TECHNICAL REPORT

Nordic Green to Scale for countries

Unlocking the potential of climate solutions in Kenya and Ethiopia

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Mbeo Ogeya, Anne Nyambane and Hannah Wanjiru

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Executive summary

The Paris Agreement was adopted by countries to enhance the implementation of the United Nations Framework Convention on Climate Change (UNFCCC) adopted in 1992 and to strengthen global response to the threat of climate change. The Agreement includes the goal of holding the increase in global average temperature to well below 2 °C and pursuing efforts to limit it to 1.5 °C above pre-industrial level.

Nations including Ethiopia and Kenya have made commitments by submitting their nationally determined contributions (NDC) towards reducing their emissions while maintaining development trends. Ethiopia seeks to reduce its emission by 255 $MtCO_2$ (by 64%) in 2030 from projected BAU emissions whereas Kenya NDC targets a 30% reduction from projected emissions of 143 $MtCO_2e$ (FDRE, 2015; MoENR, 2015).

In this report we explore how the scaling up of 10 existing Nordic climate solutions in Ethiopia and Kenya could contribute to and possibly go beyond the achievement of the NDC objectives for the respective countries. These solutions targeted the energy, agricultural and forestry, buildings and households, and transport sectors. In the energy sector, we focused on geothermal development, onshore wind power, grid solar power and combined heat and power solutions; while in the buildings and households, the solutions were energy efficiency in buildings and improved cookstoves. The agricultural and forestry sector solutions were low-carbon agriculture, afforestation and reforestation, and reduced deforestation. And lastly the transport sector solution was cycling in cities.

In summary, scaling up of the 10 solutions in the four sectors can yield a total emission reduction of 39.8 $MtCO_2e$ in Ethiopia and 23.5 $MtCO_2e$ in Kenya in 2030 – a reduction of 10% and 16% of the projected business as usual emissions[1] respectively. Generally there is similarity in abatement trend in the two countries but with different abatement potentials. Low-carbon agriculture and afforestation present the greatest opportunity for emission reduction for both Ethiopia and Kenya. This is in line with the intended nationally determined contributions plan for the two countries laying more emphasis on these sectors. Low-carbon agriculture would yield an estimated reduction of 13.9 $MtCO_2e$ and 8.2 $MtCO_2e$ for Ethiopia and Kenya respectively whereas afforestation and reforestation would contribute about 11.2 $MtCO_2e$ for Ethiopia and 3.9 $MtCO_2e$ for Kenya. In the energy sector geothermal power offers the greatest opportunity for abatement: 4.1 $MtCO_2e$ in Kenya and 2.3 $MtCO_2e$ in Ethiopia. Improved cook stoves and energy efficiency in buildings record the least abatement potential in both countries.

[1] 2030 BAU emissions taken from INDCs.

Low-carbon agriculture has the lowest abatement cost of USD -91 million in Kenya and USD -153 million in Ethiopia, meaning that implementing these solutions will save money over time. Cycling in cities is the second most cost-efficient solution for both Ethiopia and Kenya with a cost of USD -31 million and USD -45 million respectively although with medium abatement potential. Energy efficiency in buildings, combined heat and power and improved cookstoves can be considered neutral solutions with both low cost and abatement potential.

Several barriers will need to be addressed in order to scale up the various low-carbon solutions in the various sectors. They include high upfront investment costs, lack of sustainable financing, land tenure challenges, limited coordination among ministries, compliance challenges and lack of awareness among potential solution implementers and users.

Three main recommendations have been highlighted in order to overcome these barriers:

1. Formulate, implement and enforce sector specific policies and institutional structures;
2. Guarantee close collaboration with private sector actors and among sectors; and
3. Invest in capacity building and awareness creation activities.

More detailed country and solution specific barriers are detailed in sections 5, 6, 7 and 8 of the report.

1. Introduction

This report presents results from the East African case studies under the Nordic Green to Scale 2 project. The analysis was undertaken by the Stockholm Environment Institute (SEI) and funded by the Nordic Council of Ministers and Finnish Innovation Fund (Sitra). The project builds on two earlier phases implemented in 2015–2016.[2] The overall aim of Green to Scale is to highlight the potential of existing low-carbon solutions in tackling the climate crisis at low cost while delivering co-benefits to people and the environment. The Nordic Green to Scale 2 project focuses on analysing country-specific barriers and providing targeted policy recommendation of overcoming the barriers.

This project applied the general Green to Scale methodology. The concept is based on estimating the potential of a country reaching the same level with a particular solution as some countries have achieved already. The project asks the question "what if country B (target country) could implement a low-carbon solution at a similar rate as country A (originating country)" taking into account economic, demographic, size and structural governance differences between the two countries. The analysis does not, however, try to identify the full technical and socio-economic potential for implementing the solution.

We applied this methodology to explore how the scaling up of solutions in two East African countries – Ethiopia and Kenya – can play a major role in achieving the targets set out to reduce national emissions and fulfil the nationally determined contributions of the respective countries under the Paris Agreement, in line with the well below 2 °C objective.

1.1 Green to Scale: concept and background

The world is recognizing the inevitable need to deal with climate change. Paris Agreement has set the global target, now it is up to countries, cities and businesses to implement needed reductions. Nordic prime ministers have invited the world to share Nordic knowledge and experiences of Nordic solutions to global challenges as a tool in our common work to reach the United Nations Sustainable Development Goals by the year 2030.

Green to Scale, as a part of the Nordic Council of Ministers initiative Nordic Climate Solutions, has highlighted the potential of scaling up existing ways of solving the climate problem. In 2015, the project looked at 17 solutions from five different sectors, both from the global North and South. In total, the 17 global solutions would cut annual

[2] www.greentoscale.net

greenhouse gases, measured in carbon dioxide equivalent (CO_2e), by 9 billion tonnes (gigatonnes, Gt) by 2025 and by 12 Gt in 2030. These reductions are significant: 12 Gt is equivalent to nearly a quarter of annual global emissions at present.

In 2016, the Nordic Green to Scale project focused on 15 Nordic solutions ranging from wind power to electric vehicles. Scaling up the selected Nordic solutions could cut global emissions by 4.1 gigatonnes ($GtCO_2e$) in 2030. The reduction would be equal to the current total emissions of the European Union. The net cost of implementing all 15 solutions was estimated to be USD 13 billion in 2030. To put the figure into perspective, the costs of scaling up the solutions would equal what countries globally spend on fossil fuel subsidies in just nine days.

Previous phases have uncovered a vast emission reduction potential by using proven solutions which are readily available and already deployed somewhere around the world. Scaling up these solutions would be in most cases affordable and provide significant benefits to people and the environment. To reap the emission reduction potential, countries would need to reach the same level of diffusion of these solutions as others already have.

However, there is a long way from highlighting a potential at a global scale to deploying the solutions in practice in different jurisdictions. That is why this phase of Green to Scale zooms in on selected countries, moving a level closer to implementation.

Nordic Council of Ministers (NCM) has financially supported and the NCM Climate and Air Pollution group has served as the advisory council for the project. Green to Scale is included in the Nordic Prime Ministers' Initiative Nordic Solutions to Global Challenges. The Finnish Innovation Fund Sitra has hosted the project secretariat. CONCITO (Denmark), CICERO (Norway) and University of Iceland were members of the steering group. For more information on the project and the previous two phases, please refer to www.greentoscale.net.

The East Africa case study was carried out by SEI Africa with support from Addis Ababa University, Ethiopia. The analysis of the selected solutions consists of:

- Potential emissions reductions, costs and savings;
- Enablers for and barriers to applying the solutions;
- Co-benefits of their implementation; and
- Policy recommendations for efficient adoption of feasible solutions.

1.2 The East Africa Community: Strategies and Plans

The East Africa region is growing quickly: in 2016, the region's gross domestic product (GDP) grew by 6.1% (IMF, Regional Economic Outlook, 2016). However, a number of challenges continue to constrain regional and national development agendas, including continued vulnerability to shocks in climate systems, global financial markets, demographic patterns and political regimes. To mitigate these vulnerabilities, the member states of the East African Community (EAC) have initiated a five-year Regional

Development Cooperation Strategy 2016–2021. The Strategy's long-term vision emphasis is on collaboration, integration and cooperation among member states of the EAC. This forms part of policy harmonization and standards to facilitate scaling-up of innovative technologies and best practices in energy transmission, agriculture, climate change and environmental resource management. Additionally, the strategy will strengthen institutions and leadership by enhancing technical capacity, policy making and reaffirming commitments towards inclusive development.

To specifically address the issue of climate change, the EAC member states have developed an East African Climate Change Master Plan 2011. This Master Plan was developed through a unified, participatory and consultative approach facilitated by EAC Secretariat, and aims "to strengthen regional cooperation to address climate change issues that concern regionally shared resources". According to the Master Plan, the areas considered most vulnerable to climate change include energy security, agriculture, water security, tourism, ecosystem services, infrastructure (roads, buildings, waterways and airways), trade and industry, education, science and technology. The Master Plan seeks to strengthen regional cooperation on climate change through eight key activities: adaptation interventions; mitigation interventions; research, technology development & transfer; capacity building; education, training and public awareness; gender, youth and migrated groups; climate risk management & disaster risk reductions; and climate finance. Other relevant regional efforts include the EAC Climate Change Strategy, the EAC Protocol on Environment and Natural Resources and the EAC Climate Change Policy. The aims of these efforts, along with those of the Master Plan, are fully in line with the objective of the Nordic Green to Scale project to scale up low-carbon solutions.

Within the East Africa region, Kenya and Ethiopia were selected as case study countries given their continued investment in and commitment to green economy transition. Kenya's GDP in 2015 was USD 60.8 billion, of which 72% was derived from natural resource related sectors: agriculture, forestry, mining, energy and forestry (KNBS, 2017). To address climate change vulnerabilities within these sectors Kenya has established its Green Economic Strategy and Implementation Plan 2016–2030 which promotes adoption of low-carbon emission initiatives. This is in line with the country's Vision 2030 that is propelled by five-year mid-term plans. Ethiopia on the other hand, has initiated Climate-Resilient Green Economy Strategy through its ambition to "achieve middle-income status by 2025 in a climate-resilient green economy". The vision aligns with Ethiopia's ambitious targets to pursue economic development without adversely impacting the environment. The strategy follows a sectoral approach focusing on achieving development goals whilst simultaneously limiting greenhouse gas (GHG) emissions by 2030.

1.3 Research focus

The Green to Scale methodology was used to assess the potential for scaling up ten low-carbon solutions in Ethiopia and Kenya. The solutions were selected in consultation with experts in Kenya and Ethiopia and steering group based on the following criteria:

- Fit with challenges identified in national energy and climate strategies;
- Current penetration and potential scalability based on the suitability of a solution to the countries in question; and
- Representation of different sectors (energy, transport, buildings and households, industry, forestry and agriculture).

On the basis of this consultation process, ten solutions across four sectors were selected for the project, as shown in Table 1. Reference countries were chosen for each solution to use as comparators with regards to implementation, as described in the global (Afanador, Begemann, Bourgault, Krabbe, & Wouters, 2015) and Nordic (Korsbakken & Aamaas, 2016) Green to Scale reports. For each solution, emissions savings, costs and reductions, co-benefits and enablers for and barriers to implementation were analysed.

Table 1: Solutions explored in each case study

Sector	Solution	Reference country
Energy	Geothermal power Wind power Solar power Combined heat and power	Iceland Sweden Germany Finland
Transport	Cycling in cities	Denmark
Buildings and households	Improved cookstoves Energy efficiency in buildings	China Mexico
Agriculture and forestry	Afforestation and reforestation Reduced deforestation Low-carbon agriculture	Costa Rica Brazil Brazil

1.4 Report structure

Section 2 of the report gives a snapshot of project findings and section 3 presents the methodological approach used in the study of scaling-up potential of ten low-carbon solutions in Ethiopia and Kenya. Section 4 sets out the baseline from which scale-up potential was extrapolated. Sections 5, 6, 7 and 8 present the results for the energy, transport, buildings and households and agriculture and forestry sectors respectively. And finally, section 9 concludes with summarised policy recommendations.

2. Main findings

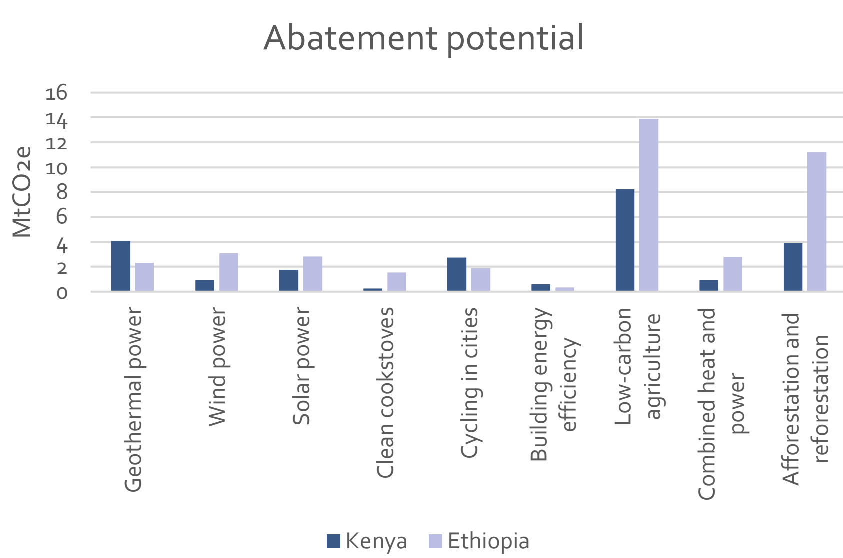
2.1 Emission abatement potential

The emission reduction potential of scaling up the ten selected Nordic and other climate solutions was estimated to be 39.9 $MtCO_2e$ in Ethiopia and 23.5 $MtCO_2e$ in Kenya compared to baseline. The national commitments by Ethiopia and Kenya are 255 $MtCO_2e$ (FDRE, 2015) and 43 $MtCO_2e$ (MoENR, 2015) by 2030.

The abatement potential for different solutions is shown in Figure 1. Low-carbon agriculture and afforestation presented the greatest opportunity for emission reduction for both Ethiopia and Kenya. Low-carbon agriculture would yield 13.9 $MtCO_2e$ and 8.2 $MtCO_2e$ for Ethiopia and Kenya respectively whereas afforestation and reforestation contribute 11.2 $MtCO_2e$ for Ethiopia and 3.9 $MtCO_2e$ for Kenya. The NDC targets for agriculture and forestry for Ethiopia are 90 $MtCO_2e$ and 130 $MtCO_2e$ respectively by 2030, whereas in Kenya they are projected to contribute to 35 $MtCO_2e$ and 26 $MtCO_2e$ respectively by 2030 in the baseline scenario (Government of Kenya, 2015).

Electricity generation in both Ethiopia and Kenya contributes marginally (less than 5%) to total GHG emission. As summarised in Figure 1 below, geothermal, solar and wind power as well as combined heat and power present a moderate opportunity for emission abatement ranging between 0.9 $MtCO_2e$ to 4.1 $MtCO_2e$ for Kenya and 1.5 $MtCO_2e$ to 2.8 $MtCO_2e$ for Ethiopia. The GHG abatement potential from energy saving in the buildings and households sector is 0.6 $MtCO_2e$ and 0.3 $MtCO_2e$ for Kenya and Ethiopia respectively.

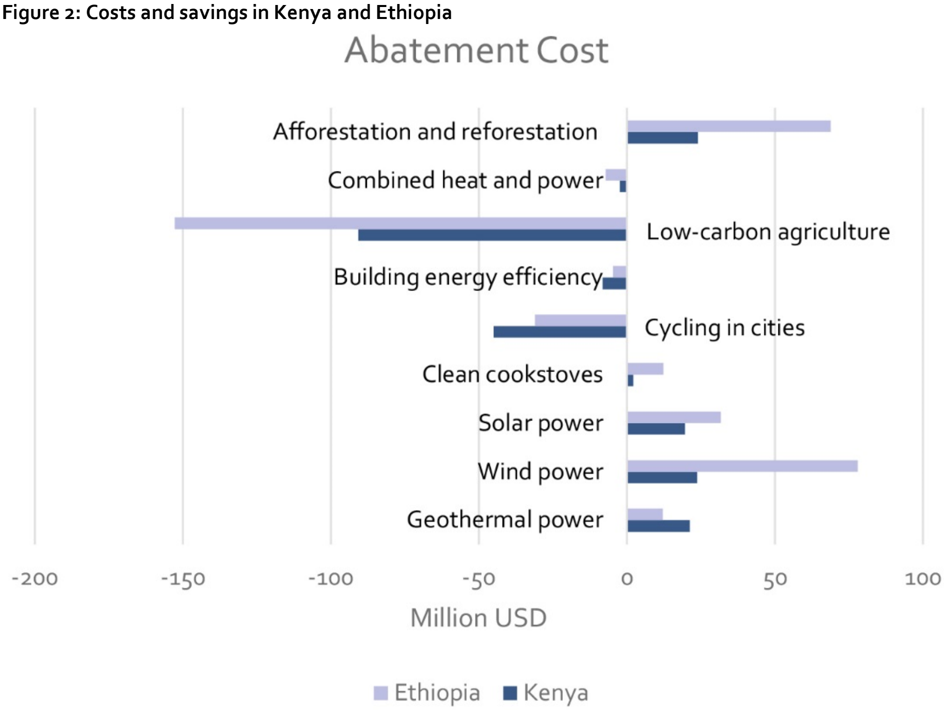
Figure 1: Emission abatement potential



2.2 Costs and savings

Figure 2 shows the abatement costs and savings for the different solutions. Four solutions have high abatement costs – afforestation and reforestation and geothermal, wind and solar power – with the main factor being upfront investment cost. However, wind and solar power present opportunities for significant cost reductions as the cost of the panels, turbines and other components continues to fall. Although onshore wind power has existed in Kenya for over ten years, the first largescale plant (310 MW capacity) is yet to be connected to the national grid and is seen as a having high potential for rapid scaling up. Generic cost curves (McKinsey&Company, 2009) were used, with moderate adjustment based on purchasing power parity and investment cost relative to the originating country to reflect as close the East African context.

Figure 2: Costs and savings in Kenya and Ethiopia



2.3 Barriers

There are various barriers that need to be addressed in order to scale up the various low-carbon solutions. These barriers are summarised below, with country and solution specific barriers detailed in sections 5, 6, 7 and 8 of the report.

For the energy sector solutions, investing in geothermal, solar and wind power is capital intensive. Most of these plants are located far from the main grid leading to high transmission infrastructure costs. Moreover, due to the land tenure challenges, the process of acquiring land is lengthy and expensive for investors, delaying the implementation of projects.

In the transport sector, there is a lack of collaboration during designing, planning and implementation of projects among various ministries. Existing city plans unfriendly to cycling and right of way challenges among motorized and non-motorized road users are also some of the barriers that need addressing to support cycling in cities.

As for energy efficiency in buildings, the main barriers include poor compliance and implementation of building codes and standards stipulated in the building proclamation (regulation); lack of awareness among consumers and contractors of the kind of appliances to use and some of the energy efficiency practices to reduce their energy consumption; and the existence of low quality appliances and even counterfeit goods. With cookstoves, quality certification is the main challenge as there are limited procedures for all improved cookstoves and no testing facilities to certify that the cookstoves being distributed meet the required standards.

The main barriers under the forestry sector include competition for land; lack of finances to support afforestation, reforestation and deforestation reduction activities and lack of knowledge on the full benefits of conserving the forest among the community. In the agricultural sector, lack of low-carbon technologies, awareness about these technologies and finance to support smallholder farmers to take up these technologies are barriers hindering the adoption of such solutions.

2.4 Policy recommendations

In order to scale up low-carbon solutions by capitalizing on the enablers and addressing the barriers reported in Kenya and Ethiopia, we present a range of policy recommendations for each sector below, developed in dialogue with local experts and stakeholders.

Energy sector low-carbon solutions:

- Establish institutional structures and formulate relevant policies such as feed-in-tariffs and renewable auctions to support investment in geothermal, solar and wind power. This is especially important in Ethiopia where the majority of renewable energy investments are done by the government;
- Promote private sector engagement and support through incentives, concessional loans and letters of guarantee to de-risk the investment in renewable energy;
- Shift power demand closer to the power generation sites to lower transmission and distribution costs. This can be done by providing incentives for ventures that establish industrial parks closer to such sites;
- Establish clear compensation procedures for landowners and communities close to geothermal, wind and solar sites in order to minimize community conflicts; and
- Accelerate the adoption of combined heat and power systems by financing retrofits, industrial process modernisation through incentives such as tax holidays and loans.

Transport sector low-carbon solutions:

- Establish institutional structures to support and mainstream activities among the various ministries and integrate the road users' needs during the design and implementation of infrastructure projects;
- Strengthen the enforcement of existing regulations (such as the Traffic Act for Kenya and Road sector Policy in Ethiopia) to ensure that various road users obey the road rules and finance activities to increase awareness of the benefits of cycling and promote behaviour change; and
- Increase public and private funding for integrated road infrastructure planning and implementation, including cycling infrastructure.

Buildings and households sector low-carbon solutions:

- Enforce various regulations related to energy efficiency such as building codes and provide incentives that will encourage more consumers to adopt energy conservation practices;
- Target awareness campaigns on energy efficient building practices and technologies;
- Establish structures that support the collection of data related to cookstoves and provide guidelines on the monitoring, reporting and verification of impacts of cookstove programmes;
- Establish standards for improved cookstoves; and
- Undertake a continuous awareness raising programme on improved cookstoves coupled with behaviour change campaigns.

Agriculture and forestry sector low-carbon solutions:

- Put in place long-term financing mechanisms from both private and public sectors to support the various afforestation, reforestation and deforestation reduction activities;
- Formulate policies and institutional frameworks that address land tenure issues, forest management challenges and benefit-sharing among various actors;
- Harmonize and ensure speedy implementation of policies on low-carbon agriculture (such as the Climate Smart Agriculture Framework in Kenya and the Climate Resilient and Green Economy Strategy in Ethiopia) – including investment in mechanization – and also promote coordination during the implementation of activities related to low-carbon agriculture; and
- Undertake awareness creation activities to showcase benefits of low-carbon solutions in agriculture and forestry sectors.

3. Methodological approach

In this section, we describe the combination of quantitative and qualitative methods used in the study to analyse the emission reduction potential, costs and savings, enablers and barriers as well as co-benefits associated with scaling up the selected low-carbon solutions in Ethiopia and Kenya.

3.1 Quantitative analysis of emissions abatement potential and costs

The estimation of GHG emissions and abatement potential was aided by Long Range Energy Alternatives Planning tool (LEAP) for the energy, transport, housing and industrial sectors. Intergovernmental Panel for Climate Change (IPCC) methodology was used for agriculture and forestry sectors.

LEAP is an integrated scenario modelling tool that is used to track energy consumption, production and resource extraction in all areas of an economy. The tool has a flexibility of applying top-down and bottom-up approaches in energy demand and supply analysis, however, we use a bottom-up approach in our analysis. The demand driven model uses activity level parameters such as the number of households, vehicle kilometres, GDP contribution and respective energy intensities (GJ/household, litres of gasoline per vehicle kilometre) for final energy demand analysis. The energy demand is subjected to transmission losses and process efficiency computation to establish total energy transformation (GJ or GWh) required to meet the demand. LEAP tool generates a business as usual or reference scenario that forecasts demand and supply based on current national growth or development trends. It provides an opportunity to enter an expression based on assumptions of possible rapid deployment of technologies to generate national plan scenarios; in our case Nordic Green to Scale solutions scenarios. Moreover, one of the unique features of LEAP is the ability to integrate with other online tools. It draws from the IPCC database emission factors for various energy transformation and conversion technologies. For instance, LEAP assigns tier 1 emission factor – tCO_2/GJ or tCO_2/kWh – for energy generated from a particular source or technology.

To compute abatement potential, the emission resulting from implementing a Nordic Green to Scale solution in target country is subtracted from the emissions in business-as-usual scenario (See Appendix 1 for elaborate description of LEAP). The first step is to determine the baseline based on current trend of deployment of technology "X". The additional deployment is the difference between baseline and deployment based on multiplying historic trend in country "Y" by current technology deployment in country "Z". Associated abatement is computed by multiplying related emission reduction factor (e.g. tCO_2/GWh) per unit of implementation of activity.

Forestry and low-carbon agriculture solutions were computed using the IPCC guideline for GHG inventory volume 4 (IPCC, 2006). Module 4 of the revised 1996 IPCC guideline for national greenhouse gas inventory provides for estimation of greenhouse gases from five sources including domestic livestock: enteric fermentation and manure management, rice cultivation, burning of savannas and agricultural residues and agricultural soil (IPCC, 1996).

The scale up methodology was largely based on the methodology developed by ECOFYS for the original global Green to Scale report (Afanador, A. et al., 2015) and the Nordic Green to Scale report by Jan Ivar Korsbakken and Borgar Aamaas at CICERO. The two reports set out the methodology for specific solutions from each originating country. They describe the case studies in reference countries. The methodologies are further elaborated in the subsequent chapters of specific solutions.

The calculation of the associated net emission reductions in the target countries consisted of the following main steps:

1. The Business-as-Usual scenario (BAU) was based on macro-economic indicators, population growth rate and implementation of relatively achievable nation plan activities. The key business-as-usual scenario assumptions that advised future growth trends are summarised in Table 2;
2. Using LEAP tool, we modelled energy demand and supply in 2030. Taking an example of improved cook stove (ICS), the model forecast additional stoves in 2030 with the population growth rate at constant share of traditional and improved cook stoves in the business-as-usual scenario (BAU). To establish abatement potential, we model a Nordic Green to Scale Scenario (NG2S) for every solution. For example, in the NG2S for ICS we seek to have a 90% adoption of ICS meaning 90% share of total population adopting ICS in 2030. This is expected to yield net energy saving thus resulting in emission reductions. The energy saving is as a result of subtracting NG2S for ICS scenario from BAU scenario;
3. Using default emission factors (112 tCO_2/TJ) for energy saving from ICS technology we multiply the saving by the emission factors to determine the abatement potential. The abatement cost was hence obtained by multiplying total abatement potential with marginal abatement cost per tCO_2 for a specific solution;
4. In agriculture and forestry sectors, we obtained historic data from FAO database. This was extrapolated to 2030 to provide the business-as-usual scenario using the historic growth trend. As in part one, above, we deployed the growth rate of the originating country to target country. The difference provided the abatement potential;
5. The abatement potential did not consider possible leakages as a result of programme activity. It also assumed similarity in many aspects from the originating country. We were however careful not to exceed the maximum achievable capacity for the target country – for instance, 10 GW of geothermal capacity for Ethiopia and Kenya each; and

6. LEAP tool computes solutions independent to related solutions but provides an opportunity to visualise benefits achieved in combined solutions.

The total cost of each solution was calculated using unit abatement costs (per tonne CO_2e) and multiplying the unit cost by the total net abatement potential. For most of the solutions, we used the McKinsey cost curve, like in previous Green to Scale reports. We recognise there are significant limitations associated with using these cost curves. For example, the costs of finance, labour and fuel in East Africa will differ significantly from the cost assumptions used in the McKinsey cost curve, which was based on global averages data. It was not within the scope of this project to undertake an analysis of more precise abatement costs for solutions in the East African context. As a result, it is important to interpret the results associated with costs with this error margin in mind. Nevertheless, we believe the results can still give a useful indication of rough orders of magnitude of abatement cost for all the solutions described in this report. We also adjusted the values based on available recent data, capital investment and purchasing power parity.

3.2 Qualitative analysis of enablers, barriers and co-benefits

The qualitative analysis involved understanding key barriers and enablers to the achievement of the Green to Scale solutions in the target country. A stakeholder engagement approach was used to discuss and point out past and present bottlenecks to deploying technologies. A focus group discussion and interviews were conducted in both the countries. Stakeholders were invited from the five main sectors of the project mainly from the government ministries and departments. Focus on government bodies was due to the heavy mandate and influence of government policies and legislations on development and investments. To avoid bias, individual interviews were additionally conducted with private sector, civil society and academia representatives.

3.2.1 Focus group discussions

Participants of the focus group discussion were two people from each ministry in the five sectors. The approach included presenting solutions and a preliminary build-up of projected solutions in the target country based on a business-as-usual scenario. This set the scene for discussion amongst the stakeholders on what is achievable, what is not and why, the co-benefits of implementing the solutions and what these activities will mean to Ethiopia and Kenya.

3.2.2 Stakeholders' interviews

The key informant interviews include persons from the treasury (responsible for finances), various development agencies and other sectors that could be relevant for the implementation of the solutions. A qualitative questionnaire was developed to support oral interviews and open expression of personal expert opinion on the various solutions. Information including policy barriers could be pointed out.

4. General baseline

In order to understand the potential of low-carbon solutions it was necessary to establish a baseline for comparison. This section presents the general baseline in Ethiopia and Kenya for different sectors.

Table 2: Key drivers for BAU forecasting

Key Assumption	Base year (2015)	End year (2030)	Data type	Reference
Kenya				
Population (million)	44.2	65.9	Total	(KNBS, 2017)
Population growth rate (%)*	2.9	2.9	Annual incremental	(KIPPRA, 2017)
Average GDP growth rate	6.9	6.9	Annual incremental	(MoEP, 2016)
Urbanisation (%)	32	39.6	Share of total	(MoEP, 2016)
Ethiopia				
Population (million)	99.87	144.6	Total	World Bank Indicators
Population growth rate (%)*	2.5	2.5	Annual incremental	Ethiopia Facts and Figure
Average GDP growth rate (%)	11	11	Annual incremental	(FDRE, 2016)
Urbanisation (%)	24	35	Share of total	Computed from World Bank Indicator and (CSA & LSMS, 2017)

Note: *Whereas in reality population growth rates will vary, we adopt a static average growth rate to forecast.

4.1 Energy sector

In the energy sector, we built the baseline or business as usual (BAU) scenario based on existing plants and committed power plants for electricity supply module. Power plants under feasibility studies or marked for future exploitation were not considered in the model due to the high level of uncertainties in implementation before 2030. The BAU demand scenario drivers are described in Table 2 above. National GDP and population growth trends were the main drivers of demand. A conservative implementation of national development plans was also assumed due to several factors including time lag in national plan implementation, governance and national priorities in implementing development projects. The following documents were used in building the BAU scenario for the two countries: Kenya Power Generation and Transmission Master Plan (2015–2035), Kenya Vision 2030, Ethiopia Growth and Transformation Plan II (2015/16–2019/20) and the Ethiopian Power Sector: A renewable Future presentation.

The historic electricity generation trend in Ethiopia is dominated by renewables accounting for about 98% of the total electricity capacity. Diesel only accounts for 2% of total installed capacity. In Kenya renewable energy sources account for 65% and fossil fuels (diesel and natural gas) for 35% of total installed capacity. The total installed capacity in 2015 is 2,259 MW (Kenya Power, 2017) for Kenya and 4,228 MW (MoWIE, 2017) for Ethiopia.

Figure 3: Base year grid electricity production by installed capacity, Kenya

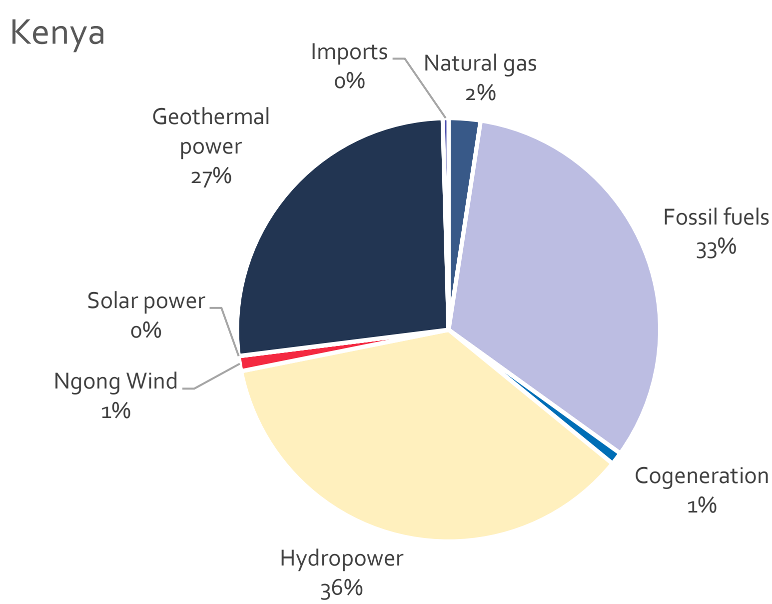
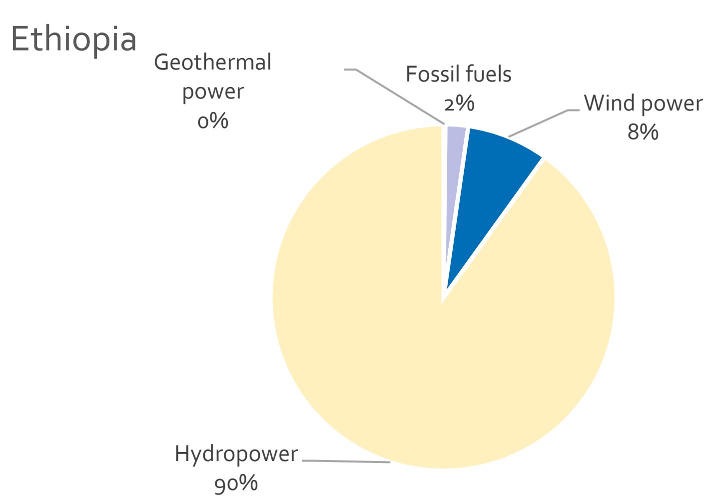


Figure 4: Base year grid electricity production by installed capacity, Ethiopia



The electricity generation trend indicates high growth in geothermal sector of 868 GWh/year (9%) (Table 3) in Kenya and 4,944 GWh/year (38%) (Table 4) for hydropower in Ethiopia. The high geothermal growth rate is a result of restructuring the geothermal sector and governments making it a priority sector to meet the national baseload requirement. A major boost was experienced in 2014/2015 in the form of commissioning of 280 MW geothermal power plants – about 45% of total installed geothermal capacity. In the National Power Generation and Transmission Master plan (2015–2031) geothermal capacity is expected to grow from 590 MW in 2015 to just over 2,900 MW in 2035 (MoEP, 2016). A major boost for Ethiopia was the first phase completion of the grand resonance dam and Gibe III hydroelectric dam with capacity of 1,870 MW and the recent 75 MW geothermal plant at Aluto Langano. The uncertainty of continued growth trajectories is dependent on several factors ranging from government policy and regulations to climate change impacts. The hydropower generation is slowly decaying in Kenya and high import levels are experienced. Ethiopia is poised to become the regional energy supply hub upon the completion of the grand resonance dam and Kenya expects to import 2,000 MW from Ethiopia. Diesel is on a rapidly declining pathway in Kenya as geothermal power generation grows and this is reflected in reducing electricity tariffs. Fossil fuel power generation is thus hoped to subside in Kenya in the future as renewable energy replaces the thermal power plants.

Table 3: Kenya electricity generation by source, in GWh

Source	2012	2013	2014	2015	2016
Hydropower	3,450.8	4,298.7	3,944.5	3,310.1	3,786.6
Fossil fuels	2,513	2,007	2,655	1,739.8	1,254
Geothermal power	1,498	1,599	2,007	4,059	4,608
Natural gas	33	27	41	4	1
Cogeneration	100	71	57	14	0
Biogas	0	0	0	0	0.3
Wind power	14.6	13.9	17.6	37.7	56.7
Imports	37.1	42.2	86.4	79.4	67.6

Table 4: Ethiopia electricity generation by source, in GWh

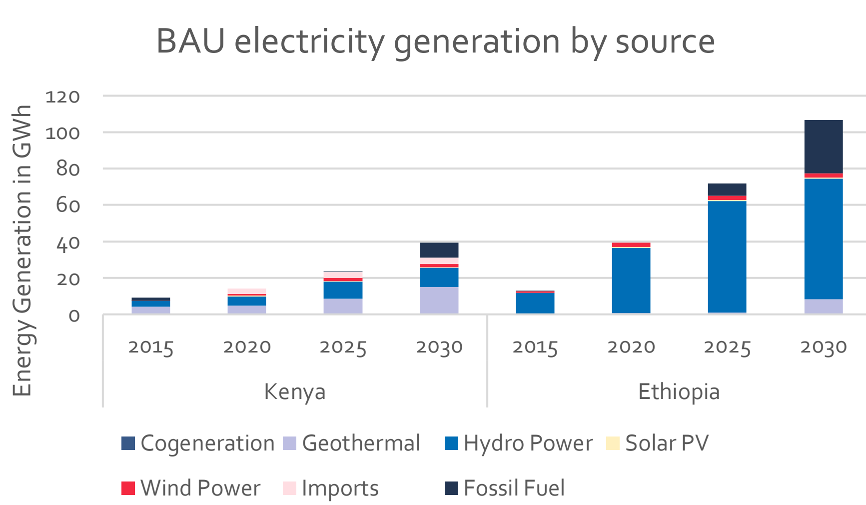
Source	2014	2015
Hydropower	6,946	11,890
Wind power	354	784
Geothermal power	28	28
Waste to energy	0	164
Fossil fuels	163	163

Ethiopia and Kenya are among the few African countries endowed with significant amounts of Geothermal power resources, scattered along the Rift Valley. The two countries have a potential of 10 GW each with only a tiny amount exploited. In the BAU scenario, the model factors additional 1,075 MW and 1,200 MW capacity of Geothermal power to grid by 2030 in Ethiopia and Kenya respectively. The additional capacities are based on the 75 MW and 1,000 MW commissioned in Ethiopia in 2017 and a conservative 50% installation of the expected 2,400 MW additional capacity in the Kenya Power Generation and Transmission Master Plan to 2035. Kenya has marked geothermal power as one of the key sectors to the achievement of its NDC. It can serve as a base load power to supplement hydropower, which relies on highly seasonal fluctuations that is worsened by climate change impacts as observed in fluctuating supply in Kenya.

Other renewables such as wind, solar and cogeneration are still at a low level with little impact on overall national generated capacity. However, wind is expected to generate high interest in the two countries. In Kenya a 300 MW wind farm is expected to get to the grid in 2018 and about 800 MW capacity expected is in Ethiopia. Ethiopia has one of the most ample wind resources in Eastern Africa with average velocities ranging from 7 to 9 m/s. The potential of wind power in Ethiopia is immense with an estimated potential capacity of 1,350 GW (Guta, 2015; MoWIE, 2013). Similar to geothermal power, exploration of wind power is aimed at diversifying the electricity mix in order to increase climate resilience. Solar is one of the renewable energy resources that most countries in Africa including Ethiopia are endowed with. However, in the past the main focus has been on household solar PV, but with the reducing cost of solar systems grid-tied solar PV is on the rise.

Whereas there is a heightened deployment of renewable energy technologies, there is similarly an incremental rise in electricity demand. The rapid economic growth rate of 11% in Ethiopia and 6.7% (IMF projections) in Kenya per year requires similar rates for the adoption of renewable energy technologies to halt the rising share of fossil fuels. In the BAU scenario, electricity supply is illustrated in Figure 5. Although there will be significant growth in the hydropower and geothermal power sector, in 2030 the share of fossil fuel burning shall have substantially increased also. In Ethiopia hydropower shall contribute 62% of final electricity supply, fossil fuel burning accounting for 27.3%, geothermal power 7.5% and other renewable 2.5%. In Kenya hydropower accounts for 26.4% of generation, geothermal power 38.4%, fossil fuels 20.9% and imports and other renewables 14.4%.

Figure 5: Electricity supply in the BAU scenario



4.1.1 Residential biomass energy use

Traditional fuels such as wood, agricultural residue and dung account for about 90% of Ethiopia's total national energy consumption with households being the major consumers. This is mainly for residential cooking purposes. In rural areas, households depend entirely on traditional fuels whereas the share of modern fuels in urban households' consumption was about 20%. This dependence is associated with economic, health, environmental and social impacts. Moreover, wood consumption is the main source of GHG emissions in Ethiopia especially since households use highly inefficient technologies and non-renewable firewood.

The CDM methodology (AMS-II.G) on emission reductions from improved cook stoves assumes that in the absence of the project activity a mix of fossil fuels (kerosene, LPG, coal etc.) shall satisfy the cooking need. However, we choose to use the gold standard assumption that in the absence of the project activity the consumption of non-renewable firewood to meet thermal energy for cooking shall rise (Climate Care, 2007) as this is more relevant in the African context. In order to reduce the negative impacts of traditional fuel use, initiatives to promote the dissemination of technologies that will lead to a reduction in wood consumption either by making the cook stove more efficient or shifting to other fuels such as biogas and modern biofuels are being implemented.

Final energy demand in the residential sector in Kenya and Ethiopia in 2015 is 334.4 and 1,615.4 petajoules respectively, with wood and charcoal accounting for 89%, kerosene 5% and electricity 2.2% in Kenya and 91.7% wood and charcoal, 5.9% cow dung and kerosene and electricity 0.8% each in Ethiopia. In 2030, final energy demand increases to 464.4 and 2,188.4 Peta Joules for Kenya and Ethiopia respectively. In the business-as-usual scenario, there is an expected rise in charcoal consumption due to a change in urban rural population dynamics. The share of population living in cities rises from 39% in 2015) to about 47% in 2030 in Kenya by 2030 and from 24% to 34% in Ethiopia. According to the country fact sheet, 100% of Ethiopian urban centres were electrified in 2012 whereas about 80% rural electrification shall be achieved in 2030. Similarly, urban electrification rate in Kenya will rise from the current 94% to 100%, and electrified rural areas will increase from 14% electrification level in 2015 to a conservative 70% in 2030. The power generation and transmission master plan however sets a goal of 99% (MoEP, 2016) rural electrification by 2035 in Kenya.

4.2 Transport sector

The transport sector contributes about 23% of the total global carbon dioxide emissions from fossil fuel combustion, of which road transport accounts for 73% of emissions (UNDESA, Bureau International des Expositions, & Municipal Government of Shanghai, 2010). Moreover, urban transport represents one of the fastest growing sources of emissions. The transport sector has the second highest energy demand after the household sector. It relies predominantly on diesel and gasoline in freight and passenger vehicles.

In Kenya, Nairobi contributes 70% of total vehicle kilometres. In rural areas people labour in the farms close to their residential homes with the main mode of transport being cycling or walking. The 30% share of total passenger kilometres is shared by long-distance buses and non-frequent commuter vans in rural areas, about 90% covered by long-distance commuter buses. Kenya targets a reduction of 2.8M tCO_2 in 2030 through a combination of bus rapid transit and light rail transit. Walk ways and cycling lanes are expressed as additional benefits that may arise from the construction of mass transport systems (GoK, 2013). Even as such, the roads 2013–2017 action plan has no mention of cycling lanes and walk ways (Ministry of Roads, 2013). However, in March 2015, a maiden non-motorised transport policy was made available for the Nairobi City County (NCCG, 2015). The objective of the policy is to create a safe, cohesive and comfortable network of foot paths, cycling lanes and tracks, green areas and other support amenities. A modal split from four reference studies on transport in the city of Nairobi is illustrated in Table 5 below. About 46% of the total population walk to their workplaces, public transport constitutes on average 41% and private cars 11.5% and only about 2% uses bicycle as their mode of transport. Main drivers for city cycling in Nairobi amongst other factors were noted to be mainly affordability (47%), convenience of use (28%) and speed compared to motorised means (18%) (NCCG, 2015).

Table 5: Modal split by share of population using transportation type in Kenya

Ref.	Public vehicle transport (%)	Private cars (%)	Walking (%)	Cycling (%)	Train (%)	Institutional Buses (%)	Others (%)
A	32.7	15.3	47.1	1.2	0.4	3.1	0.2
B	36	16.5	47		0.4		
C	51.5	7	41.2	3			
D	42	7	47	1		3	
Average	*40.6*	*11.5*	*45.6*	*1.7*	*0.4*	*3*	*0.2*

Source: JICA, 2006; Masaoe, Mistro, & Makajuma, n.d.; NCCG, 2015; World Bank, 2002.

In Ethiopia, road, air, rail and water are the main transport modes with road being the biggest transport service provider. There are more than 800,000 vehicles and it is reported that 75% of the GHGs emissions in the transport sector is from road transport (Mariam, 2017). In urban areas, the majority of the population walk short and medium distances (Aklilu, n.d.), with an estimated 70% of the population in Addis Ababa walking (Pirie, 2011). The transport sector in Ethiopia faces many challenges such as an imbalance of public transport demand and supply, increasing traffic congestion, air pollution and poverty. In order to address these challenges, the government has initiated various projects including mass transport buses and light rails and is encouraging non-motorized transport modes, e.g. bicycles and carts. So far most government efforts have been on mass bus transport and light rail, but cycling can be integrated within the ongoing road infrastructure development projects. Transport offers an opportunity to mitigate up to 10 $MtCO_2e$ by 2030 in Ethiopia through a combination of fuel efficiency and electric vehicle deployment (FDRE, 2011).

4.3 Building and industrial energy efficiency

4.3.1 Building energy efficiency

Energy efficiency for lighting is key to energy efficient buildings. In Kenya and Ethiopia, the climate ranges from tropical to wet and dry temperate. The annual average temperature is 23 °C. The country's buildings have simplified stone/block construction with a minimal insulation layer. Internal temperature control is often by opening of windows and ventilation systems. There is limited heating and cooling within residential houses. Hence the main areas of energy consumption in the buildings are the plug-ins and lighting system. There is however an expected rise in air conditioning and ventilation systems as a result of rising global temperatures. This could substantially increase energy consumption in residential and commercial buildings.

In Kenya and Ethiopia energy efficiency in buildings is significantly applied on the plugins and lighting system. New building regulation requires an appropriate architectural design that allows maximum natural lighting and sufficient air flow. Hence the limited air conditioning available is mainly in the hospitality industry that is considered in the model under the small commercial sector. There is however a deliberate government effort to enhance energy efficiency in buildings including commercial buildings. Some of the measures identified include energy efficient lighting, maximization of natural lighting, solar water heating and standards and labelling of home appliances. Ethiopian and Kenyan electric utilities have made an effort to increase efficiency among their customers. In Kenya, this has been achieved through a demand side management programme where large power consumers are required to maintain a power factor of 0.90. In both countries, the utility company has distributed about 5 million compact fluorescent lamps to replace incandescent lamps. And in Ethiopia, the government banned the importation of incandescent lamps.[3]

4.3.2 Combined heat and power

The industrial sector is one of the main sectors that supports economy and has witnessed an annual growth rate of about 20% in Ethiopia. According to the GTP II, value added in medium- and large-scale manufacturing industries registered an average growth rate of 19.2% and in micro and small industries 4.1% per annum. At the end of the plan period, the share of the industry sector in overall GDP has reached 15.1% (manufacturing 4.8%, construction 8.5%, electricity and water 1.0% and mining 0.8%). However, this performance fell short of the 18.8% target set by the end of the GTP I. This indicates the challenges to bring about rapid structural transformation in the economy. Similarly, the industrial sector in Kenya contributes 14.3% of national GDP and an average growth rate of 3.5%. The industrial sector has been identified as one of the fastest growing and also a major emitter of GHGs. An example is the cement

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[3] Climate Innovation Centre-Ethiopia, n.d.

industry that is reported to have outdated technologies that are not only energy inefficient but also cause high emissions from its production processes. These traditional and less efficient processes often result in energy loss as heat in exhaust gas or surface radiation. A study in the US reported that 20% to 50% of the energy consumed in some industrial processes is often lost through waste heat contained in streams of hot exhaust gas and liquids and through heat conduction, convention, and radiation from hot equipment surfaces and heat product streams (Otis, 2016). If such losses could be captured and reused for industrial heat input, the overall energy efficiency of some industrial processes could be improved in similar magnitude. In 2015, the final energy demand for the sector was 35.8 petajoules and 41.2 petajoules for Kenya and Ethiopia respectively.

In the baseline, the share of CHP was assumed to be 3.2% (half of world's average) of total heat requirement in Kenya and 0% in Ethiopia. This is however expected to grow to 5% under the BAU scenario necessitated by government regulation for industries in Kenya. No significant change is assumed in Ethiopia.

4.4 Agriculture and forestry

4.4.1 *Afforestation and reforestation*

Forests play an important role in Ethiopia's and Kenya's economies as they contribute on average 4% (KNBS, 2017) to the GDP through the production of honey, forest coffee and timber. They are also an important source of energy for more than 80% of the households particularly in rural areas relying on firewood as the main source of cooking energy. The forest further provides significant ecosystem services such as soil protection, water regulation, biodiversity preservation, carbon sinks and aesthetic value among others.

4.4.2 *Low-carbon agriculture*

In Ethiopia, the agricultural sector contributes about 42% of the country's GDP, 90% of exports and 85% of employment. Crops and livestock subsectors accounts for 27.4% and 7.9% of national GDP respectively. It is projected that the sector will grow by 8% (FDRE, 2016) between 2015 and 2020, with the production of major food crops such as teff, wheat and maize expected to increase from 19 million to 27 million tonnes. Fruit and vegetable production is also projected to increase fourfold to 5 million tonnes. The agricultural production systems in Kenya are characterized by subsistence, low input-low output, and rain-fed farming. However, the sector contributes 28% of national GDP in 2015 (KNBS, 2017). Crop growing has registered an average growth rate of 6.5% whereas animal production lags at 1.6% annual growth. The sector contributes 40% total GHGs emissions produced in the country.

4.4.3 Deforestation

In Kenya forests covered 8.3% and in Ethiopia 15.2% of land in 1990. High deforestation rate of more than 2% per year was observed in Kenya until the year 2000 and the trend continued in Ethiopia until 2010 at a rate of 1% per year. The alarming rate of deforestation necessitated national and international organisations including the Green Belt Movement Kenya to embark in a reforestation programme. Kenya's reforestation started in year 2000 and has continued to date at an average annual rate of 0.8%. From 2010, Ethiopia has increased its forest cover at an average rate of 0.33% per year.

5. Energy sector solutions

5.1 Geothermal power

5.1.1 Description of the solution

In 2014, 29% of electricity in Iceland was obtained from geothermal. The speedy growth of geothermal power in Iceland allows it to serve as a case model. Ethiopia and Kenya are among the few African countries endowed with significant amounts of geothermal resources that are scattered along the Rift Valley. The two countries have a potential of 10 GW each which is barely exploited. Kenya is leading in geothermal power in the region but with only 0.62GW exploited. Kenya has marked geothermal power as key to the achievement of its NDC.

The electricity generation trend indicates high growth in geothermal energy in Kenya and Ethiopia. In the base year (2015) (Kenya Power, 2017) the installed geothermal capacity was 590 MW in Kenya and 3.5 MW in Ethiopia. The model however considered both existing and committed plants raising the expected capacity to 1,779 MW and 1,082 MW for Kenya and Ethiopia respectively by 2030. The step wise extrapolation was based on Power generation and Transmission Master plan (2015–2035) for Kenya the Ethiopia Power sector: a renewable future presentation and scaling up renewable energy in Ethiopia. Under the business-as-usual scenario, geothermal will deliver 15,000 GWh and 8,600 GWh by 2030 in Kenya and Ethiopia respectively.

5.1.2 Scaling up method and baseline

Scaling up the solution is based on the Icelandic geothermal experience. The annual growth rate in Iceland was 11.3% in the period 2001–2013 (Korsbakken, J. I. & Aamaas, B., 2016). A similar analysis on the growth trend in 2003–2016 yields an average annual growth rate of 10.5%, contrasting to 2.4% global average growth within the same period. We apply the scaling up rate of 11% as experienced in Iceland for Ethiopia and Kenya. The growth trajectory is projected on the existing capacity and expected production of plants under construction for 2030 energy contribution.

In the BAU scenario, geothermal power contributes 15,000 GWh (40% of total electricity supply) of electricity to the grid in Kenya and 8,600 GWh (8.1% of total electricity supply) in Ethiopia. In the Nordic Green to Scale Scenario, geothermal power will supply 20,300 GWh (54%) and 12,900 GWh (12.1%) in 2030 for Kenya and Ethiopia respectively.

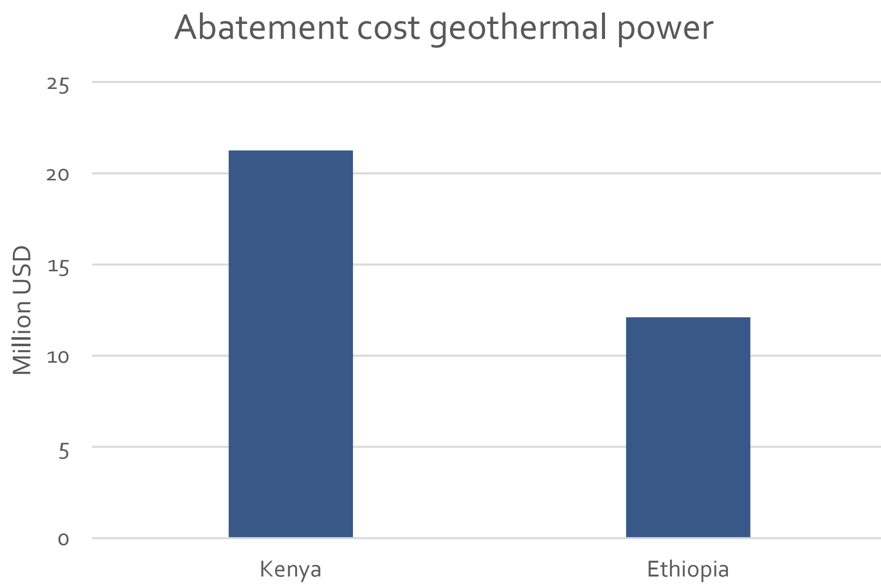
5.1.3 Abatement potential

Development of renewable energy, especially geothermal power, often experiences delays and time lag. In East Africa, it takes between five to seven years from exploration to electricity production. The recently signed agreement to build two geothermal power plants in Gornetti and Tulu Moye is expected to get to grid in 2026 – eight years later. We make the assumption that diesel power plants will be used to generate the extra energy demanded as stop gap measures. Scaling up geothermal power will yield 5,340 GWh and 4,290 GWh for Kenya and Ethiopia respectively in 2030 that would otherwise be generated by diesel power. We deducted project activity emission resulting from the fraction of CH_4 and CO_2 in the produced steam. This was obtained from the Olkaria steam monitoring report and was used in the application for CDM credits for the Olkaria II expansion program. The total project activity CH_4 and CO_2 emissions in steam was obtained to be 0.35 $MtCO_2e$ in 2030 in Kenya and 0.28 $MtCO_2e$ for Ethiopia. Thus, the net abatement potential in 2030 is 4.1 $MtCO_2e$ and 2.3 $MtCO_2e$ in Kenya and Ethiopia respectively.

5.1.4 Abatement cost

The global GHG abatement cost curve by McKinsey provides an abatement cost of about EUR/tCO_2 3.9 (USD/tCO_2 5.8) in 2030 under the BAU scenario (McKinsey&Company, 2009). Contextualising to East Africa, we geothermal investment costs in the region to global investment costs. The investment cost in East Africa ranges from USD/MWe 3.6 to 4.0 million (Ngugi, 2012; US Foreign Commercial Service, 2016) (average USD/MWe 3.8 million) against the global cost range as presented by IEA report of 2.4 to USD 5.9 million per MWe (average USD/MWe 4.2 million) (OECD/IEA, 2010; WEC, 2016). CAPEX being the major determinant of the abatement cost, we apply a marginal factor of 0.9 based on East Africa and global cost to the McKinsey global abatement cost of USD/tCO_2 5.8. Thus, the marginal abatement cost for East Africa is USD/tCO_2 5.2. Therefore, the total abatement cost for scaling up the solution is USD 21.25 million for Kenya and USD 12.5 million for Ethiopia.

Figure 6: Abatement cost for scaling up geothermal power



5.1.5 Important enablers

In recent years, geothermal exploration has been targeted more with a number of multilateral agreements. The African Rift Geothermal Development Facility project (ARGeo) is a 10-year Eastern Africa Region Geothermal programme with financial support from the Global Environment Facility (GEF) of the World Bank and the German Development Bank (KfW). The project focuses on promoting geothermal resource exploration and development by removing risks and reducing the cost of power development implementation. Through the project, Ethiopia has benefited in financial resources, technological and technical know-how transfer and promoting regional collaboration therefore contributing to the realization of the full potential of the resource. This has been the main driver in supporting the development of geothermal resources in the country.

In Ethiopia, the Ministry of Water and Electricity has made a tremendous effort to support geothermal development activities. This includes the formulation and development of various regulatory instruments in support of geothermal ventures such as the geothermal strategy, geothermal master plan, geothermal proclamation and the geothermal regulation (in process of being developed). Moreover, in order to attract private investors, the government offers to explore the resource first before inviting the investor to bid therefore reducing the risk of exploration. However, if the investor is interested in carrying out the preliminary exploration, then the government provides a support letter to apply for the Risk Mitigation Facility under the African Union.

The government of Kenya established the Geothermal Development Company (GDC) as a special purpose vehicle to accelerate the development of geothermal resources. To mitigate the risk that private developers face during exploration, the government through GDC, takes up the feasibility and drilling cost and sells the steam fields to KENGEN and private developers. GDC has succeeded in de-risking geothermal projects in Kenya making investment in geothermal energy attractive and viable hence promoting public private partnerships.

Kenya is also adopting improved technology with the potential to reduce the project development period progressively to about 10 years. The well-head generators enable energy generation while the geothermal plants are undergoing construction. Direct use of geothermal resources is being undertaken in Menengai and Olkaria sites for heating greenhouses, fish ponds and pasteurizing milk.

Kenya is being considered as a host for the Africa Geothermal Centre of Excellence. The centre is being supported by UNEP and other stakeholders. This places Kenya in a better place in terms of developing and strengthening capacity and skills.

5.1.6 Possible barriers

In Ethiopia lack of finances is one of the main challenges especially since geothermal exploration is capital intensive and it is considered a risky business especially at the exploration phase. Currently, there is low private sector involvement because previously the policy environment to support the exploitation of geothermal resources was lacking and this hindered private investor involvement in the sector.

In Kenya, the development of geothermal resources takes time including feasibility studies and long field testing. The venture is also capital-intensive. This leaves only established private companies to pursue this development opportunity. Moreover, none of the equipment and technologies for geothermal resources development are produced locally and investors must rely on other countries for imports.

Geothermal development requires high expertise, which needs further development in both countries. Impacts on wildlife and adjacent communities for the case of Kenya Olkaria sites cannot be ignored. Resettling communities within and adjacent to geothermal fields is also a barrier and the process can be lengthy therefore delaying project implementation.

5.1.7 Major co-benefits

Geothermal is a stable power source that can serve as baseload. It can contribute to rural electrification, energy security and local livelihood through the establishment of micro-enterprises. The direct use of geothermal heat reduces energy required for heating and can be used for recreational facilities. Moreover, replacing diesel power with geothermal power generation will reduce air pollution.

5.1.8 Policy recommendations

Replicate Kenya's institutional geothermal development arrangements in Ethiopia. In Kenya, the Geothermal Development Company was established specifically to support the exploration of geothermal resources reducing pre-investment risk for private developers.

Provide concessional loans and letters of guarantee to private developers in the geothermal sector by both the Kenyan and Ethiopian governments. This will de-risk the investment therefore encouraging private sector actors to be involved.

Introduce regulations supporting the assembling of geothermal equipment in the country. This would encourage growth of local industries and also encourage involvement of local actors along the geothermal value chain.

5.2 Wind power

5.2.1 Description of the solution

Denmark is known for its high share of wind power, having installed wind turbines from the 1970s and for having an ambitious goal of a fossil-free energy system by 2050 (Danish Energy Agency, 2018). Sweden is among the few European countries where more than 5 GW of wind power have been installed (WindEurope, 2018). At the same time, these countries are very different and can be treated as two outliers: Sweden as a large country with low population density and Denmark as a small densely populated country. While in the time of Nordic Green to Scale project the onshore wind production was 11 TWh in Sweden and 9.3 TWh in Denmark (Korsbakken, J. I. & Aamaas, B., 2016), by 2015 the figure for Sweden had risen quite considerably to 15.6 TWh and stayed on the same level for Denmark (IRENA, 2017). The average share of these two countries is used as a potential reflecting the share of technical potential of onshore wind actually used. The share is calculated based on electricity generation figures, not capacity.

Kenya is fast making progress in utilizing wind potential which is estimated at over 3,000 MW. Current investment includes 25.5 MW in Ngong Hills operated by KenGen, with 310 MW upcoming in Marsabit County by Lake Turkana Wind Power, and an estimated 100 MW in Kajiado County by Kipeto Wind Power. To meet increasing demand, the Government estimates that 2,000 MW of wind power need to be installed by 2030.

5.2.2 Scale-up method and baseline

With the huge potential of wind in the East Africa region we adopt directly the scaling up description from the Nordic Green to scale technical report (Korsbakken, J. I. & Aamaas, B., 2016). Both Denmark and Sweden have experienced high wind growth rates, Denmark having the world's largest share of wind power in overall electricity supply at over 40%. The level used for scaling up to the target countries in East Africa is the average built-up share of the technical onshore wind potential of Sweden and

Denmark. While this share was 6.8% in Nordic Green to Scale study based on 2014 data, by 2015 this share has increased to 7.3%.

Scaling up wind power seeks to replace fossil fuel energy investment. Like in geothermal power above, the assumption is based on the fact that delivering renewable energy to the grid in the East African context faces numerous barriers leading to delayed delivery and lag time thus requiring stop gap measures which are mainly diesel power plants. To achieve a 7.3% share of technical wind potential by 2030, a steady annual growth rate of 10.7% and 6.6% for Ethiopia and Kenya respectively is needed.

5.2.3 *Net abatement potential*

The abatement potential comes from the reduced burning of fossil fuels in the absence of project activity. LEAP computes the emission reduction as the difference between emissions in the business-as-usual scenario and upon implementation of the additional renewable energy on grid. Thus, the abatement potential in 2030 for both countries is as in Table 6 below.

Table 6: Net abatement potential for wind power ($MtCO_2e$)

Country	Net abatement potential (MtCO2e)
Kenya	0.9
Ethiopia	3.1

5.2.4 *Abatement costs*

According to the McKinsey GHG abatement cost curve, the abatement cost of onshore wind in low penetration is about 11 EUR/tCO_2e (16.4 USD/tCO_2) in 2030.

Like in geothermal power, we apply ratio of total project cost in East Africa against global cost. The average installation cost of wind in Kenya and Ethiopia is USD/MWe 2.4 million (MoE, 2013; MoEP, 2016). This is about two times more than the cost of development of wind turbines in Denmark (NREL, 2015) and more than the global weighted average cost of USD/MWe 1.5–1.6 million in 2012 (Korsbakken, J. I. & Aamaas, B., 2016). Adopting a ratio of 1.5 (i.e. 2.4/1.55) and multiplying that with USD/tCO_2 16.4 results in USD/tCO_2e 25.4. However, as the technology move from niche and as the market matures, the price differential is envisaged to change.

Total abatement costs for onshore wind are thus USD 78.0 million for Ethiopia and USD 23.8 million for Kenya (Table 7).

Table 7: Abatement cost for wind in 2030

	Kenya	Ethiopia
Unit abatement cost (USD/ tCO_2)	25.4	25.4
Total abatement cost (USD million)	23.8	78.0

5.2.5 Important enablers

The government of Ethiopia has plans to increase power generation in the country from 4,180 MW in 2014/15 to 17,000 MW by 2020, with wind power contributing 5,200 MW developed through private sector collaboration under Independent Power Producers (IPPs). In order to actualize the plan, the Government in partnership with the World Bank and Danish Aid has developed a programme on Accelerating Wind Power in Ethiopia Generation (AWPG) (Danida, 2015). This is the main driver of most activities happening in the wind sector in Ethiopia.

World Bank's Energy Management Assistance Programme will support wind resource mapping while the Danish Energy Agency will support technical and institutional capacity of the government on aspects of wind energy.

Moreover, there are policy frameworks that support wind energy generation such as Ethiopia's Growth and Transformation Plan II (GTP2, 2016–2022), the Climate Resilient Green Economy Strategy (CRGE, 2011), the Electricity Sector Specific Master Plan (2014) and the Ethiopia National Electrification Strategy (2016).

Common interest of the general public is also an important factor in the deployment of the technology.

To encourage investment in large-scale wind power in Kenya, the government has put in place a feed-in tariff (FiT) policy. For generation of 0.5–10 MW, a standard tariff of USD 0.11 per kWh is paid and the same for larger projects up to a cumulative capacity of 500 MW.

A high-level and remote Solar and Wind Energy Resource Assessment (SWERA) mapping exercise was completed and published in 2008 to stimulate investment through private sector engagement.

5.2.6 Possible barriers

The capital cost of wind technology has been one of the hindrance factors. Since all the wind equipment and accessories are imported, this increases investment cost.

Other important factors of consideration are transmission distance and grid stability. In Kenya, suitable sites are far from power demand sites therefore requiring huge investments in transmission lines and grid stabilization equipment. For example, Lake Turkana Wind Project transmission distance is about 480 kilometre from the production site to the Suswa transmission station.

Lack of finances, limited technological know-how and gaps in existing policy instruments such as lack of policies supporting private sector involvement in wind exploration are some of the challenges hindering development of wind sector in Ethiopia. Moreover, the fact that infrastructure cost has often not been included in the final cost of electricity to the consumer has inhibited private sector involvement in wind development activities. However, there are on-going programmes to support wind sector development.

The land tenure system in both Kenya and Ethiopia is a limiting factor which makes the process of acquiring land a lengthy process and expensive for investors. This at times can delay implementation of projects.

5.2.7 Major co-benefits

The major co-benefits of wind power development are related to improved air quality and energy security, as a result of replacing fossil fuel-based electricity generation and making a country less dependent on imported fossil fuel. Reduced emissions also bring health benefits.

Wind power growth will generate new jobs: direct jobs in manufacturing, operations and management and indirect jobs in upstream supply chains for materials and inputs for manufacturing. Direct jobs will also include local jobs during the construction and operating phases of wind farms.

For the owners of the land upon which the farms are installed, it will bring financial benefits.

5.2.8 Policy recommendations

Bring power demand closer to the power generation sites. This can be through providing incentives that will motivate large consumers of power to establish industrial parks closer to these sites and effective planning involving investors and power developers.

Introduce in Ethiopia policies that support private sector involvement in onshore wind exploration and opportunities for training to build capacities on wind technologies.

Establish clear compensation and relocation procedures for landowners and the community. If a resource is discovered, clear rules will reduce the time spent in negotiating with communities. Government support during such negotiations is also key so that communities do not feel that they are negotiating with an outsider.

5.3 Solar power

5.3.1 Description of the solution

Solar power covers already 7.2% of electricity production in Germany. In 2016, 1.5 GW new solar capacity was installed. However, this is still not yet the capacity foreseen by different strategies: the German Renewable Energy Act foresees an annual target of 2.5 GW of new solar power, and if the country wants to satisfy the energy demand with renewables by 2050, about 4–5 GW of solar power should be installed yearly. The feed-in tariff has been in place since 2000, but recently has witnessed substantial decrease. In addition there are limitations to new installations, which has actually led to a decrease of new solar power installations in Germany) (Fraunhofer, 2018). However, as the share of electricity produced from solar is still the highest in Germany, the country has been used as the benchmark for scaling up the solution.

Solar is one of the renewable energy resources that most countries in Africa including Ethiopia and Kenya are endowed with. In the past the main focus has been on household solar PV, but with the reducing cost of solar systems more grid-tied solar PV are expected. However, a slow uptake for grid solar systems is not unusual, mainly due to the upfront investment cost of about USD/kW 3,000 against an average of USD/kW 900 from hydropower. Government actions and policies are however changing the sector and more grid solar is expected in the region in coming years. Kenya has had a feed-in tariff policy since 2008 and has barely achieved 1 MW of solar capacity in the grid. Kenya is in the process of shifting from the feed-in tariff to auctioning policy under draft stages which is expected to spur the growth of solar power.

5.3.2 Scale-up method and baseline

Scale-up method used in the Ecofys report (2015) was based on solar potential, which in turn was based on the assessment of available amount of land, rooftops and facades, resource quality and technology. As no good data about these issues is available in Kenya and Ethiopia, the scale-up potential in this report is based on the share of solar power. We expect the two countries under study to also achieve the level of 7.2% share of electricity from solar power by 2030 as already experienced in Germany.

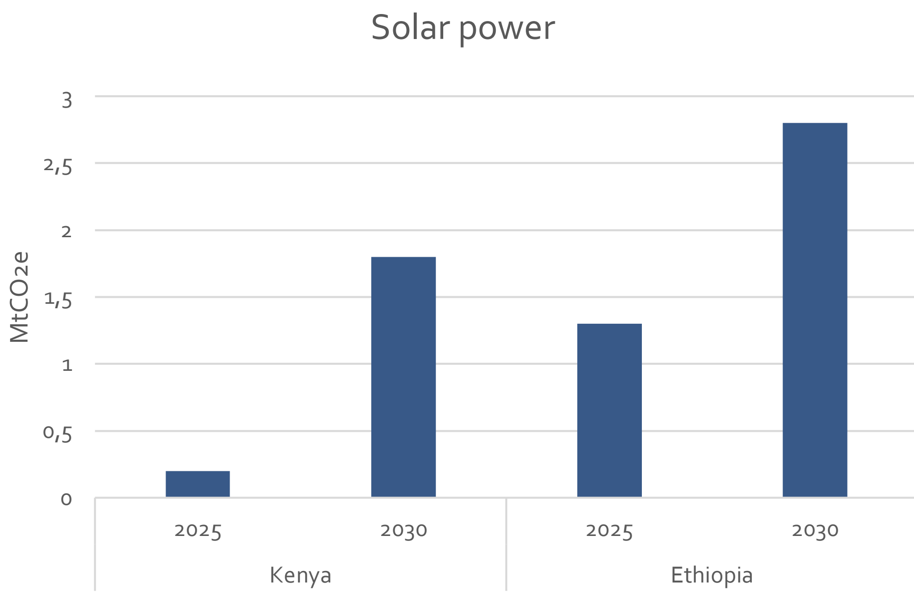
In Ethiopia, there was no solar PV in the grid and even in 2030 under the BAU scenario just a scratch is realized (0.6%) as 300 MW is commissioned in 2018. Similarly, in Kenya, there was zero grid solar in 2015, but in 2030 in BAU a 1.2% share is expected. Adopting the German solar share (7.2%) in the grid implies that the installed solar capacity shall have risen to 1,250 MW in Kenya and 3,500 MW in Ethiopia by 2030.

5.3.3 Net abatement potential

As in other renewable energy solutions described above, emission abatement potential is derived from replacing diesel-based energy generation that would have otherwise been combusted to generate the energy required. For Kenya we freeze the growth in the business-as-usual scenario at 210 MWp capacity already committed and in Ethiopia at 300 MWp committed. This is mainly because of high uncertainty related to the actualisation of planned solar PV projects which are still in the feasibility stages and government priority areas – in Kenya the focus is in geothermal power and in Ethiopia in hydropower.

Scaling up the solution would yield an emission reduction of 0.2 MtCO_2e in 2025 and 1.8 MtCO_2e in 2030 in Kenya and 1.3 MtCO_2e in 2025 and 2.8 MtCO_2e in 2030 in Ethiopia, as Figure 7 illustrates.

Figure 7: GHG abatement potential for solar power



5.3.4 Abatement costs

The cost of solar PV is reducing greatly in East Africa and the cost of diesel fluctuates on a rising trend annually. The price of solar power declined almost by half from USD/MWp 4.2 million in 2010 to USD/MWp 2.3 million in 2015 (IRENA, 2016) in East Africa. Other studies suggest that the cost shall further reduce to below USD/MWp 1.5 million by 2018. Kenya and Ethiopia are net importers of oil products even though oil exploration is in the rise and this situation is not likely to change until 2030. We thus apply a 18% learning rate of solar PV thus reducing the cost of generation while assuming a rising oil cost trend. In this instance McKinsey curve depicts a reduced abatement cost rate from EUR/tCO_2 20 to 9. And because of the rapidly falling cost of solar PV, we adopt the lower limit projection of 9 EUR/tCO_2e (USD/tCO_2e 11.25) in 2030. The total abatement costs for solar power are illustrated in Table 8 below.

Table 8: Solar power abatement cost

	Kenya	Ethiopia
Unit abatement cost (USD/tCO_2)	11.25	11.25
Total abatement cost (USD million)	15.3	35.3

5.3.5 Important enablers

Both Kenya and Ethiopia have high solar insolation, a daily average of 4–6 kWh per square meter, which is considered one of the best for solar power production in Sub-Saharan Africa.

The Kenyan solar policy framework is well-outlined. The feed-in tariff offers USD 0.12 per kWh for solar grid projects from 0.5 MW up to 100 MW. The Solar PV Regulations of 2012 provide guidance for sector products and requirements on services and capacity building.

The Government of Kenya has zero-rated the import duty and removed the value added tax (VAT) on renewable energy equipment and accessories. The prices of solar PV have reduced over time making them more affordable.

The main driver of solar power in Ethiopia is the scaling solar programme supported by International Financial Corporation and the World Bank. Through the program, the Ethiopia Electric Power will be supported in developing up to 500 MW of solar power by carrying out feasibility studies, securing an insurance facility for investors and designing tender guidelines for future solar auctions.

5.3.6 Possible barriers

The huge investment required especially for large-scale solar projects and the bureaucratic process of selling the power to the national grid are some of the challenges identified that discourage investments in the solar sector in Kenya. Moreover, the process of acquiring land for huge solar farms is tedious and solar product standards are still a challenge.

In Ethiopia, the main challenge is that solar plants are located far from the grid therefore transmission to consumers is a problem. A better coordination between land use planners and developers is of key importance.

5.3.7 Major co-benefits

Solar power has a positive impact on air quality and health. It provides an opportunity for a country to be energy secure. With a limitation of intermittent power supply, it is more reliable in the tropical than colder countries.

Reductions in prices of solar technology bring economic benefits to entrepreneurs and consumers. There are emerging mini-grids and micro solar PV solutions.

Food security is enhanced through solar powered irrigation. Many farmers in Kenya and Ethiopia are adopting small scale solar powered water pumps enhancing agricultural productivity and climate change adaptation.

5.3.8 Policy recommendations

Introduce government guarantees in Kenya, for example a letter of support so that investors are able to access funds for the various projects. Centralization of the various activities to ensure an easy way of selling the power to the grid will also encourage investment in the sector. Moreover, support by the government especially during a land acquisition process and clear compensation and relocation procedures for landowners and community will be key.

Provide incentives for large power consumers such as industries to establish industrial parks closer to the power production sites. This would play a key role in addressing the grid challenge in Ethiopia.

5.4 Combined heat and power in industry

5.4.1 Description of the solution

Combined heat and power (CHP) production provides heating for both industries and residential areas in Finland and Denmark. Jan Ivar Korsbakken and Borgar Aamaas (2016) report a high share of heat supplied by combined heat and power plants. Thermal power generation loses large amounts of energy as waste heat, from 40% in high efficient gas power plants to as much as 85% in waste burning and coal power plants. CHP offers the benefit of utilising this waste heat, thus reducing the need for burning additional fossil fuels solely to generate heat and avoiding additional CO_2 emissions.

The solution here is defined as CHP heating or pre-heating industrial processes. The degree of implementation is the share of total heating energy that is supplied by CHP.

The industrial segment in Kenya is classified as manufacturing. This constitutes manufacturing of food, beverage and tobacco and other manufacturing, repair and installation. This however does not form the entire manufacturing portfolio in Kenya. Other manufacturing, for example cement industries, are accounted for in the construction sector. In the computation, we classify manufacturing based on the economic reporting of the country as food, beverage and tobacco, cement and construction materials and other small-scale manufacturing. Similarly, in Ethiopia we take into consideration the pharmaceutical industry, beverage industry including sugarcane processing, cement and textiles. The sector demands about 60% of fossil and electrical energy in Kenya (The Swedish Trade and Investment Council, 2016).

There is no recorded data on CHP even though it is practised in a few manufacturing sectors, e.g. tea factories, sugarcane processing and cement factories. However, there is large potential for scaling up CHP in the industrial sector in both the countries. Based on the LEAP model and attribution of energy demand by GDP contribution, the industrial sector final thermal energy requirement is 35.8 petajoules in Kenya and 41.2 petajoules in Ethiopia in 2015. This is in the form of heat supplied by fossil fuel, wood and other biomass burning and excluding electric power.

5.4.2 Scale-up method and baseline

The Finnish case included four industries: paper and pulp industry, chemical, food and wood product industries. The average share of final heat input delivered by CHP was 29% (Korsbakken, J. I. & Aamaas, B., 2016).

Although there is no available data on CHP in industrial processes in the target countries, there are legal requirements for energy efficiency and waste heat recovery in industry. Several industries are increasingly adopting the technology in both Kenya and Ethiopia. In this respect, we adopt a conservative figure of global average of 2.3% (3.2% without electricity) and a marginal rise to 5% without electricity in 2030 for Kenya and 0% share for Ethiopia. As in the originating country, electricity is excluded in the scaling up because it is far more expensive than other sources of energy, therefore in most instances it is used for non-heating purposes. In the scale-up scenario, we attempt to achieve conservatively a third of what was achieved in Finland – an additional 9.7pp rise in the share of CHP. This implies that the share of CHP heat input in final heating energy demand is 11.97% for Kenya and 9.7% for Ethiopia. This is due to technological and financial factors and a willingness to change barriers as explained in subsequent chapters.

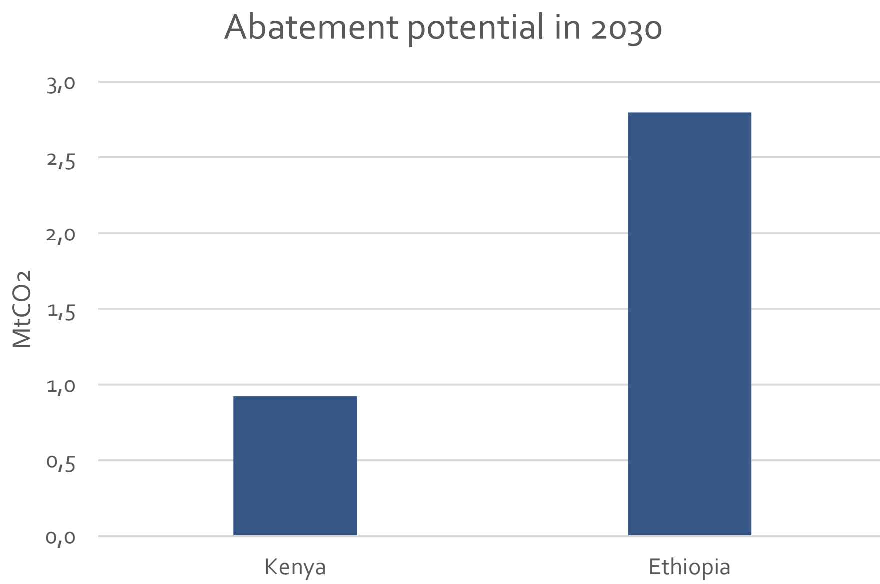
In the base year, the industrial sector contributes 3.2 $MtCO_2e$ and is forecast to contribute about 21.1 $MtCO_2e$ in 2030 in Ethiopia and 1.5 $MtCO_2e$ in 2015 and 3.9 $MtCO_2e$ in 2030 for Kenya.

5.4.3 Net abatement potential

The abatement potential results mainly from saving diesel, coal or residual fuel oil to generate the extra heat supplied by CHP. We model the abatement potential by estimating how much heating energy from other sources must be replaced by heat delivered from CHP. Assumption about what fuel type will be replaced with the CHP heat is dependent on cost. The cost of energy greatly contributes to final production cost and reduction of fuel cost in processing is most desirable. Residual fuel oil and diesel are the commonly used fuels in Kenya and Ethiopia for industrial heating. In 2015, the price of diesel ranged between USD 0.70 and 1.06 per litre whereas the price of residual fuel oil (RFO) ranged between USD 0.60 and 0.80. The model thus first reduces diesel requirement for heat energy input and then reduces RFO.

The LEAP tool multiplies the saving with the respective emission factors of fossil fuels saved. Thus the abatement potential for Kenya is 0.9 $MtCO_2e$ and 2.8 $MtCO_2e$ for Ethiopia in 2030, as Figure 8 illustrates. The high mitigation potential in Ethiopia in 2030 is attributed to the high average expected industrial GDP growth rate of 15.6% (Ethiopian Electric Power Cooperation, 2014).

Figure 8: Net abatement potential



5.4.4 *Abatement costs*

Abatement cost as a result of CHP will be a factor of investment into retrofits and/or complete replacement of old and inefficient technologies. Korsbakken and Aamaas (2016) assume an abatement cost of USD/tCO_2 -6.6 based on the McKinsey cost curve for retrofit and new building in the chemical industry. We adjust this abatement cost with the average purchasing power parity for Kenya and Ethiopia to USD/tCO_2e -2.574. We thus obtain a total abatement cost of USD -2.4 million and USD -7.2 million in Kenya and Ethiopia respectively.

5.4.5 *Important enablers*

Kenya's key enablers are tied to regulations and policies already in place. The draft energy bill of 2016 mandates that energy intensive industries must have energy audits carried out by an independent body and explores ways in which to reduce their energy consumption by promoting energy efficiency and conservation practices. Under the Kenya Association of Manufacturers and the Centre for Energy Efficiency and Conservation, industries are supported in carrying out energy audits and recommendations on processes that can be tapped to reduce energy consumption such as CHP retrofitting. This provides financial incentive for carrying out the audits. Further incentives emanate from the Energy Management Award, which is an annual event where companies with the best and most innovative ways of promoting energy efficiency in their operations are rewarded.

There is not as clear and elaborate a policy for industrial energy efficiency in Ethiopia as in Kenya. However, the Climate Resilience and Green Growth strategy introduces energy management and control systems that can aid in decreasing the energy demand. This raises an opportunity for other industries to take up practices that promote energy efficiency while increasing productivity.

5.4.6 Possible barriers

In Ethiopia, some of the challenges identified were existing systems being very rigid therefore hindering the incorporation of CHP, limited technological know-how at industrial level and lack of specific policy to scale up CHP in the various industries.

In Kenya, completely changing a whole system or integrating CHP systems into an already existing system is very expensive hence a major challenge. Moreover, carrying out energy audits that assess opportunities for integrating CHP on existing systems is expensive and time consuming.

5.4.7 Major co-benefits

In both Kenya and Ethiopia, CHP reduces energy need and therefore replaces imported fuels and balances foreign trade. There are environmental benefits as it is an environmentally friendly way of disposing of heat and other wastes.

In Ethiopia, benefits include cost savings due to heat that would have otherwise been lost and promoting innovation due to the engineering processes that come with such systems.

5.4.8 Policy recommendations

Formulate policies that specify minimum energy requirements for different consumers. Finance activities that promote energy conservation and incentives supporting retrofitting such as tax holidays, loans among others in Ethiopia.

Provide government support in Kenya in the form of incentives to industries to aid them to carry out energy audits and also retrofitting. There are programmes supporting the same under the Kenya Association of Manufacturers. However, more can be done to support many industries including capacity building, research and linking local manufacturing industries to technology providers. There is also a need to strengthen the enforcement and compliance mechanisms.

6. Transport sector solutions

6.1 Cycling in cities

6.1.1 Description of the solution

Danes living in urban areas cycle 2.8 kilometre per day on an average – one of the highest numbers in the world. The majority of this is in cities/urban areas facilitated by infrastructure policies. The policies focus on urban planning and transport that favours cycling.

Whereas non-motorised transport has a high potential for GHG abatement, it has not been given serious thought in Ethiopia and Kenya. Nuriye (2014) describe it as economically feasible, environmentally less damaging and socially inclusive (Nuriye, Jafri, & Asfaw, 2014). Using the case example of Hawassa city south of Addis Ababa – a rapidly growing urban centre, where cycling and walking were the main modes of transportation – the problems associated with walking and cycling are related to failures in city planning to ensure the provision of necessary cycling facilities. Most road network design focuses on motorised transport systems.

Nonetheless, non-motorised transport has been linked to mass transit systems in the Kenya national climate change action plan (KNCCAP) as a starting point for the development of bicycle lanes and pavements alongside transit lanes (GoK, 2013). The only known non-motorised policy in East Africa is the Nairobi City County Government (2015) policy. The policy seeks to increase the cyclist modal share from 2% to 10% in 2025 through the construction of dedicated cycling lanes, bicycle parking, security of cyclists, and innovative upscaling including, bicycle hire ventures, connection mode to city centre from mass transport terminals and dedicated cycling neighbourhoods.

6.1.2 Scale-up method and baseline

We do not have any data for Ethiopia so we use the Nairobi County Government Policy to build the scaling up methodology. The Nairobi City County Government (2015) non-motorized policy identifies that about 2% of Nairobi city population cycle to work, 41%, 12% and 46% uses public transport, private cars and walk to work daily respectively. We assume this as a homogeneous trend in the major cities in Kenya and Ethiopia. Adopting a 30% share of people biking is too ambitious in the two growing economies, so we implement a 10% target described in the NMT policy for Nairobi city. The implementation is delayed for 3 years as it takes time to implement changes in infrastructure and legislation to support city cycling.

6.1.3 Net abatement potential

The GHG abatement was determined by the final energy requirement saved by replacing motorised transport with city cycling. LEAP uses urban population growth to extrapolate total passenger kilometres covered in 2030 but freezes the share of modal split. Although modal shift can happen in many directions – walking to cycling, cycling to using public transport and private cars users to cycling – we make an assumption that the 10% share of cyclists comes from those currently using public transport. We thus compute the final energy demand in the business-as-usual scenario (only 2% total passenger kilometres covered by cyclist and 98% by motorist) and the biking scenario where 10% share of total passenger kilometres are covered by cycling and 90% share by motorist. The model computes petrol and diesel saved and multiplies by the CO_2 emission factor to yield net abatement.

From the model net abatement potential was determined to be 2.8 MtCO_2 in Kenya and 1.9 MtCO_2 in Ethiopia.

6.1.4 Abatement costs

The McKinsey global abatement cost curve does not include any solution similar to this solution (McKinsey&Company, 2009). Whereas we keep the assumptions from the Nordic Green to Scale technical report (Korsbakken & Aamaas, 2016) on estimating the abatement cost, we adjust the costs using purchase power parity ratio for Kenya and Ethiopia. We make a simplistic estimate of calculation made in the technical report by adjusting the abatement cost of USD/tCO_2e -42 in 2030 by a quarter (Table 9) which yields an abatement cost of USD -45.1 million for Kenya and USD -31.1 million for Ethiopia.

Table 9: Abatement cost for city biking

	Kenya	Ethiopia
Unit abatement cost (USD/tCO_2)	-16.34	-16.34
Total abatement cost (USD million)	-45.1	-31.1

6.1.5 Important enablers

The Integrated National Transport Policy of 2012 acknowledges in Kenya the need for Non-Motorized Transport (NMT), which includes walking, cycling and cart pushing, in addressing the needs of the majority of the poor. The policy further recognizes the biased nature of the transport policy that only focused on motorized transport at the expense of NMT therefore marginalizing the NMT users. It proposes ways in which NMT infrastructures can be integrated into the existing and new motorized transport infrastructures. The Nairobi Metropolitan Area Transport Authority (NaMATA) was established to support the establishment of the Bus Rapid Transport and the Non-Motorized Transport systems in Nairobi and surrounding counties such as Murang'a, Narok, Machakos and Kiambu. This is the key driver in supporting cycling activities in

Nairobi and the surrounding areas. Further, the development of the NMT policy for Nairobi is also critical in supporting cycling activities with various initiatives underway that will integrate NMT infrastructure in major roads in Nairobi.

Despite there not being any programme to support the development of cycling in Ethiopia, the GTP II and the CGRE offer opportunities for scaling up the use of cycling as a sustainable mode of transport in Ethiopian cities. The Road Sector Development Programme can also support cycling by integrating bicycle lanes and pedestrian walkways during the ongoing road network expansion projects. Capitalizing on towns such as Hawasa that is known for its culture of cycling can be targeted as it grows to integrate bicycle lanes. Moreover, the ongoing expansion in buildings within the various cities in Ethiopia can support cycling infrastructure e.g. bike parking spaces/stands. Furthermore, the Ethiopian Cities Sustainable Prosperity Initiative can play an important role in promoting cycling activities.

6.1.6 Possible barriers

Both Kenya and Ethiopia reported similar challenges that hinder cycling in cities. These include lack of collaboration during designing, planning and implementation of projects among various ministries, existing city plans especially in Addis Ababa and Nairobi being unfriendly to cycling and right of way challenges among motorized and non-motorized road users. Moreover, in Kenya, cycling is considered a poor-man's means of transport or a leisure activity. For example, in both Nairobi and Addis Ababa, the on-going road expansion projects have only included pedestrian walks and lack cycling lanes.

6.1.7 Major co-benefits

Cycling is associated with health benefits accrued from the peddling exercise. In terms of environmental benefits, there is a reduction in the number of vehicles therefore reduced air pollution. Economically, the cycling industry boom can also contribute to job opportunities and also reduce dependence on imported fossil fuels.

6.1.8 Policy recommendations

Establish institutional structures to support and mainstream activities between the various ministries. Integrating the various road users' needs during the design and implementation of various infrastructure projects is key.

Introduce people to the benefits of cycling and promoting behaviour change, especially in Kenya where cycling is perceived negatively.

7. Solutions for buildings and households

7.1 Energy efficiency in buildings

7.1.1 Description of the solution

This solution covers the Mexican case of improving energy efficiency in buildings. Measures include solar water heaters, replacing inefficient lighting with compact fluorescent and LED lamps, improving appliance efficiency, green mortgages water saving faucets and thermal insulations (Afanador, A. et al., 2015).

Kenya and Ethiopia are in the tropics but with an annual average temperature of 23 °C. As such both country's building envelope is a simplified stone/block construction with a minimal insulation layer. Internal temperature control is often by opening of windows and ventilation systems. Thus, the main areas of energy consumption in the buildings are the plug-ins (refrigeration, television, radio, battery charging), lighting system and heat, ventilation and air conditioning (HVAC). Whereas water heating is a growing high consumer of electricity, government regulations such as the energy, solar water heater regulation (2012) in Kenya requires every premise consuming more than 100 litres of hot water to adopt roof top solar water heaters (ERC, 2012). Furthermore, new building regulation requires appropriate architectural design that allows maximum natural lighting and sufficient air flow. Other energy efficiency measures for the residential sector by the governments include: energy efficient lighting, consumer education and awareness creation and standards and the labelling of home appliances.

Ethiopia has no legislation or mandate in place to incentivise utilities or public entities to invest in energy efficiency. Ethiopian Electric Utility has made an effort to increase efficiency among its consumers. This is through their demand side management programme where industries are required to maintain a power factor above 0.9 of inductive loads. Lower power factors attract heavy penalties. The programme has also distributed about 5 million compact fluorescent lamps to replace incandescent lamps. In support of the program, the government also banned the importation of incandescent lamps (Climate Innovation Center, Ethiopia, n.d.).

7.1.2 Scale-up methods and baseline

In scaling up, we focus on improving the energy efficiency of residential buildings. More houses are increasingly adopting compact fluorescent lamps (CFL) as a result of forced regulation – such as a ban on importing incandescent bulbs – as in Ethiopia or arising from behaviour change.

In the business-as-usual scenario, Ethiopia electricity connection will grow to 80% in rural areas from the base-year level of 8%. 100% of households connected to grid will use electricity for lighting and the share of household using fluorescent bulbs will only grow from just about 1% to 5% in 2030. The assumption is that the national regulations are not fully implemented. In the energy efficient buildings scenario, 30% share of households in both rural and urban household will adopt CFLs. The implementation of standards and labels equally achieve the adoption of more efficient appliances thus annually reducing final energy intensity at a rate of (-1.5%).

Similarly, in Kenya, 70% of the rural households will be electrified in 2030 from 14% in 2015. The majority of households still rely on incandescent lamps and inefficient appliances. The government policy will enhance the adoption of efficient appliances in 2030. The model assumes a 30% share of households connected to electricity in both rural and urban areas using efficient CFLs and appliances. The gradual decrease in final energy intensity from the plugins is -1.5% per year.

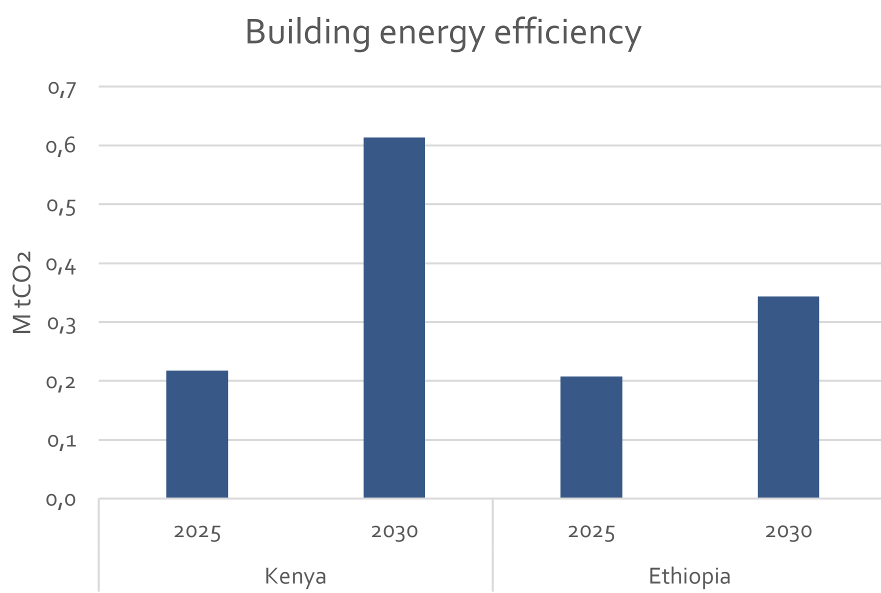
Electricity consumption per capita in Kenya is 166 kWh/year. In its vision 2030 this is projected to grow to 1,800 kWh/year per household. We recognise the ambitious government development plan and expected increase in energy use, but historically energy consumption per capita has increased on average only 3%. In the baseline we assume conservatively that the per capita energy use grows at the same rate as the GDP and the share of efficient lighting increases from 1.4% to 5%.

The solution energy efficiency in buildings seek to reduce electricity demand in the residential sector. We apply electricity specific factors – 0.119 tCO_2/MWh for Ethiopia and 0.332 tCO_2/MWh for Kenya – to obtain abatement potential.

7.1.3 Net abatement potential

The abatement potential is calculated from the energy saved multiplied by the electricity specific emission factor. Total energy saved in the residential sector is 2,889 GWh and 1,786 GWh for Ethiopia and Kenya respectively by 2030. The abatement potential for Kenya is 0.6 $MtCO_2$ in 2030 and 0.3 M tCO_2 for Ethiopia in 2030, as Figure 9 illustrates.

Figure 9: Abatement potential for Kenya and Ethiopia



7.1.4 Abatement costs

From the McKinsey curve, the global abatement cost for residential appliance efficiency is EUR/tCO_2 -66 and for switching from incandescent light bulbs to LEDs is EUR/tCO_2 -93 (McKinsey&Company, 2009). Ecofys (2015) report that global abatement costs for building efficiency range between USD/tCO_2 -73 and -15 in 2030. Therefore, considering the investment cost we use a conservative highest limit of USD/tCO_2 -15. Adjusting this cost on purchasing power parity of Kenya and Ethiopia we obtain USD/tCO_2 -13.4. Then the total abatement cost in 2030 is USD -8.2 million for Kenya and USD -4.6 million for Ethiopia.

7.1.5 Important enablers

The Ethiopian Cities Prosperity Initiative can support the development of energy efficient buildings in cities. The initiative recognizes the need for making the various cities in Ethiopia green, resilient and well governed and thus can be a driver for the various activities on building efficiency. In addition, the ongoing second urban local government development programme that focuses on cities can integrate building efficiency in their activities and plans. At the household level, the CRGE plan has listed accelerating high efficiency light builds for residential, commercial and institutional builds as a key activity under the building sector.

In Kenya, the support for promoting energy efficiency in buildings has been mainly through government legislation including the Energy Act of 2006, which has been revised and there is a draft energy bill 2016. The Bill promotes the use of appliances or equipment that conform to minimum energy efficiency performance standards. These include energy saving bulbs and household appliances that are energy efficient.

Standards and labelling regulation are expected to reduce the use of inefficient appliances. The Government has gone further to stop the importation of appliances that do not meet the minimum energy efficiency standards. This includes incandescent light bulbs, with outlets being given a window to exhaust the existing stock of non-compliant appliances or equipment.

7.1.6 Possible barriers

In both Ethiopia and Kenya, poor compliance and implementation of building codes and standards stipulated in the building proclamation were reported as major challenges. There was also lack of awareness among consumers and contractors on the kind of appliances t and energy efficiency practices o use to reduce their energy consumption. Moreover, installing energy efficient technologies is expensive therefore consumers opt for cheap yet inefficient options. Both countries reported low quality appliances and even counterfeit goods, which denies the user value for money and the achievement of the intended benefits.

7.1.7 Major co-benefits

Cost savings in energy bills will bring along reduced energy poverty. Decrease in electricity consumption of houses significantly benefit the electricity system in general and can result in a more resilient grid. The reduced demand for energy leads to a greater security of energy supply.

7.1.8 Policy recommendations

Enforce the various regulations related to energy efficiency in building and providing incentives that will encourage more consumers to adopt the various energy conservation practices in both Kenya and Ethiopia.

Allocate financial resources to awareness campaigns on the various practices and energy efficient technologies for buildings.

Put in place in both countries specific compliance and enforcement mechanisms to allow only high-quality energy efficient equipment in the market.

7.2 Improved cook stoves

7.2.1 Description of the solution

China's improved cook stoves (ICS) distribution is considered a success, with around 90% of households having access to cooking and heating stoves with at least some improved efficiency and emission features today. The direct cost of purchasing and installing the stoves was mostly borne by households and only subsidized marginally by the government. In addition, the governmental subsidization system was tailored according to the different needs of provinces, allowing the system high flexibility and efficiency in expenditure. Instead of fully subsidizing improved stoves, the government spent most funding on R&D, training, product demonstration and public outreach. As a result, the majority of the programme's costs were contributed by households themselves, followed by local governments. National funds were mainly used for co-ordination, promotion and R&D activities. An educational campaign eased public anxiety about using new products. The investment in R&D and training laid the foundation for the successful implementation.

For this solution we analyse the change in the adoption of improved cook stoves in Kenya and Ethiopia. In the baseline year, 39% of total households are urban and 61% rural in Kenya (KNBS, 2009, 2017). About 94% of total households were electrified in cities and 14% on the countryside. The main energy sources for cooking are charcoal and wood. About 27% of urban households in Kenya use charcoal whereas 17.2% use firewood either in improved or traditional stoves. Kerosene accounts for 26.6% and LPG 24.5%. In rural areas, 84.2% of households use firewood and 9.7% use charcoal. In Ethiopia, 24% of households are in urban centres, the urbanisation rate is expected to grow to 34% in 2030 based on current urban population growth rate. In urban areas, about 65% of households use firewood and 17.5% use charcoal for cooking, whereas in rural areas, over 90% of households rely on firewood.

7.2.2 Scale-up method and baseline

In scaling up we seek to adopt an aggressive promotion of improved cook stoves through government and civil society efforts to match the China adoption rate of 90%.

There is limited information on firewood and charcoal conversion technology shares. However using limited literature references, in Ethiopia, about 57% of rural and 45% of urban households still use a traditional three stone fire for cooking – mainly for wood conversion. This can be interpreted as 43% of the rural population using firewood as an energy source have already adopted some improved cook stoves such as mud wood stove or modern efficient stoves such as envirofit, and 55% of the urban population have adopted some forms of improved firewood stove.

There is no such technology segregation description for charcoal use in both countries. In this case we use the deployment share of 26% of improved cookstoves in Sub-Saharan Africa (Afanador et al., 2015) for both Ethiopia and Kenya charcoal ICS and freeze the share to 2030.

Using LEAP tool, we assign an improved cook stove with 26% share of the fuel type. For example in Kenya, 17.2% of urban households use firewood and 26% of 17.2% is 4.5%. In the model, we re-assign the share distribution in the base year as 4.5% of urban households using improved wood stoves and 12.7% of urban households still relying on traditional firewood stoves. Scaling up the solution thus seeks to replace 90% of the 12.7% share of households that still rely on traditional firewood stoves in 2030, hence only 1.27% share of household will be relying on wood in Kenya urban areas and 15.9% adopt improved firewood stoves in 2030. This process applies to all biomass fuel types in Kenya and Ethiopia.

7.2.3 Net abatement potential

The abatement potential is calculated from the energy saving achieved multiplied by the emission factor of the biomass conversion technology. The emission reduction potential in 2030 is 0.3 $MtCO_2e$ for Kenya and 1.5 $MtCO_2e$ for Ethiopia – one of the smaller potentials in this study. Whereas replacing inefficient cook stoves with efficient cook stoves is rewarding, the rising population rapidly continue to degrade forest for firewood and charcoal.

7.2.4 Abatement costs

The purchasing power in Kenya and Ethiopia is much lower than in China and the cost of investment in improved cook stove technologies is equally high. We thus apply a conservative abatement cost of USD/tCO_2e 8 (Afanador et al., 2015). The abatement cost in 2030 will therefore be USD 2.1 million and USD 12.4 million in Kenya and Ethiopia respectively.

7.2.5 Important enablers

The key driver for improved cookstoves in Ethiopia and Kenya is the National Improved Cookstove Programme designed to contribute to the implementation of the countries' improved cookstoves distribution plan. This is through building a sustainable and vibrant market for improved cook stoves and building institutional capacity at all levels.

The programme addresses both the supply and demand side of the market, including among others: capacity building support for the government and private sector operators (producers and distributors), saving and credit service providers among others on the one hand, and customer support (credit services), awareness creation and promotion on the other.

Various plans, such as the Growth and Transformation Plan II, renewable energy efficiency plan and climate resilient green economy strategy support activities related to improved cookstoves. Further, there are several Payments for Ecosystem Services (PES) and Reducing Emissions through Deforestation and Degradation (REDD) programmes whose activities include the distribution of improved cookstoves to households.

7.2.6 Possible barriers

In Ethiopia's case, there was lack of data on the distribution of improved cookstoves. That is why it was a challenge for the government, through their national cookstove programme, to determine the adoption rate. Moreover, due to the lack of data, it is difficult for the programme to monitor, report and verify the various impacts of the programme.

In Kenya, the sustained use of these cookstoves is a challenge because households purchase or are given the stoves for free yet they stop using them after some time.

In both Kenya and Ethiopia, quality certification is a challenge as there are limited procedures for all improved cookstoves and no testing facilities to certify that the cookstoves being distributed are of accepted quality.

7.2.7 Major co-benefits

In Ethiopia, improved cookstoves are associated with various benefits such as reduced deforestation, health benefits, expenses reduction, reduced drudgery and empowerment for women and children. Moreover, it is an opportunity to create jobs for those involved along the improved cookstove value chain and to promote industrial development for locally manufactured cookstoves.

Similarly, in Kenya, improved cookstoves offer a clean cooking solution for households, health and time benefits for women and children who spent most of their time collecting firewood and cooking and offers disposable income due to reduced expenditure on fuel. Furthermore, the improved cookstoves sector has created jobs for women, men and the youth who have been trained and are involved along its value chain. Local industries that manufacture cookstoves have also been established, promoting local industrial development.

7.2.8 Policy recommendations

Establish structures that will support the collection of data related to cook stoves and provide guidelines on monitoring, reporting and verifying the impacts of a cook stove programme in Ethiopia.

Establish standards for the various improved cook stoves in the Kenyan and Ethiopian market. This should be followed by allocating resources to establish testing facilities to ensure that cook stoves in the market are of accepted quality.

Commission research to understand the needs of the users at the household level and incorporate these needs during the design phase of the cook stoves to promote the sustained use of these technologies.

Enhance financial incentives to promote investments and create awareness in the clean cooking sector.

8. Agriculture and forestry sector solutions

8.1 Reduced deforestation

In the East Africa region, Uganda and Tanzania have the highest deforestation rates. Kenya started its reforestation program already in 2000. Ethiopia suffered deforestation of above 2% until 2010 when it achieved a steady afforestation rate. As the forest area is growing in the target countries, scaling up the Brazilian case would not deliver emission reductions.

Whereas the two countries have active afforestation programs, there are great lessons that could be shared from the Brazilian case to further enhance them.

8.1.1 Description of the solution

The Brazilian government has since 2004 implemented a national plan to reduce deforestation at both federal and state level. The action plan has three elements a) territorial and land-use planning, b) environmental control and monitoring, and c) fostering sustainable production activities. The implementation of the action plan was done through a set of policies: the enforcement of dedicated laws to punish illegal deforestation and clarify land owning rules, interventions in soy and beef supply chains to increase transparency on the origin of goods, restrictions on access to credit and the expansion of protected areas.

Land deforestation and degradation in Kenya and Ethiopia was great between 1990 and 2010. In Kenya, deforestation rate was 2.8% per year (1,320 square kilometres) between 1990 and 2000 when afforestation programme started. In Ethiopia, the deforestation rate between 1990 and 2010 was 1% per year (1,530 square kilometres). The trend changed in Kenya in 2000 and in Ethiopia in 2010 when larger afforestation efforts began (Figure 10 and 11).

Figure 10: Observed and projected forest cover as share of land area in Kenya (adopted from FAOstat)

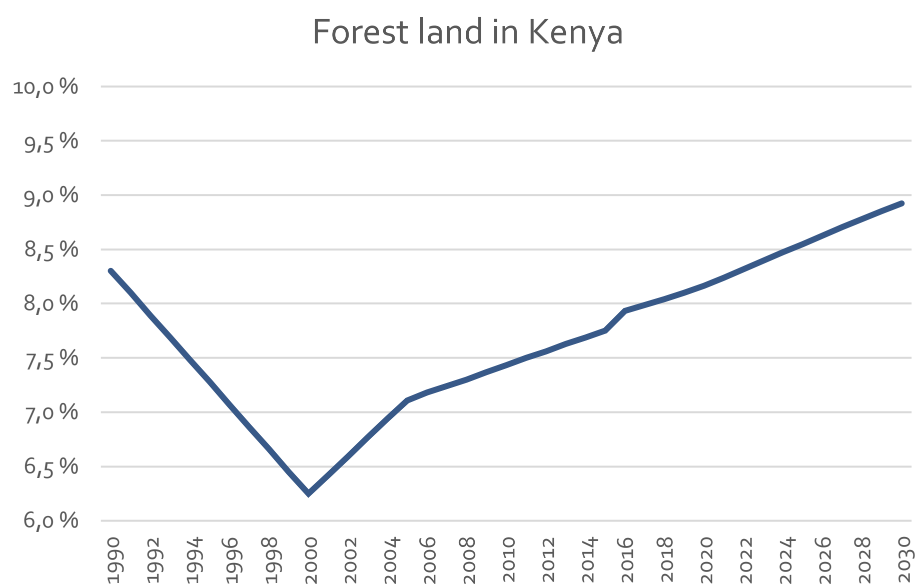
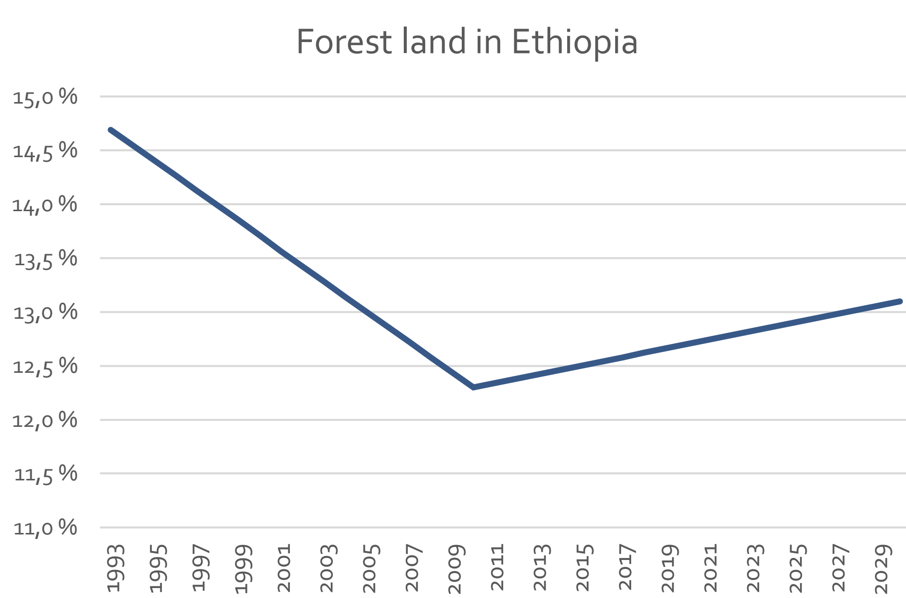


Figure 11: Observed and projected forest cover as share of land area in Ethiopia (adopted from FAOSTAT)



Kenya and Ethiopia both have growing forest cover. The Kenyan reforestation programme started way back in 1996 with the development of the Kenya forest master plan (Luukkanen, 1996). It proposed urgent studies on new patterns of forestry administration which would put an end to deforestation and improve forest management in Kenya. Farm forestry and government owned forests were main outcomes that brought change in the Kenya deforestation profile. Studies highlight that the farm forestry evolved from the successful project, "miti mingi shambani" in the early 1990s which resulted in the overall volume of trees planted by farmers equalling the indigenous forest and forest plantation all together (Keskinen & Broberg, 2004). The aim of the project was to improve the ecosystem in tropical forests. The recent national forest programme 2016–2030 is to develop and sustainably manage, conserve and utilise forests for socioeconomic growth and climate resilience (MoENR, 2016). Amongst the key messages in the national forest programme are a 10% increase in forest cover, increase in food, water and energy security, increased community participation in forest development, good governance, reduced bureaucracy and increased transparency. The eight thematic focuses in the national forest plan are: forest productivity, governance, natural forest management and conservation, forest for water, forest for energy, forestry education and training, forest and climate change and forest financing. Implementation of the eight thematic areas would see Kenya realise sustained growth of forest cover as demonstrated in Figure 10 above.

Ethiopia's bid to transform the forestry sector is based on the implementation of forest landscape restoration. This is a global initiative for the improving resilience of land and communities in the face of increasing environmental degradation through different activities. Ethiopia made a voluntary commitment to restore 15 million ha of degraded forest land (Pistorius, Carodenuto, & Wathum, 2017). The commitment aligns with the aim of transitioning towards a climate resilient green economy with zero net greenhouse gas emission and corresponding plans for large scale afforestation and re-afforestation. Key measures adopted include: afforestation and reforestation, enrichment planting, forest protection, wood land management through the protection of over grazing and area enclosure, and community participation in the restoration of vulnerable land.

8.2 Afforestation and reforestation

8.2.1 Description of the solution

Costa Rica adopted a mix of economic and regulatory policies to protect and expand its forests using the Payment for Ecosystem Services (PES) programme, which was enacted in 1996. It has a two-fold objective to increase the generation of ecosystem services while reducing poverty. To achieve this, PES gives monetary payments to land owners who maintain forest and agroforestry plantations, which provide environmental services. The PES programme has five modalities for the use of private land: 1) forest protection, 2) commercial reforestation, 3) agroforestry, 4) sustainable forest management, and 5) regeneration of degraded areas. Since the start of the programme, nearly one million hectares of forest in Costa Rica have been part of PES. Tt aims mainly at supporting afforestation and reforestation. The forest cover in Costa Rica in 1950 was 70% of land area. Deforestation saw the forest cover declining by

22 percentage points to only 48% in 1996. The PES initiative resulted in afforestation between 1996 and 2013 yielding a 53% share of forests.

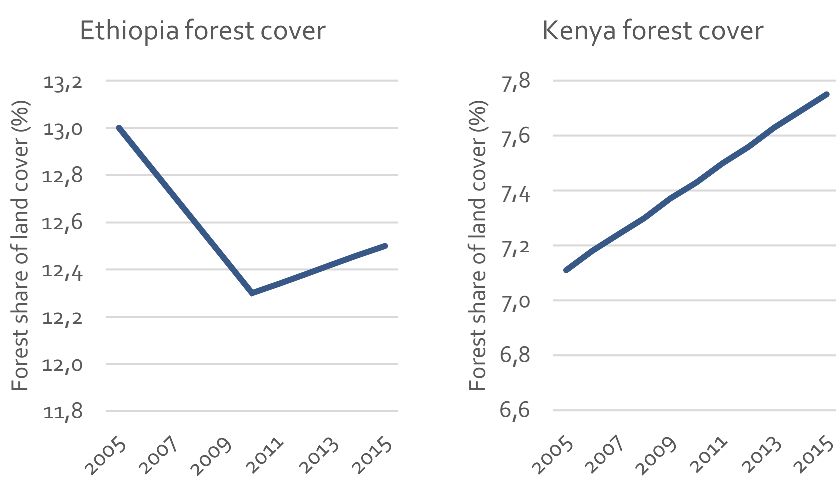
Kenya's and Ethiopia's geographical location limits the highest possible level of reforestation and afforestation that could be possibly achieved. The two countries are more arid and semi-arid than Costa Rica. In Ethiopia the forest cover in 1990 was 15.2% and in Kenya 8.3%. The Ethiopia forest cover declined to 12.3% in 2010, started a rising trend and by 2015 had reached 12.5% with an average growth rate of 0.32% annually. Similarly, the Kenya forest cover in 1990 was 8.3%, declined to 6.25% in 2000 and reached 7.75% by 2015.

8.2.2 Scale-up method and baseline

The scaling up considered the increase in forest cover with similar growth rate as in Costa Rica. To achieve a 53% share of forests in Costa Rica, an average annual growth rate of 0.31% was maintained between 1996 and 2013.

Based on FAOSTAT data, the forest cover in Ethiopia and Kenya is increasing (Figure 12). The growth rate has been 0.32% and 0.85% for Ethiopia and Kenya respectively in 2010–2015. We consider this growth as business as usual.

Figure 12: Forest cover as share of total land area in Ethiopia and Kenya in the last 10 years



To achieve the Costa Rican rate of afforestation, a growth rate of 0.31% needs to be maintained above the business as usual scenario in both Kenya and Ethiopia. We thus forecast the BAU to 2030 based on the historic growth trend and extrapolate the scaling up scenario with a total annual growth of 0.63% for Ethiopia and 1.18% for Kenya.

Figure 13: Projected increase in forest cover in Ethiopia

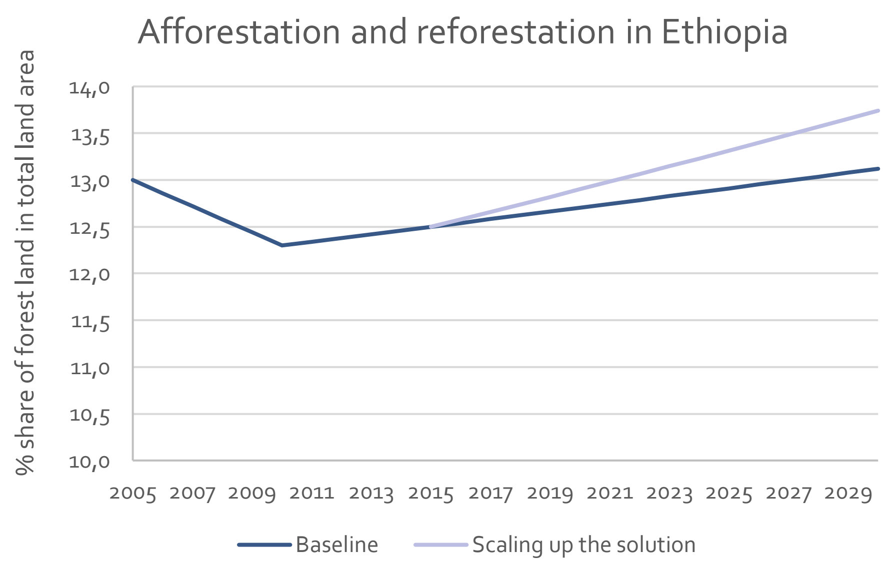
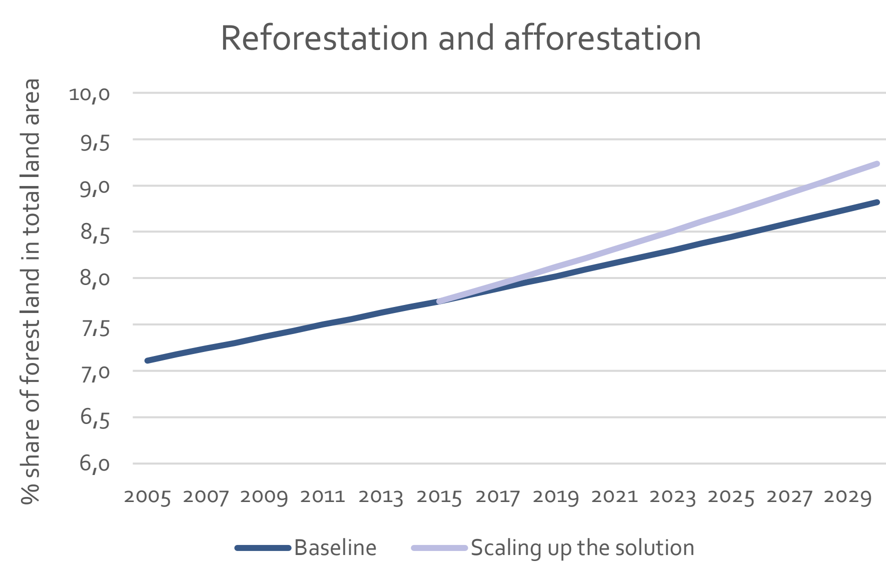


Figure 14: Projected increase in forest cover in Kenya

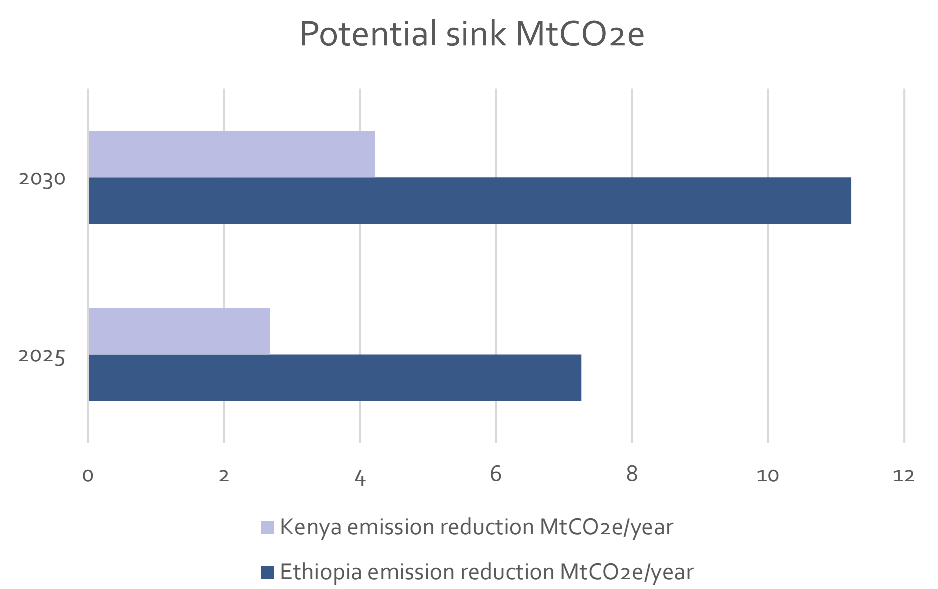


Figures 13 and 14 above show increased growth in forest cover in the implementation of the Costa Rican case, achieving a 0.31% growth rate above the business as usual scenario. By 2030, the share of forest cover in Kenya would rise to 9.24% in the scale-up scenario against 8.82% in the business as usual scenario. In Ethiopia forest land would rise to 13.74% in the scaling up scenario against 13.12% in the business as usual scenario. This would result in an afforested area of 0.22 million hectares in Kenya and 0.64 million hectares in Ethiopia in 2030.

8.2.3 *Net abatement potential*

The carbon stored in forests is quite complex to establish. IPCC AR4 estimates the carbon sink between 1 and 35 tCO_2/ha, depending on the type of the forest. In Kenya and Ethiopia, forestation faces high uncertainties as a result of climate impacts such as prolonged drought. In addition, the sustainability of an afforestation programme in private land is influenced by demand for wood. To reflect these uncertainties, we use half of the maximum in the literature and apply 17.5 tCO_2/ha. The resulting abatement potential is illustrated in Figure 15 below.

Figure 15: Carbon sink potential in Kenya and Ethiopia



8.2.4 *Abatement costs*

The abatement cost as suggested by the McKinsey cost curve is EUR/tCO_2 13.5 for pasture land afforestation and EUR/tCO_2 15 for degraded forest reforestation. We adopt an average of EUR/tCO_2 14. We adjust the figure based on PPP since the cost element is mainly labour, which translates to USD/tCO_2 6.14.

Table 10: Abatement cost

	Kenya	Ethiopia
Unit abatement cost (USD/ tCO_2)	6.14	6.14
Total abatement cost (USD million)	24.0	68.9

8.2.5 Important enablers

The forest cover in Kenya is estimated to be about 6%. Increasing forest cover to 10% is a requirement under the Constitution. To promote afforestation and reforestation, Kenya is a signatory to global initiatives like Bonn Challenge, New York Declaration on Forest and Afri100. Under Afri100, the country is committed to restore 5.1 million hectares by 2030. The Ministry of Environment and Natural Resources management have mapped all areas that will be restored under this initiative such as along roads, rails and rivers including assessing tree species and vegetation suitability.

The Kenya Forest Service (KFS) and a local bank have piloted a Tree Fund initiative in order to provide incentives for farmers to grow trees. KFS have 150 forest stations to support forest extension work. Under the REDD initiative, the country is working on establishing a National Forestry Monitoring System and information system. Through practices like participatory forest management (PFM), Kenya is promoting afforestation. Community engagement through establishing Community Forest Associations (CFAs) is also promoting afforestation and reforestation.

There are a number of private investments in the forest sector with others expected to come on board. This sort of investment is expected to complement government efforts.

In Ethiopia, The Climate Resilient Green Economy strategy is one of the main documents that will drive the promotion of afforestation and reforestation. The activities under the strategy are to plant 2 million ha of forests in areas where they were non-existent and up to 1 million ha of forest in areas that were previously covered by forests. Other drivers of afforestation and reforestation activities will be under the cook stove program, PES programmes and REDD projects that encourage woodlot establishment and forest conservation activities. The Ministry of Environment and Forestry second round GTP plan also includes activities to support plantation forests and agroforestry practices that will enhance afforestation and reforestation.

8.2.6 Possible barriers

In Ethiopia, land tenure issues, competition for land due to population increase and lack of finances to support the various afforestation, reforestation and deforestation reduction activities were reported as some of the challenges. Moreover, due to the limited nature of finances, sustainability of such initiatives was compromised. Furthermore, communities around the various initiatives lacked knowledge of the full benefits of conserving the forest, with incentives from CDM, PES and REDD programmes considered being not substantiated.

In Kenya, there is immense competition for forestland as priority is given to agricultural land. At the project level, most of the projects supporting afforestation and reforestation activities do not consider post-planting practices during their planning phase hence there are low survival rates of the trees. At the management level, there is poor enforcement of forest management policies mainly due to lack of adequate allocation of resources such as patrol vehicles and personnel to support the enforcement of these policies. As a business, financing forest activities is not considered attractive therefore hindering access to finance facilities to support such activities.

8.2.7 *Major co-benefits*

In both Kenya and Ethiopia, afforestation, reforestation and deforestation reduction programmes were reported to have various benefits such as energy generation for the local communities, job creation for those involved in seedlings planting and timber selling, carbon financing and other environmental benefits like reduced soil siltation and biodiversity conservation.

8.2.8 *Policy recommendations*

Establish long-term financing mechanisms from both private and public sectors to support the various afforestation, reforestation and deforestation reduction activities that promote the sustainability of such ventures. This could be done by payment for ecosystem services (PES) derived from the environment. The motivational approach is an incentive for the communities to conserve the forests.

Establish policies and institutional frameworks that address the land tenure issues, forest management challenges and benefit sharing among the various actors so that they combine efforts in conserving the forests. Moreover, strict enforcement of the policies will be key through allocating adequate resources needed to support policy enforcement.

8.3 Low-carbon agriculture

8.3.1 *Description of the solution*

Brazil's Low-Carbon Agriculture Programme, also referred to as the ABC-Plan (Programma Agricultura de Baixo Carbono), was started in 2010 to tackle the country's second largest source of GHG emissions: agriculture. The aim of the programme is to "promote the adoption of sustainable agricultural systems and practices that at the same time reduce GHG emissions, whilst improving the efficiency and resilience of rural communities and agricultural activities". The programme encourages six activities through offering farmers attractive lines of credit, and these include:

1. No-till agriculture;
2. Rehabilitation of degraded pastures;
3. Integrated crop-livestock-forest systems;
4. Planting of commercial forest;
5. Biological nitrogen fixation to reduce N-fertilizer use; and
6. Animal waste treatment.

Ethiopia's low-carbon objective under the climate resilience strategy seeks to improve crop and livestock production practices for high food security and farmer income while reducing emissions. The sector contributes 40% of GDP, 80% of employment and 50% of national GHG emissions (about 75 $MtCO_2e$). Also in Kenya agriculture is key to the economy, contributing 26% of GDP directly and another 27% indirectly through linkages with other sectors. The sector employs more than 40% of the total population and more than 70% of Kenya's rural people. It contributes about 30 $MtCO_2e$ and is projected to contribute 35 $MtCO_2e$ in 2030.

The government of Kenya has been employing different mechanisms to reduce emissions from agriculture, such as reducing pressure on current arable land and increasing productivity, reducing use of chemical fertilizer and promoting livestock productivity. Existence of effective policies in the agriculture sector is key driver to low-carbon agriculture. Kenya Climate Smart Agriculture Framework (2017–2022) provides guidance as to how Kenya can increase its productivity with minimum emissions. Others include National Land Use Policy, National Adaptation Plan, National Climate Change Action Plan and National Livestock Policy.

Ethiopia has envisaged the following activities:

1. Increasing productivity rather than the herd of cattle and size of land;
2. Agricultural intensification by improved inputs;
3. Reclamation of degraded land through irrigation;
4. Reduced nitrogen fertilizer application through promotion of nitrogen fixation crops; and
5. Reduced re-introduction of crop residue.

8.3.2 Scale-up method and baseline

The Brazilian case yielded a reduction of 8% in final agricultural GHG emissions. We seek to achieve the same 8% reduction in final agricultural emissions reduction through:

- Increased productivity of animals thus reducing the number of cattle;
- Anaerobic waste treatment and CH_4 capture.

We use IPCC emission factors and approved methodology for estimating emissions and FAO statistics for projections to 2030. Specifically we look at three main emission streams under production intensification:

- Enteric fermentation in dairy and non-dairy cattle;
- Manure left on farm; and
- Anaerobic waste treatment and methane capture.

The study covers both dairy and non-dairy cattle. In Kenya, there were 5.4 million dairy cattle and 14.6 million non-dairy cattle in 2015 with an annual average growth rate of 1.0% and 8% respectively. In Ethiopia, there were 13.6 million dairy cattle and 45.3 million non-dairy cattle with an annual average growth rate of 17% and 2% respectively. Enteric fermentation is the highest GHG emission source and continuously takes place as cattle feeds. Moreover there is barely any management of manure left on farms from non-dairy cattle. Anaerobic manure treatment hence starts from a low or even zero level. In the EAC community, non-dairy cattle are often left to graze free-range with minimal boundary limitations. Dung is left on field to aerobically decompose. Livestock manure management is thus recorded as the highest GHG emitter in the EAC countries.

8.3.3 Net abatement potential

The abatement potential was computed in two stages: 1. Emission from enteric fermentation and 2. Emissions from manure left on farm. In both the cases, the livestock population was projected to 2030 using the average annual growth rates for dairy and non-dairy cattle. The abatement result from agricultural intensification is such that instead of increasing the herds of animals the productivity in terms of milk yield and wet mass is increased. While we reduce the total population of animals – without reducing the national food production – we reduce enteric and manure on pasture emissions. The abatement is hence obtained by multiplying the head of cattle avoided with the enteric and manure on farm emission factors.

Figure 16: Enteric and manure on farm GHG emission reduction through intensified cattle keeping for Kenya

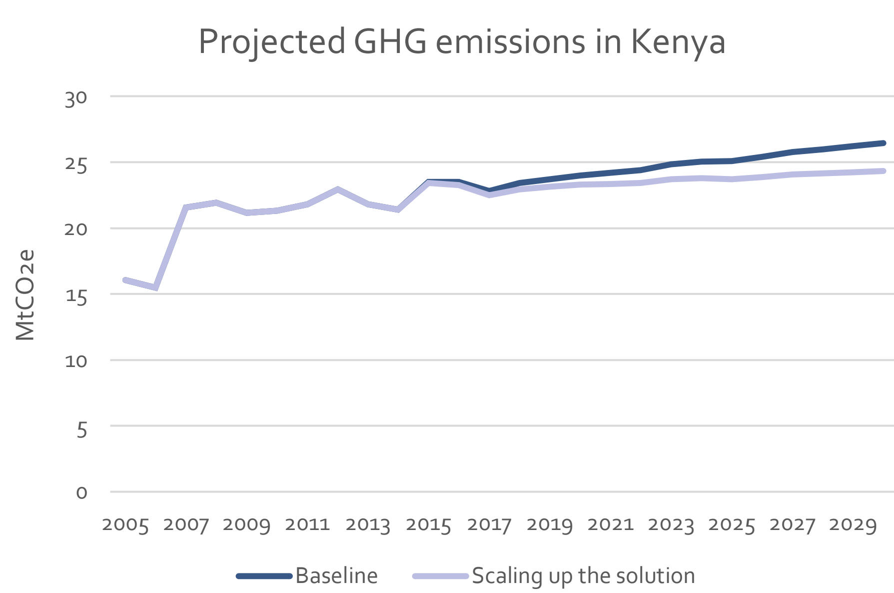
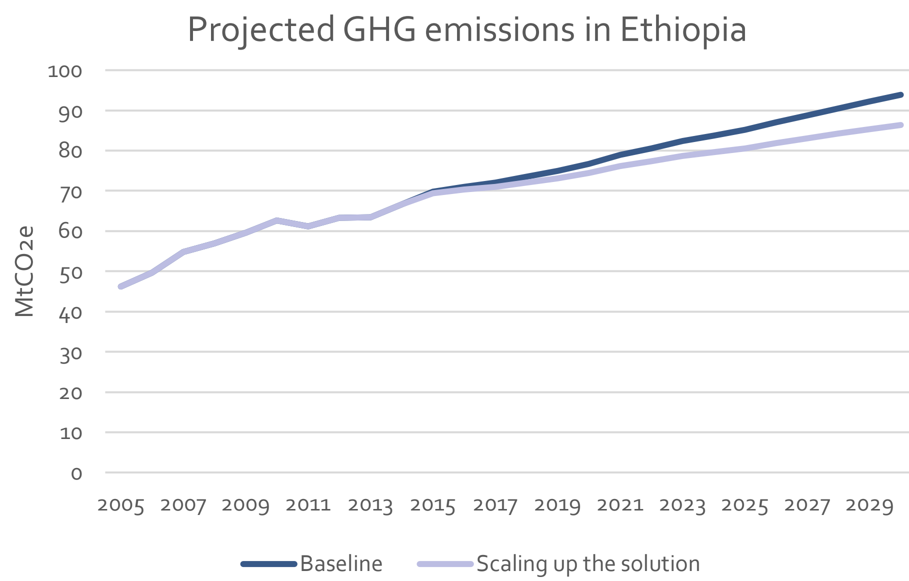


Figure 17: Enteric and manure on farm GHG emission reduction through intensified cattle keeping for Ethiopia



Manure management through anaerobic fermentation and methane capture is another way of reducing GHG emissions from animal's excreta. We are applying IPCC methodology tier 1 – CH_4 emissions from manure management. The net abatement potential was obtained to be 8.2 $MtCO_2e$ for Kenya and 13.9 $MtCO_2e$ for Ethiopia in 2030.

8.3.4 Abatement costs

Adopting data from Ecofys's report (2015) and recognising the expected savings in the East African context through avoided livestock loss, we used abatement saving of 11 US$/tCO2. Thus the abatement saving is 90.7 million US$ for Kenya and 152.7 million US$ for Ethiopia.

8.3.5 Important enablers

Crop and livestock insurance initiatives have been taken up to protect farmers against extreme losses especially during drought. Technologies like farm equipment, breeding and feeding are another driver promoting low-carbon agriculture. The Kenya Agriculture and Livestock organization (KARLO) is working with farmers to improve animal feeds like pelletizing hay for ease of portability and is encouraging agro pastoralists to consider zero grazing rather than free range.

The Ethiopia National Plan supports the adoption of agricultural and land use efficiency measures. These include lower-emissions agricultural techniques ranging from use of carbon- and nitrogen-efficient crop cultivars to the promotion of organic fertilizer use. For livestock, the plan will support the consumption of lower-emitting sources of proteins and introduce mechanical equipment for ploughing instead of animal power. Other frameworks that can spearhead low-carbon agricultural practices are the Ethiopia's agricultural sector policy and investment plan of 2010–2020 and the Comprehensive Africa Agriculture Development Programme framework.

8.3.6 Possible barriers

There is inadequate coordination within the agriculture sector during policy implementation often leading to overlap and inefficiencies. Post-harvest handling techniques still remain a challenge in the sector – this leads to production inefficiencies and losses.

The quality of farm input is also a challenge. The market has seen low-quality fertilizers and other farm input which leads to low productivity. Capacity still remains low among potential users of low-carbon solutions which requires more training and follow-ups. Low-carbon agriculture needs to take a market approach to enable farmers to realize value for money. At the present time some of the climate smart agriculture approaches have not yet been commercialized.

Despite the ambitious plans to promote sustainable agriculture and rural development, lack of low-carbon technologies, lack of awareness about these technologies and lack of finance to support smallholder farmers to take up these technologies are barriers hindering the adoption of such solutions.

8.3.7 Major co-benefits

The main environmental co-benefits are the reduced N_2O emissions – less leaching of nitrogen to the environment and improved water quality. Sound manure management practices make better use of nutrients in manure for soil fertilisation. A reduction of fertiliser consumption would also reduce the costs for the farmers.

8.3.8 Policy recommendations

Harmonize policies on low-carbon agriculture and promote coordination during implementation in both Kenya and Ethiopia. For instance in Kenya, the county government agriculture officers need to work closely with national government and research organizations. Technology training and awareness is a crucial element in promoting the sector.

Establish policies promoting extensive agriculture extension services for farmers in Ethiopia. Incentives that promote farmers' use of organic farming techniques and sustainable land management practices also need to be designed. A policy framework that supports investment in mechanization in the agriculture sector can improve productivity per unit hectare.

9. Conclusions

This report explored how the scaling up of 10 low-carbon solutions in two East African countries – Ethiopia and Kenya – might play a major role in achieving their climate targets and going beyond them in line with the Paris Agreement and its objective of limiting global warming to well below 2 °C. To do so, we applied the Green to Scale methodology, focusing on GHG abatement potential, abatement costs, key enablers and barriers and major co-benefits. A summary of results is presented in Table 11.

The emission reduction potential of Green to Scale solutions was estimated to be 38.9 MtCO_2e in Ethiopia and 23.5 MtCO_2e in Kenya. This compares with the current targets of 255 Mt CO_2e[4] for Ethiopia and 43 MtCO_2e[5] for Kenya.

Table 11: Summary of key findings

Solution	GHG abatement potential		Abatement costs (USD million)	
	Kenya	Ethiopia	Kenya	Ethiopia
Energy sector				
Geothermal power	4.1	2.3	21.3	12.1
Wind power	0.9	3.1	23.8	78.0
Solar power	1.8	2.8	19.7	31.7
Combined heat and power	0.9	2.8	-2.4	-7.2
Transport sector				
Biking in cities	2.8	1.9	-45.1	-31.1
Buildings and households sector				
Energy efficiency in buildings	0.6	0.3	-8.2	-4.6
Improved cook stoves	0.3	1.5	2.1	12.4
Agriculture and forestry sector				
Reduced deforestation*	-	-	-	-
Afforestation and reforestation	3.9	11.2	24.0	68.9
Low-carbon agriculture	8.2	13.9	-90.7	-152.7
Total	*23.5*	*39.9*	*-55.5*	*7.5*
Share of 2030 BAU emissions in the INDCs	*16%*	*10%*		

Note: *Reduced deforestation has no abatement potential as the target countries are currently not losing forest cover.

Unlike in developed countries, focus on agriculture and afforestation programs would yield more GHG abatement potential in East Africa. The energy sector in the two study countries generally contributes less to total emissions and a high renewable energy share in electricity generation provides little opportunity to contribute to substantial emission reductions. However, with rapid economic growth, a renewables deployment

[4] Ethiopia INDC.

[5] Kenya INDC.

rate equal to the economic growth rate is required to just maintain the current low share of fossil fuels in electricity generation. Industrial and transport energy use is the main source of energy-based emissions. Energy efficiency programs targeting these sectors would reduce burning fossil fuels directly and hence provide immediate emission reductions.

On the basis of these results, we propose a number of generic policy recommendations related to scaling up the low-carbon solutions:

- Adequate institutional structures to support the development of the energy sector with a high priority on deploying barely exploited renewable energy sources such as geothermal, solar and wind power. Rapid deployment of these technologies to the grid would match the fast economic growth rate that threatens to require additional fossil fuels for electricity generation;
- National plans on new electricity generation should be demand driven and appropriate supply generated for the demand. Creation of power demand closer to the power generation sites such as the establishment of industrial parks would reduce power transmission costs and thus marginal abatement cost;
- Compensation and relocation procedures for landowners need to be established and help provided to the affected communities to reduce societal conflicts that has been a major barrier in the development and adoption of renewable energy;
- Formulate policies that specify minimum energy requirements for different consumers. Finance activities that promote energy conservation and incentives supporting retrofitting such as tax holidays and loans in Ethiopia;
- There is a need for enforcing the various regulations related to energy efficiency and providing incentives that will encourage more consumers to adapt energy conservation practices in both Kenya and Ethiopia;
- There is a need for establishing structures that will support the collection of data related to energy and climate change and provide guidelines on monitoring, reporting and verifying the impacts of various solutions implemented by government and private sectors;
- There is a need for establishing long-term financing mechanisms from both private and public sectors to support the various afforestation, reforestation and deforestation reduction activities that promote sustainability of such ventures;
- There is also a need for policies and institutional frameworks that address the land tenure issues, forest management challenges and benefit sharing among the various actors so that they combine efforts in conserving the forests. Moreover, strict enforcement of the policies will be key through allocating adequate resources to support policy enforcement; and
- Road infrastructure planning and implementation with different user groups needs to be inclusive. Non-motorised transport modes should be given priority.

References

Afanador, A., Begemann, E., Bourgault, C., Krabbe, O., & Wouters, K. (2015). *The potential of scaling up proven low-carbon solutions (Final report)*. Ecofys.

Aklilu, T. (n.d.). *The role of the transport sector in Ethiopia's economic development*, 9(4), 30.

Climate Care. (2007). *Indicative Programme, Baseline, and Monitoring Methodology for Improved Cook-Stoves and Kitchen Regimes*. Gold Standard Premium Quality Carbon Credits. Retrieved from https://www.goldstandard.org/sites/default/files/gs_methodology_cookstove.pdf

Climate Innovation Center, Ethiopia. (n.d.). *Renewable Energy*. Retrieved December 1, 2018, from http://www.ethiopiacic.org/index.php/2016-10-08-09-55-01/renewable-energy

CSA, & LSMS. (2017, February). *LSMS—Integrated Surveys on Agriculture Ethiopia Socioeconomic Survey (ESS) (2015/2016)*. Central Statistics Agency of Ethiopia (CSA) and World Bank Living Standards Measurement Study (LSMS). Retrieved from http://microdata.worldbank.org/index.php/catalog/2783/download/39555

Danida. (2015). *Project: Accelerating Wind Power Generation in Ethiopia (2016-2019)*. Retrieved January 12, 2018, from http://openaid.um.dk/en/projects/dk-1-255979

Danish Energy Agency. (2018). *Find facts on statistics, subsidies, grid connection and the technical certification scheme*. Retrieved December 1, 2018, from https://ens.dk/en/our-responsibilities/wind-power/facts-about-wind-power

ERC. (2012). *The Energy (Solar Water Heating) Regulation, 2012*. Energy Regulatory Comission of Kenya (ERC).

Ethiopian Electric Power Cooperation. (2014). *Ethiopia Electric Power: Power Sector Development*. Ethiopia.

FDRE. (2011). *Ethiopia's Climate- Resilient Green Economy Strategy*. Federal Democratic Republic of Ethiopia (FDRE).

FDRE. (2015*). Intended Nationally Determined Contribution (INDC) of the Federal Democratic Republic of Ethiopia (FDRE)*. Retrieved from http://www4.unfccc.int/ndcregistry/PublishedDocuments/Ethiopia%20First/INDC-Ethiopia-100615.pdf

FDRE. (2016). *Growth and Transformation Plan II (GTP II) (2015/16-2019/20)* (Main Report No. Volume 1). Addis Ababa: Federal Democratic Republic of Ethiopia, National Planning Commission.

Fraunhofer, I. (2018). *Recent Facts about Photovoltaics in Germany, 86*.

GoK. (2013). *National Climate Change Action Plan 2013 - 2017*. Nairobi, Kenya: Government of Kenya (GoK) Vision 2030.

Government of Kenya (Ed.). (2015). *Kenya: second national communication to the United Nations Framework Convention on Climate Change*. Nairobi, Kenya: National Environment Management Authority (NEMA-Kenya). Retrieved from http://unfccc.int/resource/docs/natc/kennc2.pdf

Guta, D. D. (2015). *Energy resource use options for improved energy security in ethiopia*. United Nations University Institute for Integrated Management of Material Fluxes and of Resources (UNU-FLORES). Retrieved from http://collections.unu.edu/eserv/UNU:5735/DNC2015_PolicyBrief_No3.pdf

IPCC. (1996). *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (Workbook No. Volume 2)* (p. 63). Retrieved from https://www.ipcc-nggip.iges.or.jp/public/gl/invs5c.html

IPCC. (2006). *2006 IPCC guidelines for national greenhouse gas inventories*. (Eggleston H.S., Buendia L., Miwa K., Ngara T., & Tanabe K., Eds.). IGES, Japan. Retrieved from https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

IRENA. (2016). *Solar PV in Africa: Costs and Markets, 84*.

IRENA. (2017). *REthinking Energy 2017: Accelerating the global energy transformation, 130*.

JICA. (2006, March). *The Study on Master Plan for Urban Transport in the Nairobi Metropolitan Area in the Republic of Kenya (NUTRANS)*. Ministry of Roads and Public Works. Retrieved from http://open_jicareport.jica.go.jp/pdf/11823093_01.pdf

Kenya Power. (2017). *Annual Report and Financial Statements for the year ended 30 June 2017* (p. 200). Nairobi, Kenya. Retrieved from http://www.kplc.co.ke/content/item/2255/2016--2017-full-annual-report-for-the-year-ended-30th-june-2017

Keskinen, A., & Broberg, A. (2004). *Geodatabase over Taita Hills, Kenya, 148*.

KIPPRA. (2017). *Kenya Economic Report 2017: Sustaining Kenya's Economic Development by Deepening and Expanding Economic Integration in the Region* (p. 138). Kenya Institute for Public Policy Research and Analysis (KIPPRA). Retrieved from http://kippra.or.ke/newkippra/wp-content/uploads/2017/05/KER-2017.pdf

KNBS. (2009). *2009 Kenya Population and Housing Census: Counting our people for implementation of vision 2030 (National Census report)*. Kenya National Bureau of Statistics.

KNBS. (2017). *Economic Survey, 2016*. Kenya National Bureau of Statistics (KNBS); ISBN: 9966-767-54-1.

Korsbakken, J. I., & Aamaas, B. (2016). *Technical Report: Nordic Green to Scale (Technical report)*. Denmark: Nordic Council of Ministers. Retrieved from http://dx.doi.org/10.6027/TN2016-545

Luukkanen, O. (1996). Kenya Forestry Master Plan. In M. Palo & G. Mery (Eds.), *Sustainable Forestry Challenges for Developing Countries* (pp. 359–369). Dordrecht: Springer Netherlands. https://doi.org/10.1007/978-94-009-1588-6_20

Mariam, K. H. (2017, June). *Ethiopian Initiatives to Cleaner Public Transport*. Presentation, Accra-Ghana. Retrieved from http://wedocs.unep.org/bitstream/handle/20.500.11822/21451/Ethiopian%20Initiatives%20to%20Cleaner%20Public%20Transport,%20Kasahun%20H.Mariam,%20Ethiopian%20Transport%20Authority.pdf?sequence=1

Masaoe, E., Mistro, R. D., & Makajuma, G. (n.d.). *Travel Behaviour in Cape Town, Dar Es Salaam and Nairobi Cities, 10*.

McKinsey&Company. (2009). *Pathways to a Low – Carbon Economy: Version 2 of the global greenhouse gas abatement cost curve (version 2 of the Global Green House Gas Abatement Cost Curve)* (p. 192). Retrieved from https://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/sustainability/cost%20curve%20pdfs/pathways_lowcarbon_economy_version2.ashx

MoENR. (2015). *Kenya's Intended Nationally Determined Contribution (INDC)*. Ministry of Environment and Natural Resources (MoENR), Kenya. Retrieved from http://www4.unfccc.int/ndcregistry/PublishedDocuments/Kenya%20First/Kenya_NDC_20150723.pdf

Ministry of Roads. (2013). *Roads 2000 strategic plan 2013 – 2017*. Kenya Roads Board. Retrieved from http://www.krb.go.ke/wp-content/uploads/2016/09/KRB-STRATEGIC-PLAN-2013-2017.pdf

MoE. (2013). *Wind Sector Prospectors - Kenya* (p. 32). Nairobi, Kenya: Ministry of Energy (MoE).

MoENR. (2016). *National Forest Programme 2016 - 2030* (p. 155). Nairobi, Kenya: Ministry of Environment and Naturla Resources (MoENR) of Kenya.

MoEP. (2016). *Development of a Power Generation and Transmission Master Plan, Kenya*. Long term Plna 2015 - 2035 (Main Report No. Volume 1) (p. 292). Nairobi, Kenya.

MoWIE. (2013). *Updated Rapid Assessment and Gap Analysis on Sustainable Energy for All (SE4All): The UN Secretary General Initiative* (p. 39). Ethiopia: Ministry of Water, Irrigation and Energy (MoWIE) of the Federal Democratic Republic of Ethiopia. Retrieved from https://www.se4all-africa.org/fileadmin/uploads/se4all/Documents/Country_RAGAs/MWH_-_Updated-Rapid_Gap_Analysis.pdf

MoWIE. (2017). *The Ethiopian Power Sector: A renewable Future*. Presented at the Berlin Energy Transition Dialogue. Retrieved from https://www.energiewende2017.com/wp-content/uploads/2017/03/betd_2017_bekele_ethiopia.pdf

NCCG. (2015). *Non motorized transport policy: Towards NMT as the Mode of Choice*. Nairobi City County Government (NCCG). Retrieved from https://www.kara.or.ke/Nairobi%20City%20County%20Non%20Motorized%20Transport%20Policy.pdf

Ngugi, P. K. (2012). *What does geothermal cost? – the Kenya experience*. United Nations University, 13.

NREL. (2015). *IEA Wind Task 26: Wind Technology, Cost, and Performance Trends in Denmark, Germany, Ireland, Norway, the European Union, and the United States: 2007–2012, 163*.

Nuriye, G., Jafri, S. S. A., & Asfaw, M. (2014). Trends and Factors Affecting the Use of Non-Motorized Modes of Transportation in Hawassa City, Ethiopia. *Civil and Environmental Research, 6*(5), 12.

OECD/IEA. (2010). *Renewable Energy Essentials: Geothermal. International Energy Agency (IEA)*. Retrieved from https://www.iea.org/publications/freepublications/publication/Geothermal_Essentials.pdf

Otis, P. (2016). *Many industries use combined heat and power to improve energy efficiency* [Public]. Retrieved January 13, 2018, from https://www.eia.gov/todayinenergy/detail.php?id=27252

Pirie, G. (2011). *Sustainable Urban Mobility in 'Anglophone' Sub-Saharan Africa, 53*.

Pistorius, T., Carodenuto, S., & Wathum, G. (2017). Implementing Forest Landscape Restoration in Ethiopia. *Forests, 8*(3), 61. https://doi.org/10.3390/f8030061

The Swedish Trade and Investment Council. (2016). *Energy Sector Opportunities in Kenya*. Retrieved from https://www.business-sweden.se/contentassets/918a154e345c45a3b9f6fe0b39600b59/energy-sector-in-kenya--2016.pdf

UNDESA, Bureau International des Expositions, & Municipal Government of Shanghai. (2010). *Shanghai Manual: A guide for sustainable Urban Development of the 21st Century*. Retrieved from http://www.un.org/esa/dsd/susdevtopics/sdt_pdfs/shanghaimanual/Introduction.pdf

US Foreign Commercial Service. (2016). *Ethiopia: Power Sector Market*. Retrieved from https://build.export.gov/build/idcplg?IdcService=DOWNLOAD_PUBLIC_FILE&RevisionSelectionMethod=Latest&dDocName=eg_us_tx_106929

WEC. (2016). *World Energy Resources Geothermal, 2016* (p. 54). World Energy Council (WEC). Retrieved from https://www.worldenergy.org/wp-content/uploads/2017/03/WEResources_Geothermal_2016.pdf

WindEurope. (2018, February). *Wind in power 2017: Annual combined onshore and offshore wind energy statistics*. Retrieved from https://windeurope.org/wp-content/uploads/files/about-wind/statistics/WindEurope-Annual-Statistics-2017.pdf

World Bank. (2002). S*coping Study Urban Mobility in Three Cities: Addis Ababa, Dar es Salaam and Nairobi (SSATP Working Paper No. 70)*. The sub-Saharan Africa Transport Policy Program (SSATP), The World Bank and United Nations Economic for Africa (UNEC A). Retrieved from http://documents.worldbank.org/curated/en/604221468313218556/pdf/273240PAPER0SS110Scoping0Study1web1.pdf

Exekutiv sammanfattning

Parisavtalet ingicks i syfte att stödja genomförandet av klimatkonventionen United Nations Framework Convention on Climate Change (UNFCCC) som antogs 1992 och stärka de globala åtgärderna mot hotet från klimatförändringen. Avtalet innehåller målet att hålla ökningen av den globala genomsnittstemperaturen väl under 2 °C och sträva efter att begränsa den till 1,5 °C över den förindustriella nivån.

Nationer inklusive Etiopien och Kenya har gjort åtaganden genom att lämna in sina nationellt fastställda bidrag (NDC) för att minska sina utsläpp och samtidigt stödja utvecklingstrenden. Etiopien siktar på att minska sina utsläpp med 255 $MtCO_2$ (64 procent) före 2030 jämfört med de beräknade utsläppen med nuvarande åtgärder, medan målet för Kenyas nationellt fastställda bidrag är en minskning med 30 procent eller 143 $MtCO_2e$ jämfört med de beräknade utsläppen (FDRE, 2015; MoENR, 2015).

I denna rapport utforskar vi hur en utvidgning av tio befintliga nordiska klimatlösningar i Etiopien och Kenya kan bidra till och eventuellt överträffa målen för de nationellt fastställda bidragen i respektive land. Lösningarna var inriktade på energisektorn, jord- och skogsbruket, byggnader och hushåll samt transportsektorn. Lösningarna inom energisektorn var fokuserade på utveckling av geotermisk energi, landbaserad vindkraft, solenerginät och kombinerade kraftvärme, medan lösningarna inom sektorn för byggnader och hushåll inriktades på energieffektivitet i byggnader och förbättrade matlagningsspisar. Inom jord- och skogsbruket inkluderade lösningarna koldioxidsnålt jordbruk, beskogning och återbeskogning samt minskad avskogning. Som lösning inom transportsektorn föreslogs cykling i städerna.

Sammanfattningsvis kan en utvidgning av de tio lösningarna inom dessa fyra sektorer medföra en total minskning av utsläppen på 39,8 $MtCO_2e$ i Etiopien och 23,5 $MtCO_2e$ i Kenya före 2030 – en minskning på 10 procent och 16 procent av de beräknade utsläppen med nuvarande åtgärder[6] i respektive land. I allmänhet finns en likhet i fråga om minskningstrenden i de två länderna men olika stor minskningspotential. Koldioxidsnålt jordbruk och beskogning utgör den största möjligheten till att minska utsläppen i både Etiopien och Kenya. Det är i linje med planen för de preliminära nationellt fastställda bidragen i båda länderna, som lägger större vikt vid dessa sektorer. Koldioxidsnålt jordbruk kan ge en uppskattad minskning av utsläppen på 13,9 $MtCO_2e$ respektive 8,2 $MtCO_2e$ i Etiopien och Kenya, medan beskogning och återbeskogning kan bidra med en minskning på 11,2 $MtCO_2e$ i Etiopien och 3,9 $MtCO_2e$ i Kenya. Inom energisektorn erbjuder geotermisk energi den största möjligheten till minskning av utsläppen: 4,1 $MtCO_2e$ i Kenya och 2,3 $MtCO_2e$ i Etiopien. Bättre matlagningsspisar och energieffektivitet i byggnader har den minsta minskningspotentialen i båda länderna.

[6] De beräknade utsläppen 2030 med nuvarande åtgärder är tagna ur de preliminära nationellt bestämda bidragen. *Nordic Green to Scale 2 5*.

Koldioxidsnålt jordbruk har den lägsta kostnaden för utsläppsminskning på -91 miljoner USD i Kenya och -153 miljoner USD i Etiopien, vilket innebär att dessa lösningar kan spara pengar på längre sikt. Cykling i städerna är den näst mest kostnadseffektiva lösningen för både Etiopien och Kenya med en kostnad på -31 miljoner USD respektive -45 miljoner USD, men med medelstor minskningspotential. Energieffektivitet i byggnader, kombinerad kraftvärme och bättre matlagningsspisar kan betraktas som neutrala lösningar med både låga kostnader och liten minskningspotential.

Flera hinder måste åtgärdas för att möjliggöra en utvidgning av olika koldioxidsnåla lösningar i de olika sektorerna. Dessa inkluderar höga investeringskostnader, avsaknad av hållbar finansiering, problem med markinnehav, begränsat samarbete mellan ministerierna, problem med att efterleva kraven samt bristande kunskap och medvetenhet bland potentiella aktörer och användare.

Tre huvudsakliga rekommendationer har betonats för att övervinna dessa hinder:

1. Utforma, verkställa och genomdriva sektorspecifik politik och institutionella strukturer.
2. Garantera nära samarbete med aktörer i den privata sektorn och mellan sektorerna.
3. Investera i kapacitetsutveckling och åtgärder för att öka medvetenheten.

Mer detaljerade beskrivningar av hinder och lösningar i respektive land finns i avsnitt 5, 6, 7 och 8 i rapporten.

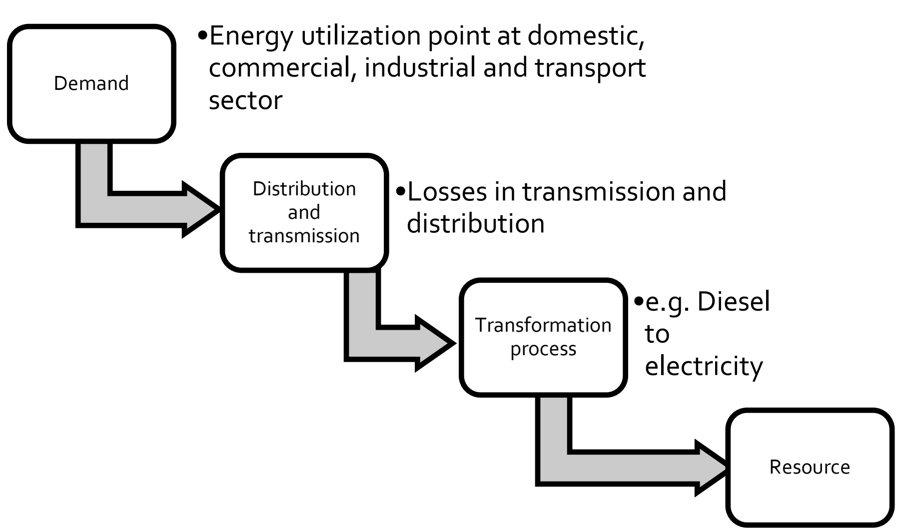
Appendices

Appendix 1. Long Range Energy Alternatives Planning Tool

Modelling methodologies

LEAP is not a model of a particular energy system, but rather a tool that can be used to create models of different energy systems, where each requires its own unique data structures. LEAP supports a wide range of different modelling methodologies: on the demand side these range from bottom-up, end-use accounting techniques to top-down macroeconomic modelling. LEAP also includes a range of optional specialized methodologies including stock-turnover modelling for areas such as transport planning. On the supply side, LEAP provides a range of accounting, simulation and optimization methodologies that are powerful enough for modelling electric sector generation and capacity expansion planning, but which are also sufficiently flexible and transparent to allow LEAP to easily incorporate data and results from other more specialized models.

Figure 18: LEAP tool



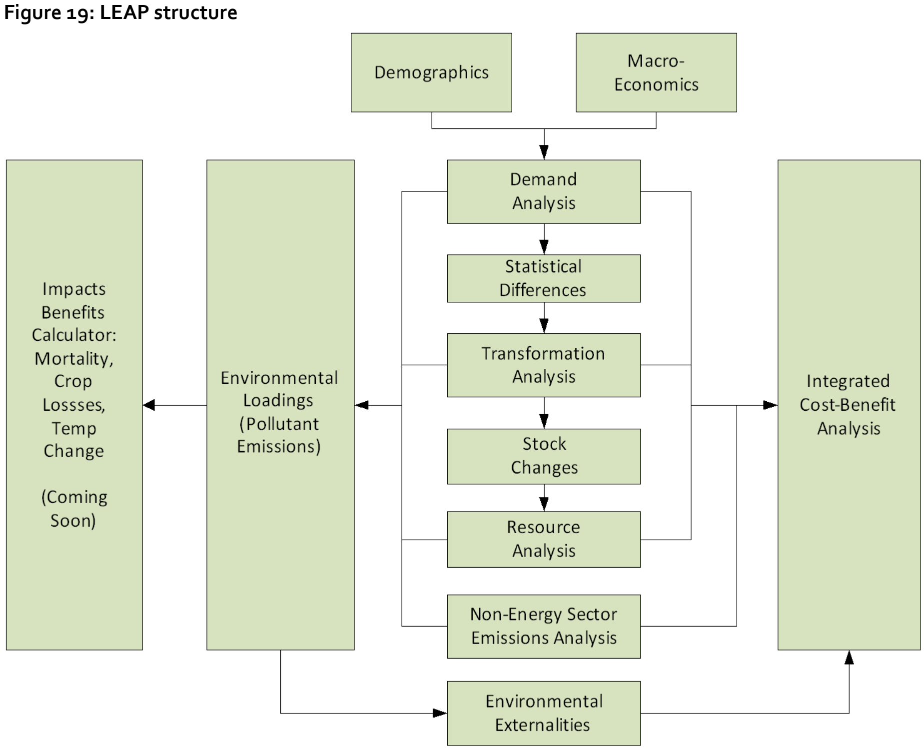
Time frame

LEAP does calculations on an annual time-step, and the time horizon can extend for an unlimited number of years. Studies typically include both a historical period known as the Current Accounts, in which the model is run to test its ability to replicate known statistical data, as well as multiple forward-looking scenarios. Typically, most studies use a forecast period of between 10 and 50 years. Some results are calculated with a finer level of temporal detail.

Scenario analysis

LEAP is designed around the concept of long-range scenario analysis. Scenarios are self-consistent story lines of how an energy system might evolve over time. Using LEAP, policy analysts can create and then evaluate alternative scenarios by comparing their energy requirements, social costs and benefits and environmental impacts. The LEAP Scenario Manager can be used to describe individual policy measures which can then be combined, in different combinations and permutations, into alternative integrated scenarios. This approach allows policy makers to assess the marginal impact of an individual policy as well as the interactions that occur when multiple policies and measures are combined. For example, the benefits of appliance efficiency standards combined with a renewable portfolio standard might be less than the sum of the benefits of the two measures considered separately. Individual measures can also be combined into an overall GHG Mitigation scenario containing various measures for reducing greenhouse gas emissions.

Figure 19: LEAP structure



Appendix 2. Guiding questions to solutions selections

Table 12: Guiding questions to solutions selections

Question	Selection 1	Selection 2	Selection 3	Selection 4
Does the solution address major goals/challenges in national climate/energy strategy/policy?	Solution is targeted towards a minor/marginal problem, issue in national policies, strategies, legislation	Solution addresses one of the lesser problems at national, regional level	Solution addresses important challenge, goal in policy document	Solution addresses one of the key challenges and has been specifically prioritised in relevant national policy documents, strategies
What is the current level of penetration of the selected solution?	Solution has not been tried, implemented so far	Some investments, pilots, activities have been implemented	Considerable amount of activities have been carried out and solution is widely known	Solution has been implemented to very large extent, it is one of main areas of investment, policy focus for some time already
How big is the scalability and further CO_2 reduction potential of the solution (given its fit with challenges and socio-economic, environmental, technical conditions, local resources)?	Solution lacks potential to become widely used and lacks notable CO_2 reduction potential	Solution might become more widely used with significant effort, but even then will bring along moderate CO_2 reduction	If the right enablers and drivers are used, the uptake of solution can be significant and will bring along noticeable CO_2 reduction	With right set of policy tools, solution can become one of the major areas for investment and will reduce drastically CO_2 emissions in target sector

Appendix 3: Ethiopia focus group discussion attendance list

Table 13: Ethiopia focus group discussion attendance list

S. No.	Name	Department
1.	Belachew Alelign	Ministry of Environment, Forestry and Climate Change (NDC)
2.	Abraha Misghina	Ministry of Environment, Forestry and Climate Change (National Improved Cook Stove Program)
3.	Mengistu Basho	Ministry of Environment, Forestry and Climate Change
4.	Desalegn Atnafu	Ministry of Environment, Forest, and Climate Change
5.	Tilahun Andarge	Ministry of Environment, Forestry and Climate Change (National Improved Cook Stove Program)
6.	Mesfin Dabi Seboka	Ministry of Water, Irrigation and Electricity
7.	Jobir Ayalew	Ministry of Transport
8.	Yizengau Yitayih	Ministry of Transport
9.	Fikadu Sahile	Ministry of Urban Development and Housing
10.	Melaku Mesfin	Ministry of Urban Development and Housing
11.	Gebremichael Gebirekidan	Ministry of Industry
12.	Tsion Elias	Ministry of Mine, Petroleum and Natural Gas
13.	Beza Yetimgeta	Ministry of Mine, Petroleum and Natural Gas
14.	Maikel Mulugeta	Ministry of Water, Irrigation and Electricity
15.	Atnafseged Kifle	Ministry of Transport *(Advisor to the Minister)*

Appendix 4: Kenya stakeholders interview list

Table 14: Kenya stakeholders interview list

S. No.	Name	Organization
1.	Esther Nyambura	Geothermal Development Company
2.	Dickson Kisoa	Ministry of Energy and Petroleum
3.	Victor Gathogo	Kenya Association of Manufacturers
4.	George Tarus	Kenya Forest Service
5.	Michael Okoti	Kenya Agriculture Research and Livestock Institute (KARLO)
6.	Daniel Wanjohi	Global Alliance for Clean Cookstoves
7.	Eustace Njeru	Energy Regulatory Commission
8.	Henry Kamau	Sustainable transport
9.	Jack Andati	Bamburi Cement Limited
10.	Stephen King'uyu	Ministry of Environment and Natural Resources
11.	Eng John Mwangi	Nairobi Metropolitan Area Transport Authority

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Technical report: Nordic Green to Scale for countries

Nordic Green to Scale for countries zooms in on two regions: Kenya and Ethiopia in East Africa and the Baltic States, Poland and Ukraine in Europe. This report presents the emission reduction potential of 10 selected solutions for the African target countries. The study highlights the costs, savings and co-benefits of implementing the solutions as well as makes policy recommendations for capturing the potential. The technical analysis was conducted by Stockholm Environment Institute (SEI) Africa Centre in close collaboration with African organisations and networks on key environmental and development issues. The project was carried out by the Finnish Innovation Fund Sitra, together with partners CICERO, CONCITO and Institute of Sustainability Studies at the University of Iceland. The project is part of the Nordic Council of Ministers' Prime Ministers' Initiative Nordic Solutions.

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