenya

1	**The Energy Sector**		
	a)	Final Draft Energy Policy, 2015	The policy enhance vast exploration of geothermal resource and the government shall continue financing exploration activities to make the sector more attractive to investors
	b)	Energy Bill, 2015	Places geothermal as a vested national interest and provides guidelines for exploration and granting of geothermal licences and transfer of the same.
	c)	LCPDP, 2013	Considered geothermal as core to the achievement of the vision 2030 and extrapolate increased geothermal contribution to national energy mix
	d)	Kenya Electricity Grid Code; 2008	Provides clear guidelines to investors on power connection to grid, controls and ownership
	e)	Energy Act 2006	The Energy (Complaints and Disputes Resolution) Regulations, 2012, contained in the Energy Act 2006 touch upon critical complaints coming from customers including wayleaves, easements or right of way. However the Act does not provide a provision for complaints from developers on the same for delivery of power to the nearest grid line.
	f)	FiT Policy, 2013	Provides for connection of small scale energy generation (<10MW) and transmission through negotiated feed in tariff.
2	Land		
	a)	The Way Leave Act, Revised in 2010	The act only provides for laying of pipelines
	b)	National land use policy, 2016	Recognises that land use for energy generation has significant negative impact to the environment and that most of the land is either communally or privately owned. The main drawback is the acquisition process. However, the policy largely is not clear on setting how to address these issues. Section 3.9.3 promotes prioritisation of land use for climate change mitigation activities
3	Environment		
	a)	EMCA, 1999	Provides for carrying out of Environment Impact Assessment for any energy projects that is coming up with intention to conserve the environment
	b)	Sessional Paper No. 10 of 2014, on National Environment Policy	Section 5.10.3 states that, 'Climate-resilient, low carbon development is a national priority for Kenya because it will support Kenya to absorb disturbances and build capacity to adapt to additional stress and change. And that by pursuing a green economy path and minimising carbon footprints, the country will better deliver constitutional right to a clean and healthy environment while minimising the country's contribution to global climate change.'
	c)	National Climate Change Action Plan	Focus on geothermal as key to low carbon development pathways
4	Kenya Wildlife Services		
	a)	Wild life Conservation and Management Act, 2013	Article 26 provides authority to the environment laws (EMCA, 1999) to apply for the intention of conservation of wildlife.
5	Water		
	a)	The Water Act of 2002	Provides for water resource management and setting up community Water Resource Users Associations as community water use control mechanisms.
6	Others		
	a)	The New Constitution	Devolves some power for energy planning to county level, including electricity and gas reticulation and energy regulation.
	b)	VAT Act, 2013	Issue tax exception for all equipment and renewable energy generators for grid connection.
	c)	Kenya Second National Communication to the UNFCCC	In the energy sector, the communication report points out geothermal as the largest abatement potential (14MtCO_2e) by 2030

1.3.4 Enabling environment: government institutions

There are a range of institutions actively engaged in the geothermal sector in Kenya. The Ministry of Energy and Petroleum (MoEP) has overall responsibility for development of the geothermal sector. Exploration of geothermal resources is typically done by the Geothermal Development Corporation and by KenGen – Kenya's state-owned electricity generation utility. Both of these organisations are majority owned by the government, who then provides strategic guidance on further exploration and development. Steam field management and power generation is typically taken on by KenGen or independent power producers. From there, power is dispatched to Kenya Power, the state-owned electricity distribution utility, or in some cases to KETRACO, the state-owned electricity transmission utility. The sector is regulated by the Energy Regulatory Commission, which sets tariffs. These main institutions, as well as others active and/or relevant for the energy sector, are set out in Figure 8.

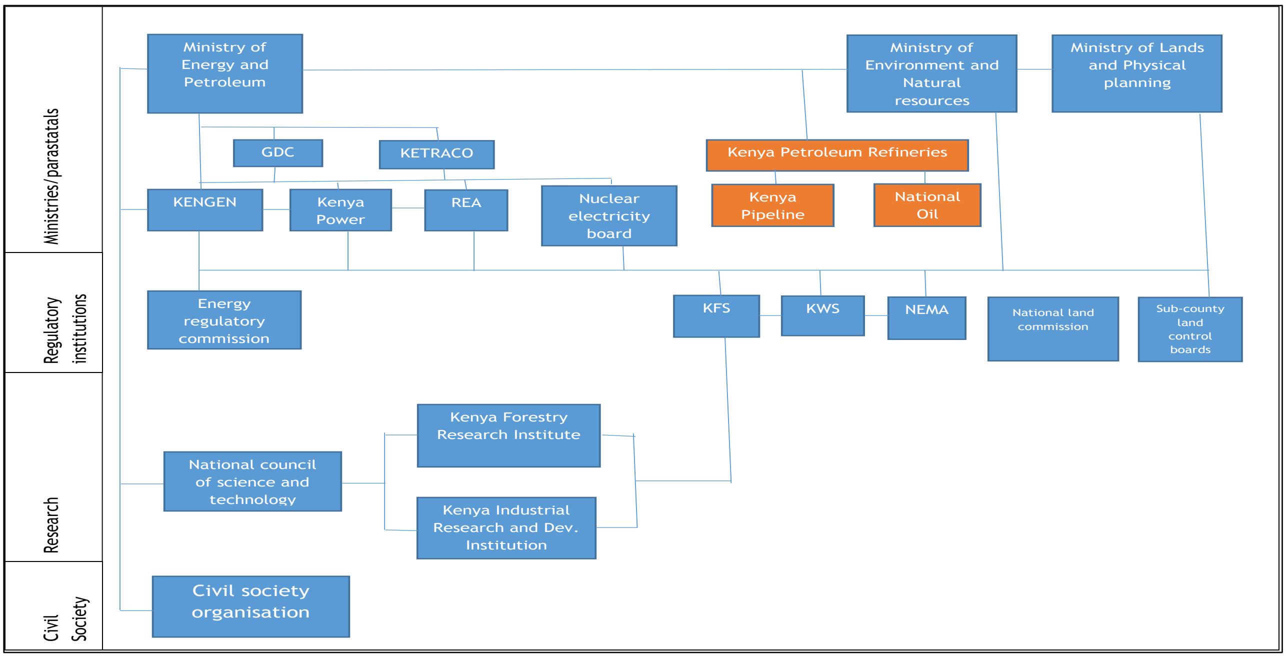


Figure 12 Major institutions in the energy and geothermal power framework in Kenya

Source: Author's own work

1.4 The Human Innovation System Narrative (charcoal in Kenya)

1.4.1 Overview of the development of the charcoal sector in Kenya

Whereas the African Union's Agenda 2063 foresees Africa as amongst the best global performers in global quality of life (African Union, 2015) and the African Economic Outlook 2016 shows that the continent is on a steady growth path to economic, social and governance (AfDB/OECD/UNDP, 2016), the continent is still grappling with the key issue of over-dependence on biomass and unsustainable biomass harvesting for energy. The African Economic Outlook 2016 highlights that Africa lost USD 232 billion due to premature death tolls in 2013 as a result of indoor air pollution stemming from over-reliance on traditional use of solid biomass for cooking. An estimated 755 million people in Sub-Saharan Africa use firewood and charcoal in a poorly ventilated houses and use inefficient stoves (AfDB/OECD/UNDP, 2016).

In Kenya about 70% of the population relies on firewood and charcoal as a source of energy. Unmet demand was about 10.3million m^3 as at 2013, and the deficit is expected to increase in coming years as depicted in Figure 9 below, which will lead to unsustainable harvesting and imports.

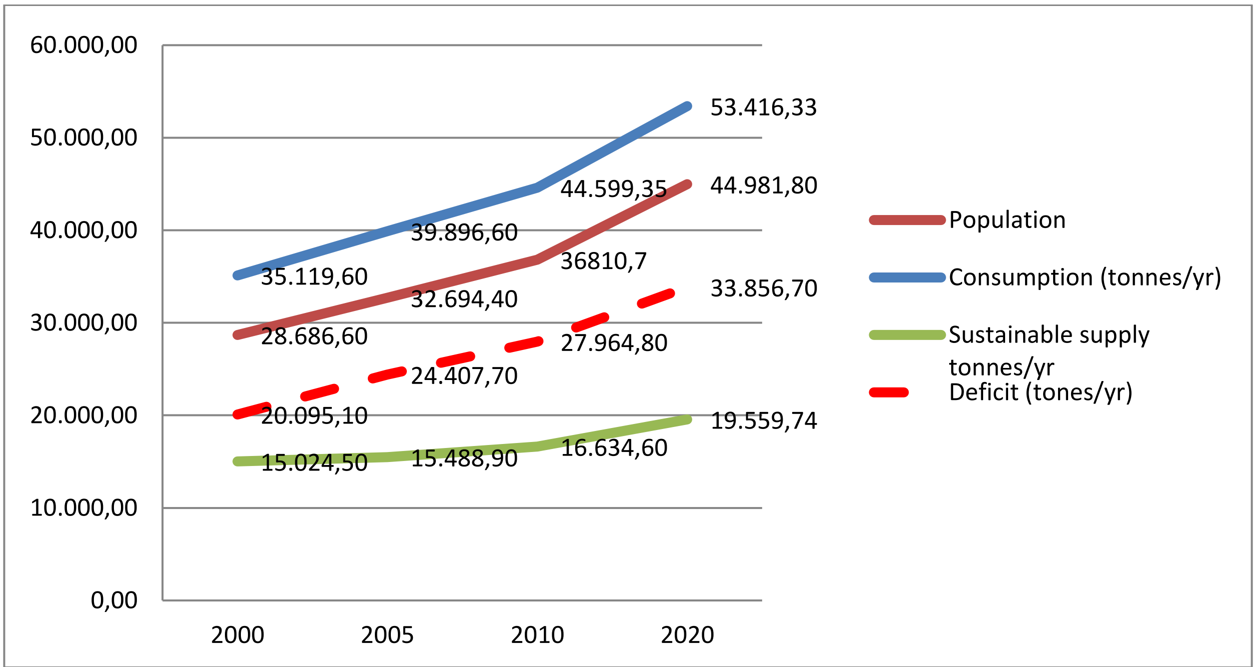


Figure 13 Projected annual biomass energy consumption/supply (in thousands)

Source: Derived from KIPPRA (2010)

About 87% of rural households use firewood for cooking, whereas 82% use charcoal for cooking in urban centres (Wanleys Consultancy Services, 2013). The rising levels of Illegal logging, cutting down of trees for wood and charcoal and over-grazing have contributed significantly to the degradation of national forests. Yet the sector is barely recognised in formal annual national economic reporting of growth pattern and future forecasting. M. Njenga et. al (2013) reiterates that "[d]espite the charcoal industry providing employment to 500,000 people and generating over US$427 million that benefits grassroots communities, it has been kept out of the formal economies of this country."

To achieve a 2030 target of 100% access to modern cooking solution requires concerted government, civil society and private sector involvement. In particular, enhanced efficiency is important in supply and demand side production and utilisation of biomass energy resource. Priority actions as depicted in the Kenya SE4ALL (2016) document include:

a. Development of specific regulations for sustainable efficient charcoal production and utilisation linked with appropriate forestry management plan and afforestation;
b. Creation of cross sectoral initiatives to bring together different efforts and improve coordination across agencies, private sector, CSOs and NGOs; and
c. Develop woodfuel (firewood and charcoal) supply and demand master plan for main supply and demand centres.

Charcoal use has long been a key part of energy use in Kenya as in many African countries. Charcoal has come under greater scrutiny since the global call for environmental protection, arising from United Nation Conference on Human Environment in 1972, the convention on climate change and convention of biodiversity (1992) and now with the current debates of United Nation Framework Convention on Climate Change. Charcoal conservation efforts started in earnest in 1997 with the promotion of Kenya Ceramic Jiko by GTZ, Ministry of Agriculture, Universities and other donors.

Today, the Draft 2012 National Environment Policy isolates charcoal burning as a major threat for ASAL land and national forest degradation (Ministry of Environment and Mineral Resources, 2012). The National Climate Change Action Plan (2013) highlights charcoal production as a main contributor to GHG emission in Kenya and that the introduction of more efficient kilns is the most significant low carbon opportunity in regard to process emission reduction (about 1.6MtCO_2e annually by 2030) (Government of Kenya, 2013). A similar observation is reported in the Kenya Second National communication to the UNFCCC (Government of Kenya, 2015a). As the supply side plays an important role in reducing greenhouse gas emission through introducing efficient kilns, so is the demand side contribution through adopting energy efficient cook stoves. Moreover, at market value, charcoal generate approximately US$ 426 million annually (Mutimba and Murefu, 2005). 80% of the charcoal income is equally shared between the vendors, police, buyer and, charcoal makers. Most of the remaining 20% goes to landowners, brokers and transporters, whilst government retains little or none from taxation (Bailis, 2011). Therefore, if the sector was streamlined, the government would retain about US$ 60 million with a 16% VAT. Additionally, the value chain is a source of employment to between 0.5 – 0.7 million Kenyans (KFS, 2013; Mutimba and Murefu, 2005).

The charcoal technological innovation system life cycle starts from wood harvesting and ends when the charcoal is finally used. The supply chain involves complex relationships amongst the actors and regulators however a simplified flow can be described as producer to distributer and to consumer (Figure 14).

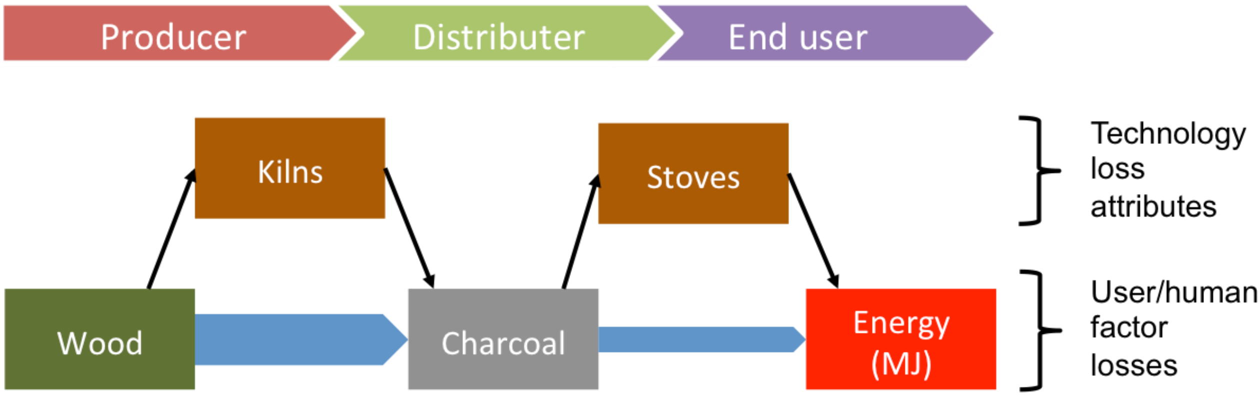


Figure 14 A simplified charcoal value chain schematic

Source: Author's own

1.4.2 TIS life cycle value chain: a cradle to grave analysis

The charcoal industry cuts across many sectors and areas of the economy, from forestry and farming to production, transport and retail. As Figure 11 shows, the sector is incompletely regulated from many different perspectives, resulting in disconnected efforts to improve its sustainability and transparency. The different elements of the charcoal value chain are described below:

a) Biomass resource and harvesting:

Wood for charcoal is commonly sourced from four main sources – communal land, personal land, government forest and private land (Njenga et al., 2013). Government forest cover an area of 1million ha and with plantation covering approximately 0.14million ha, natural forest covers about 0.9ha, whereas community and private forest land covers about 3million hectares. The government has encouraged trees on farm with a constitutional threshold of 10% tree cover on farm lands (KFS, 2013). Wood for charcoal is often harvested as a small business to meet national demand. In other areas like Garissa and Baringo the drive is to eliminate invasive species to reclaim grazing land, and on arable land, charcoal production provides a quick source of income while also clearing land for other agricultural purposes (Ministry of Environment and Mineral Resources, 2013).

b) Wood to charcoal:

Charcoal production is the carbonisation of wood and other woody biomass by pyrolysis. Charcoal production in Kenya is done throughout the year although with varying quantities across the seasons. Demand peaks during rainy season, but during the same period supply reduces due to weather attributes, transportation challenges, kiln problems and farming activities. There are several charcoal production technologies in Kenya. Traditional earth mould and pit kiln are the most prevalent conversion technologies with 10% – 14% efficiency level (KFS, 2013). However, donor driven project through civil societies and government sectors such as Miti Mingi Maisha Bora (MMMB) project and Micro-enterprise support program trust have been promoted. These kilns include improved earth kiln, casamanse and Brazilian masonry, with an average efficiency level of 30% (Bailis, 2009). Other kilns include: KEFRI drum, Kinyanjui type, Meko retort, portable metal kiln, ring kiln and dome and square brick kilns.

c) Charcoal transportation and distribution network:

According to Mutimba and Murefu (2005) there were 500,000 charcoal transporters and venders in 2004. There is no defined packaging for charcoal from the producer side. Charcoal packaging depends on the region and recyclable bags in the area. In western Kenya, where there is more maize farming and 90kg maize bags are prevalent, charcoal is stocked in 90kg sacks; in central Kenya small 50kg – 70kg bags are prevalent, recycled from fertilizer and coffee products. The supplied unit weights of charcoal therefore vary from location to location, and sales figures are based on volume rather than weight.

From the production site, charcoal is brought to the roadside where the middlemen purchase them from the producers. A middleman (transporter) is served with several producers stocking their charcoal by the roadside dependent on the transportation means available. Common transportation means range from large tracks to motorcycles that supply the local market. In some areas of low transport frequencies, producers collect the charcoal at a common central point for the transporters to ease marketing of the charcoal. They then transport the charcoal to market outlets in the neighbouring cities or to the capital city dependent on the regular customer base or orders from vendors.

d) Charcoal end use practices

Consumers can purchase charcoal in 2-litre tins, 20-litre buckets and whole sacks of charcoal. The delivery is either made at the doorstep, but in most cases, consumers prefer going to the vendor to make a selection of the type and quantity of choice.

Efficiency in the use of charcoal is dependent on the stove technology that consumers own and prefer to use. There is rising recognition of improved cookstoves in Kenya with numerous actors involved (manufacturers, distributers, resellers and stockist). In particular, increasing diversity of improved cookstoves is bringing stoves to the market that have significantly higher life-spans.

e) Greening the charcoal industries

About 25% of total charcoal volume is degraded into dust that cannot be sold. Recently charcoal briquettes are gaining recognition amongst entrepreneurs, who make briquettes out of the dust and resell them.

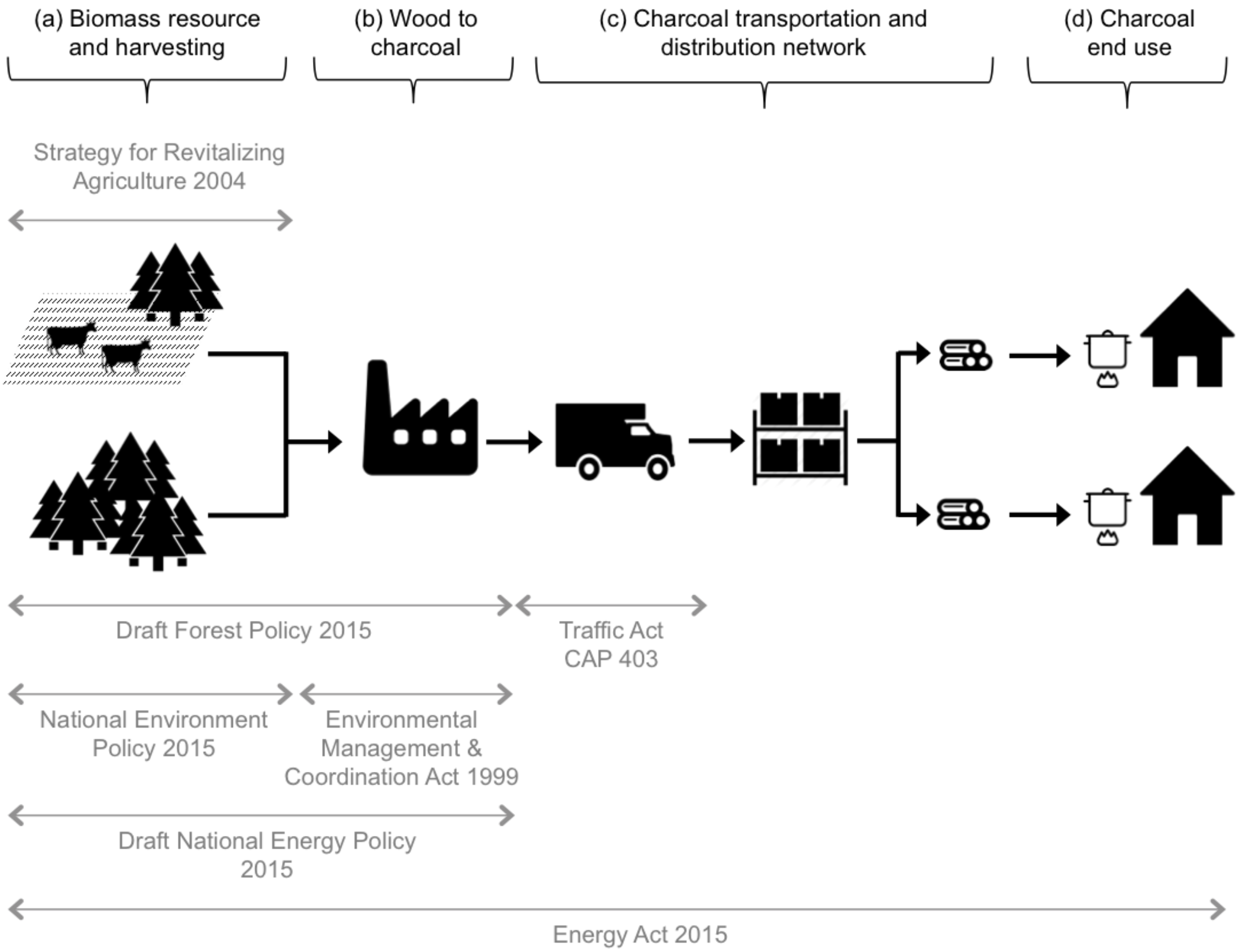


Figure 15 Policy overlaps along the charcoal TIS life cycle value chain

Source: Author's own



Figure 16 Brick kiln, traditional earth kiln and improved earth kiln respectively

Source: KFS (2013)

1.4.3 Enabling environment: policy mixes in the socio-economic system

The charcoal sector is considered one of the most complex sectors with various interactions between varied stakeholders with diverse backgrounds and involvement. The sector consists of the charcoal production value chain and the stove technology value chain, linking energy, forestry and agriculture. There are a range of national policies and regulations guiding the charcoal sector in Kenya. A number of international obligations – such as Kenya's INDC and Second Communication to the UNFCCC – also have relevance to the charcoal sector, particularly through mitigation actions related to achieving tree cover on 10% of the country's land and promoting clean energy technologies to reduce overreliance on wood fuels. These national policies/regulations and international influences are listed in Table 4.

Table 4 Policies guiding the charcoal sector

	Policy/regulation/strategy	Policy statement with direct positive influence
1	Energy sector	
	a) Final Draft Energy Policy, 2015	The policy seeks to promote the use of LPG as a way to eliminate the use of kerosene, charcoal and firewood. Chapter 28 seek to establish a mechanism to eliminate use of charcoal by 2022". This shall be achieved by providing incentives (such as fiscal incentives on LPG, tax exemptions for imported efficient cookstoves, etc.). It also provide for regulation and licensing of charcoal producers, transporters and traders
	b) Sessional Paper No. 4 on Energy, 2004	Licenses charcoal in order to ensure sustainability, also promotes private sector participation in the charcoal sector
	c) Energy Bill, 2015	Promotes the development and use of renewable energy including charcoal. Also champions county energy regulations for charcoal producers and dealers
	d) Energy (Improved Biomass Cookstoves) Regulation, 2013	Provides for guidelines to license ICS manufacturers, distributers and installers
2	Environment sector	
	a) EMCA, 1999	Makes EIA a requirement for all projects involving wood and promote widespread adoption of energy efficient technologies
	b) National Environment Policy, revised draft 5, 2012	Recognises that charcoal burning is a major cause of forest pressures and indoor air pollution and hence seeks to promote alternative non-polluting technologies
	c) National Climate Change Action Plan, 2013	Recognises that charcoal production is one of the main sources of greenhouse gas emission besides cement industry. And that introduction of more efficient charcoal kiln has a potential to save 1.6MtCO_2e annually.
3	Forestry sector	
	Ministry of Agriculture, Livestock and Fisheries	Requires a minimum 10% tree cover on farm, this shall promote use of on farm trees for charcoal production
	a) The forest management and conservation bill, 2015	Provides for licensing of charcoal producers be it in own farm, private land or community forest or government and county land. Also provides for regulation of producers, transporters and vendors
	b) The Forest (Charcoal) Regulation, 2009	Provide guidelines on the legal requirement for producers, transporters and, traders engaged in charcoal business. Also legislates that all charcoal producers form charcoal producer's associations (CPA). Make it a requirement to have charcoal permits to transport charcoal.

	c)	Sessional Paper No. 9 of 2005 on Forest Policy	Promotes sustainable production and utilisation of wood, Empower communities to manage forest through community forest associations and promote production and marketing of charcoal
	d)	Draft National Forest Policy, 2015	Key statement for promotion of sustainable charcoal production. Seek to concentrate afforestation programme in community and private land to achieve 10% of land area.
4	Others		
	a)	The New Constitution	Schedule IV, Chapter 22 protects the environment and natural resources with a view to establishing a durable and sustainable system of development including energy.
	b)	Kenya Second National Communication to the UNFCCC	Identifies that the most significant low carbon development opportunity is the introduction of more efficient kilns for charcoal production with an abatement potential of 1.56MtCO_2e per year in 2030.

1.4.4 Enabling environment: government institutions

As mentioned previously, the charcoal industry is governed by a number of different institutions, each partially regulating and guiding the sector. Ministry of Energy and Petroleum (MoEP) has formal responsibility for the charcoal sector from the energy perspective. This includes advocating for regulation of cleaner charcoal production at county level and promotion of clean fuels and energy technologies. To some extent, MoEP also has the mandate to regulate charcoal production. However, this mandate also falls under the Ministry of Agriculture, Livestock and Fisheries (MoALF) under its Forest (Charcoal) Regulations 2009. MoALF works in close coordination with the Kenya Forest Service (KFS) and the Kenya Forest Research Institute (KEFRI) to license charcoal producers, where sustainable woodstock and more efficient kilns are used. The Ministry of Environment and Natural Resources, along with the National Environment Management Authority (NEMA), also seek to promote sustainable use of woodfuel. Given the largely informal nature of the charcoal sector, formal regulation from the energy perspective by the Energy Regulatory Commission is largely absent. These main institutions, as well as others in the broader energy sector, are set out in Figure 17.

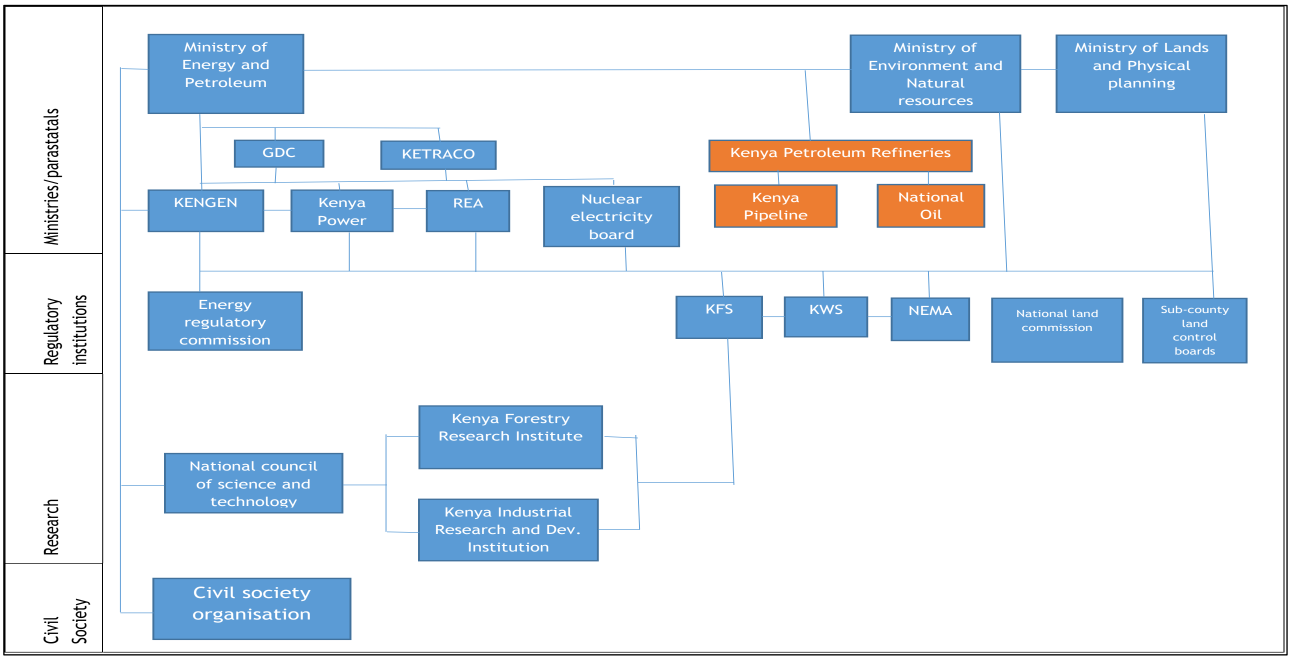


Figure 17 Major institutions in the charcoal sector in Kenya

Source: Author's own

1.5 The Innovation System map

In Figures 18 and 19, we present the innovation system maps for both geothermal and charcoal. For geothermal, the innovation system is dominated by large centralised government institutions and government-owned utilities, although private independent power producers are becoming more visible as the sector develops. Development partners continue to be the main source of funding. The charcoal sector is rather more complex and decentralised. Actors within the TIS life cycle are typically small-scale, with large supply needed in urban areas accumulating from charcoal transported from different parts of the country. Although many government institutions have some engagement in the sector, enforcement of regulation is difficult in such a diffuse sector. The informal nature of the sector means it rarely receives much high-level attention from development partners or government, despite it being a huge part of the national economy and a major source of ecological impacts and GHG emissions.

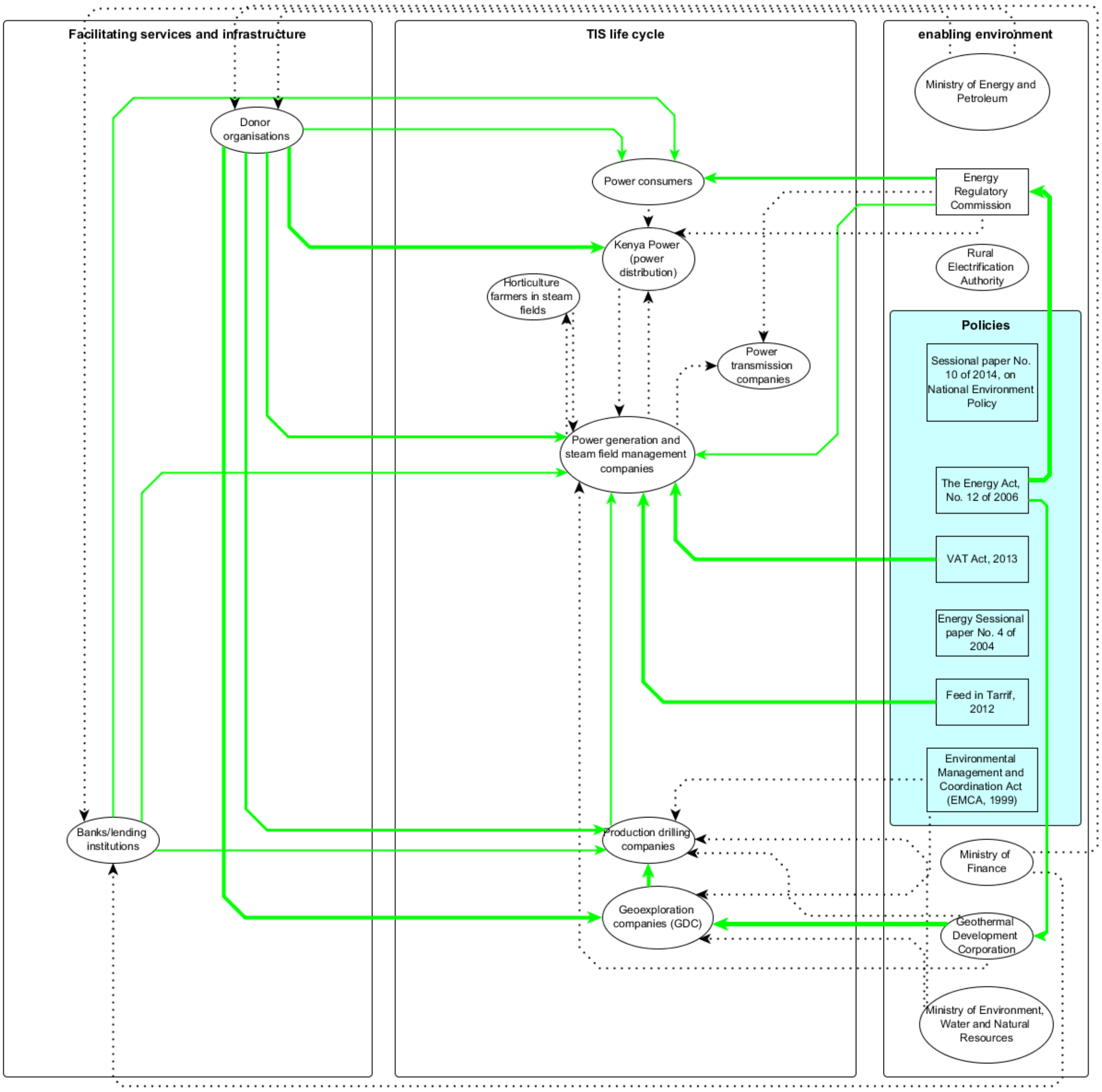


Figure 18 Innovation system map for geothermal for Kenya

Source: Author's own work

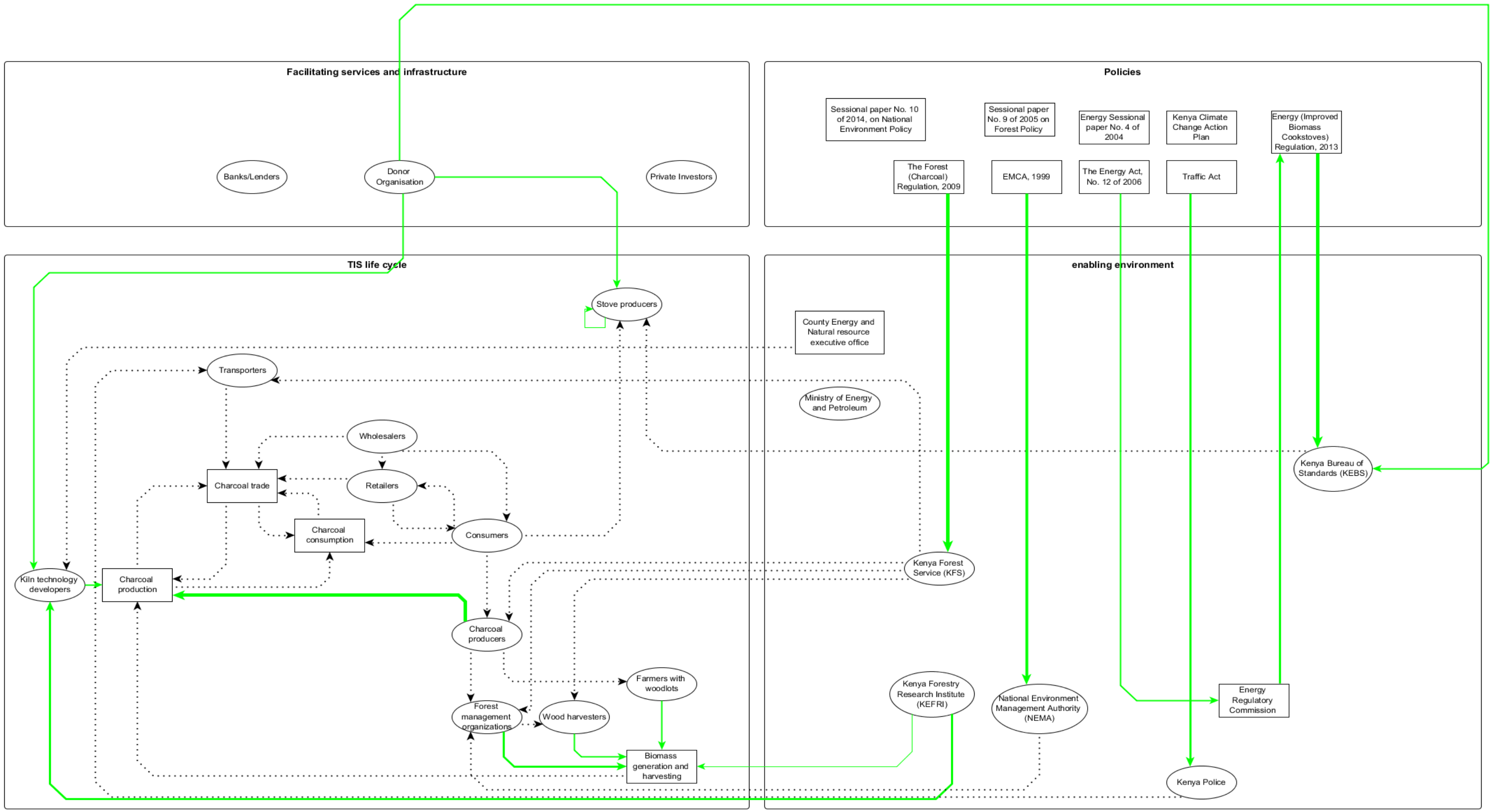


Figure 19 Innovation system map for charcoal for Kenya

Source: Author's own work

1.6 Stakeholder engagement

Stakeholder engagement for the Kenya case study revolved around a workshop in May 2016 and expert interviews in November 2016 (see Table 5).

Table 5 Stakeholder Engagement

Type of stakeholder	Position in the organisation*	Economic sector**	Type of engagement ***	Month and year contacted
1. Academia	Energy Specialist	Solar energy	Workshop	Jun-16
2. Academia	Lecturer	Wind energy	Workshop	Jun-16
3. Civil society	Climate Change Expert	Climate Change	Workshop	Jun-16
4. Electric utility	Planning Engineer	Power	Workshop	Jun-16
5. Government	National coordinator	Forestry	Workshop	Jun-16
6. Government	Renewable Energy Officer	Energy	Workshop	Jun-16
7. Government research	Environmental Researcher	Environment/climate change	Workshop	Jun-16
8. Government research	Senior Scientist	Forestry	Workshop	Jun-16
9. NGO	Energy Markets Expert	Energy	Workshop	Jun-16
10. Electric utility	Engineer	Geothermal	Interview	Oct-16
11. Academia	Lecturer	Geothermal	Interview	Nov-16
12. Industry association	Coordinator	Geothermal	Interview	Nov-16

* Government (national / subnational), research / consultancy, business, other (specify)
** Energy, Industry, transport, environment, agriculture / forest, financial / trader, other (specify)
*** Interview, focus group, workshop, survey etc.

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