Kenya's Climate Change Action Plan: Mitigation
Chapter 8: Industrial Processes

Raouf Saidi (ECN), Laura Würtenberger (ECN) and Seton Stiebert (IISD)

August 2012

ECN
ASB Partnership for the Tropical Forest Margins
iisd International Institute for Sustainable Development
Institut international du développement durable

* The Climate and Development Knowledge Network ("CDKN") is a project funded by the UK Department for International Development (DFID) and the Netherlands Directorate-General for International Cooperation (DGIS) and is led and administered by PricewaterhouseCoopers LLP. Management of the delivery of CDKN is undertaken by PricewaterhouseCoopers LLP, and an alliance of organisations including Fundación Futuro Latinoamericano, INTRAC, LEAD International, the Overseas Development Institute, and SouthSouthNorth.

Kenya's Climate Change Action Plan:

Mitigation

Chapter 8: Industrial Processes

Mitigation Team:

Deborah Murphy, Seton Stiebert, Dave Sawyer, Jason Dion, Scott McFatridge, International Institute for Sustainable Development

Laura Würtenberger, Lachlan Cameron, Raouf Saidi, Xander van Tilburg, Energy Research Centre of the Netherlands

Peter A. Minang, ASB Partnership for the Tropical Forest Margins at the World Agroforestry Centre

Tom Owino, ClimateCare

Peterson Olum

The mitigation analysis was funded by the Climate Development Knowledge Network.

The website for Kenya's Climate Change Action Plan can be accessed at: http://www.kccap.info

International Institute for Sustainable Development

IISD is a Canadian-based, public policy research institute that specializes in policy research, analysis and information exchange. The institute champions sustainable development through innovation, research and relationships that span the entire world

Energy research Centre of the Netherlands

ECN develops high-quality knowledge and technology for the transition to sustainable energy management. ECN introduces this knowledge and technology to the market. ECN's focus is on energy conservation, sustainable energy and an efficient and clean use of fossil fuels.

ASB Partnership for the Tropical Forest Margins at the World Agroforestry Centre

ASB is the only global partnership devoted entirely to research on the tropical forest margins. ASB aims to raise productivity and income of rural households in the humid tropics without increasing deforestation or undermining essential environmental services.

For further information, please contact:

Deborah Murphy, IISD
Tel: +1-613-238-2296
Email: dmurphy@iisd.ca

Laura Würtenberger, ECN
Tel: +31 88 515 49 48
Email: wuertenberger@ecn.nl

Table of Contents

Abbreviations

BAU	business as usual
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
GHG	greenhouse gas
ICPS	improved charcoal production system
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
MPND	Ministry of State for Planning, National Development and Vision 2030
Mt	million tonnes
MW	megawatt
NAMA	nationally appropriate mitigation action
REDD+	reducing emissions from deforestation and forest degradation plus the role of conservation, sustainable management of forests and enhancement of forest carbon stocks
UNFCCC	United Nations Framework Convention on Climate Change

8.1 Introduction

This chapter is part of a larger analysis of low-carbon development options in Kenya, which covers the six mitigation sectors set out in Article 4.1 of the United Nations Framework Convention on Climate Change (UNFCCC): energy (divided into electricity generation and energy demand), transport, industry, waste, forestry and agriculture. The holistic, sectoral analysis aims to inform the Kenya Climate Change Action Plan and provides the evidence base for prioritizing low-carbon development options and developing proposals for Nationally Appropriate Mitigation Actions (NAMAs) and REDD+ actions.

The analysis includes a preliminary greenhouse (GHG) emissions inventory and reference case projecting GHG emissions to 2030 for the entire Kenyan economy and by sector. The analysis then demonstrates how low-carbon development options can bend down emissions from the proposed reference case in each sector. Recognizing Kenya's development priorities and plans, the analysis also considers how the various options can contribute to sustainable development. The overall work concludes with the identification of priority actions to enable low-carbon development.

This chapter analyses low-carbon development options related to industrial process emissions in Kenya and is one of seven sectoral chapters published as part of the overall low-carbon analysis.

The current level of GHG emissions from the Kenyan industrial processes sector is low compared to other sectors. This chapter is therefore less extensive than the analysis undertaken in larger sectors such as electricity generation or forestry. The report focuses on an overall inventory for industrial processes but then focuses on one low-carbon development option with the largest expected potential for short-term GHG emission reductions – improved charcoal production.

8.2 Industrial Process Sector: Background

8.2.1 Sector context

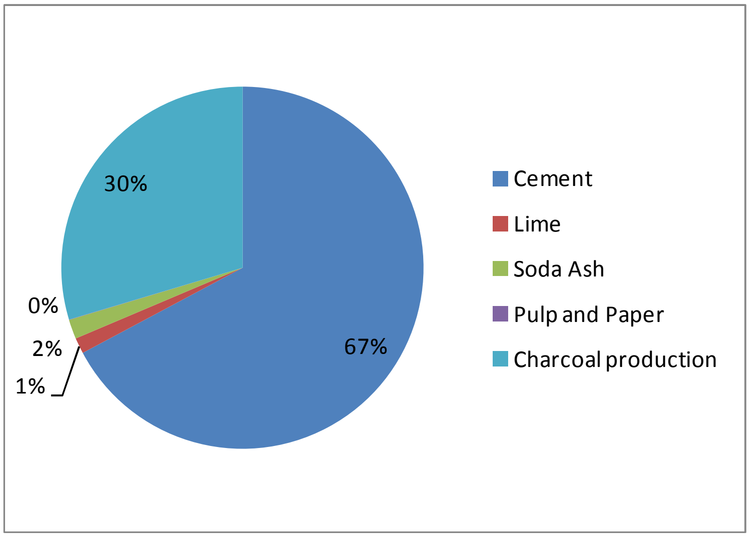
This chapter deals with GHG emissions and reduction options from industrial processes. Some industrial processes emit GHGs directly from the industrial process itself. In Kenya, such industrial processes include calcination in clinker production for cement manufacturing that emits carbon dioxide (CO_2) as a result of the chemical breakdown of limestone. Charcoal production results in CO_2 and methane emissions from incomplete combustion of biomass, and soda ash production through calcining of trona or sodium sesquicarbonate.

The industrial process emissions discussed in this Chapter are due to the emissions released during the manufacturing process. This is not related to the emissions associated with the use of energy carriers, such as electricity or fossil fuels.

Industrial process emissions in Kenya are dominated by the cement and charcoal manufacturing industries (see Figure 8.1). However, the sources of GHG emissions are very different in the two sectors. Process emissions from the cement sector are due to calcination, whereby limestone releases CO_2 as it is heated in the kiln and transformed into clinker. The emissions associated with soda ash production are insignificant in relation to those associated with charcoal and cement production.

Process emissions from charcoal burning are generated during incomplete burning of wood in charcoal manufacturing kilns. Although charcoal manufacturing is an important part of the Kenyan economy, the wood-based biomass energy sector is systematically neglected in formal economic analyses due to its informal nature. In 2007, total income from the charcoal industry in Kenya was estimated to be US$450 million, equal to the country's tea industry.[1]

Figure 1: Industrial process emissions per industry in 2010



Due to this informal nature the Government of Kenya loses substantial amounts of income as a result of not having any regulatory and tax collection mechanism for the charcoal industry.

However, energy and forestry policies and acts have recently legalized sustainable charcoal production, and efforts are underway by government agencies, including the Kenya Forest Service in the Ministry of Forestry and Wildlife and the Ministry of Energy to take forward the implementation of this legislation.

It is important to note, however, that the level of GHG emissions from industrial processes in Kenya is low compared to other sectors. This low-carbon scenario analysis estimates that emissions from industrial processes make up about four percent of total GHG emissions in 2010 and would account for approximately six percent of GHG emissions in 2030 in the reference scenario.

For the cement sector, energy-use related emission reductions are been considered in Chapter 6, Energy Demand. Although a reduction of process emissions from cement is feasible by replacing a certain amount of clinker by slag or Pozzolana (the latter being abundantly available in Kenya), this is not analyzed in detail in this report (see Section 8.5). Existing cement plants are either blending the maximum allowable level of Pozzolana in the blended cement or are at advanced stages of implementing such blending projects because they are financially very attractive, while the new plants being constructed have been designed for maximum Pozzolana blending (see chapter 6, Energy Demand).

8.2.2 Structure of the industrial processes sector

The informal nature of the charcoal production sector limits the official stakeholders that are actively engaged with the charcoal sector in Kenya. Below is a list of bodies that directly or indirectly engage in activities associated with charcoal production:

- Ministry of Forestry and Wildlife:
    - Kenya Forestry Research Institute;
    - Kenya Forest Service;
    - Kenya Wildlife Service;
- Ministry of Energy;
- Ministry of State for Planning, National Development and Vision 2030 (MPND);

- National Environment Authority;
- Energy Regulation Commission;
- Kenya Bureau of Standards; and
- Centre for Energy Efficiency and Conservation, Kenya Association of Manufacturers.

The majority of the organisations active in improving charcoal production processes are international organisations and non-governmental organization. Examples are the World Bank Group, Food and Agriculture Organization of the United Nations and bilateral development agencies such as the French Development Agency and the German Development Agency. These groups undertake research and implement projects to develop alternatives to charcoal or woody biomass and improve the conversion processes.

8.2.3 Policy

The wood-based biomass energy sector in Kenya operates within a complex and multi-layered regulatory context, often resulting in an unclear framework for stakeholders operating in the sector. Stakeholders interact with several government bodies and must adhere to various policies and laws at the national, local and village levels. No comprehensive targeted policy, strategy or legal framework addresses the charcoal sector; although an existing set of policies, legislation and regulations influences how wood-based biomass exploitation, production and consumption is managed.

Kenya has a number of policy instruments that recognize charcoal as an important source of energy. They highlight issues pertaining to charcoal production (tree growing and wood conversion to charcoal), transportation, trade and utilization. The key policy documents relevant to charcoal include the following:

- Sessional Paper No. 4 of 2004 on Energy Policy;
- Sessional Paper No. 9 of 2005 on Forest Policy;
- Sessional Paper No. 6 of 1999 on Environment and Development; and
- Strategy for Revitalizing Agriculture of 2004.

8.3 Development Priorities of the Government of Kenya

Vision 2030 aims at transforming Kenya into “a newly industrializing, middle income country providing a high quality of life to all its citizens in a clean and secure environment”. Manufacturing is part of the economic pillar of Vision 2030, which aims to achieve an economic growth rate of 10 percent annually to generate additional resources to support the Millennium Development Goals. Kenya aspires to have a robust, diversified and competitive manufacturing sector.[2]

Although no direct link is made between industrial GHG emissions and the goals in Vision 2030 for Kenya’s manufacturing sector, there may be opportunities where both targets are mutually reinforcing. Modernization of the sector and increased competitiveness may be achieved through the use of state-of-the art equipment that also leads to lower GHG emissions from industrial processes. In addition, efforts to reduce GHG emissions from industrial processes may improve general efficiencies in a sector.

8.4 GHG Reference Case

This section briefly discusses the methodology, data and assumptions that were used to generate the GHG emissions baseline for the industry sector between the years 2000 and 2030. This is followed by a discussion of data availability and quality. Finally, emissions are projected out to 2030 to create the reference case against which to measure abatement potential. Figure 8.2 illustrates the methodology used to develop the reference case and low-carbon scenario (discussed in Section 8.5).

8.4.1 Emissions reference case methodology

The emissions baseline for the industrial processes sector is aligned with the sector definitions of the Intergovernmental Panel on Climate Change (IPCC) for Industrial Processes and Product Use (IPPU). These definitions cover GHG emissions occurring from industrial processes from the use of GHGs in products and from non-energy use of fossil fuel carbon. One exception to this alignment is that charcoal production from the partial combustion of fuelwood is included as an industrial process, while in the IPCC Guidelines it is included in the energy sector along with charcoal consumption.

The biggest challenge in creating the industrial process inventory was in selecting appropriate emission factors that relate to available data on production levels. In all cases IPCC default emission factors (IPCC, 2006) or emission factors from the first national communication (MoE, 2002) were used.[3,4] The methodologies, along with the specific data and assumptions to estimate emissions, are described in detail in Chapter 2, Preliminary Greenhouse Gas Inventory.

The annual average growth rate used to forecast emissions to 2030 for the reference case was based on projections of overall economic growth under a baseline condition. The growth rate used compares reasonably well to other forecasts including the Kenya Threshold 21 model developed by the MPND that reports an average baseline GDP growth rate between 4.25 percent and 4.76 percent. In addition, an average increase in autonomous efficiency is assumed of 0.25 percent annually for the charcoal production process over time. The efficiency per unit of production for cement, lime and soda ash from Trona and pulp and paper does not change as the release of CO_2 is an unavoidable in the industrial process.

8.4.2 Data availability and quality

Uncertainty in the emissions reference case is primarily associated with the use of default emission factors and to a lesser degree the production values available. The 2006 IPCC guidelines express the default uncertainty of production values for cement, lime, soda ash and pulp and paper products to be likely in the range of one to two percent[5] compared to an uncertainty in the range of eight to 20 percent for their different emission factors. Specific uncertainty in production values may be higher in Kenya depending on the rigour of reporting requirements.

Greater uncertainty exists for charcoal production values as there are many small producers and not all production and commercial sale is regulated. In charcoal production, the uncertainty of the emission factor is also large as it is dependent on assumptions regarding the average efficiency of conversion of fuelwood, which can vary substantially. The 2006 IPCC Guidelines report that upper and lower estimates for methane and nitrous oxide emission factors vary by several orders of magnitude.[6]

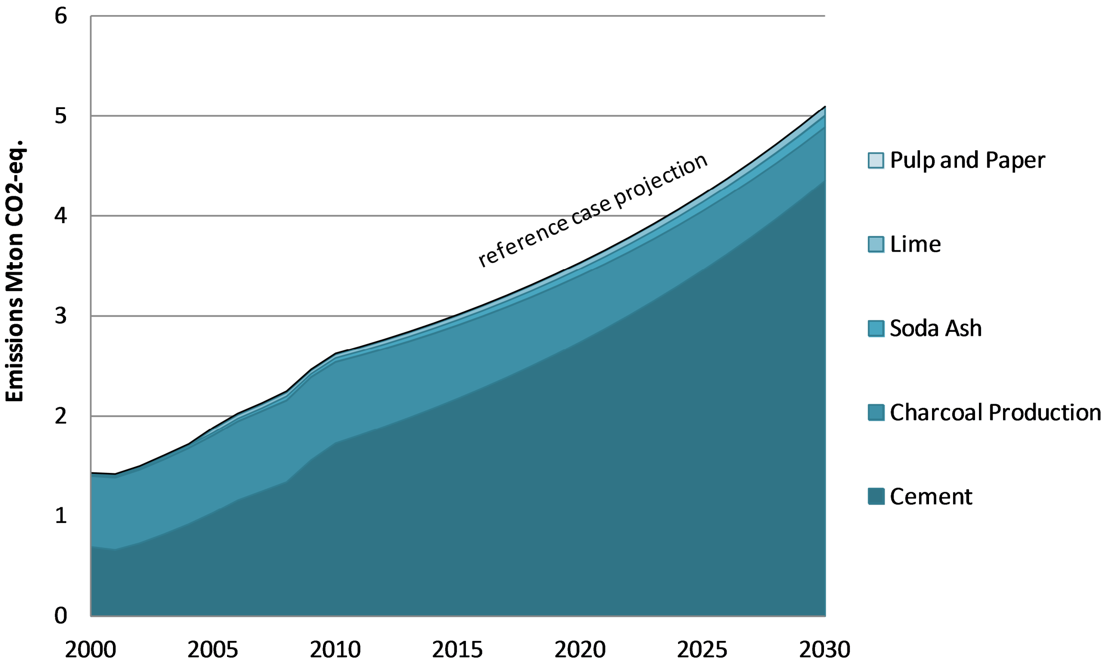
Emission estimates from GHGs used in products such as refrigerators, foams or aerosol cans have not been estimated in this analysis. These emissions were not estimated in the first national communication greenhouse gas inventory.[7]

8.4.3 Emissions reference case

The emissions reference case for industrial processes is summarized in Figure 8.2. Industrial process emissions account for approximately 4 to 5 percent of total emissions in Kenya in the emissions profile developed as part of this low-carbon scenario analysis. Cement is the largest industrial process that contributes nearly 80 percent of industrial emissions between 2010 and 2030.

Emissions from charcoal production would be substantially larger if carbon emissions from the use of unsustainably harvested fuel wood were considered. These emissions are accounted for in the forestry and land use sector. Figure 8.3 illustrates the impact if these emissions were included assuming an unsustainable biomass ratio of 35 percent.

Figure 8.2: Total industrial process emissions (MtCO$_2$e)



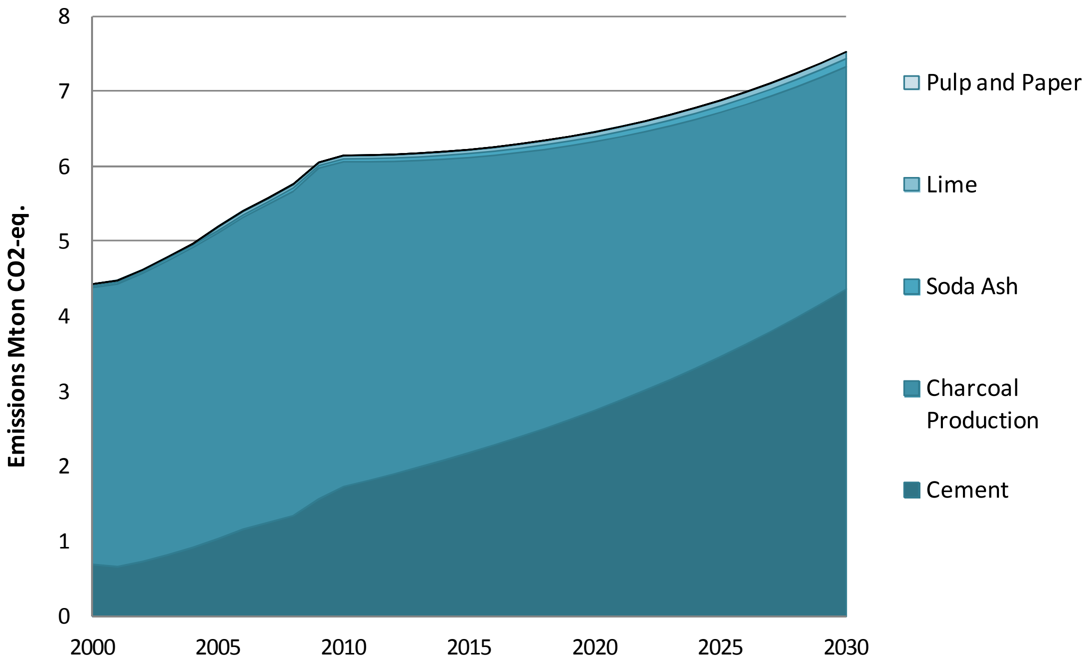
8.5 Low-carbon Scenario Analysis

The low-carbon scenario analysis consists of identifying low-carbon development options, and calculating the mitigation potential against the reference case. The resulting wedge analysis demonstrates the emission reduction potential by low-carbon technology in the sector.

8.5.1 Choice of abatement options

The identification of low-carbon options for further analysis followed a participatory multi-step approach that is described in Chapter 1. Few viable options were identified in the industrial process sector and one option was analysed: improved charcoal production.

Figure 8.3: Total industrial process emissions including carbon emissions from charcoal production ($MtCO_2e$)



This option and the results were presented at a local validation meeting in May 2012 for review by and input from Kenyan experts. Kenyan experts suggested analysing the cement industry, but after examination this sector was not included because reducing process emissions from charcoal production has higher development benefits in Kenya than reducing process emissions from cement. Energy-related emission reductions in the cement sector are analysed in Chapter 6, Energy demand. In the cement sector, the use of Pozzolana (a type of volcanic rock) does offer an opportunity to both lower the price of production and the attributed CO_2 emissions, as up to a certain extent Pozzolana can replace clinker in cement. This option has been, or is already being, taken up by some cement companies in Kenya.

8.5.2 Calculation of abatement potentials

Using the baseline data described in Section 8.5, total process emissions from charcoal production are determined. It is then assumed that all of this charcoal was produced using earth mound kilns, which generally have an efficiency between 10 and 22 percent (calculated using oven-dry wood with zero percent water content) while the efficiency of improved charcoal production systems (ICPS) using retort kilns is approximately 30 to 42 percent.[8] The emission reductions associated with the use of improved charcoal production are, however, far higher. Traditional charcoal kilns lead to a slow pyrolysis[9] of wood causing excess methane and CO_2 emissions. The corresponding emission factor for methane is higher than that for CO_2 and hence the net emission factor is higher than that observed in other types of combustion cycles. This standard emissions reduction was then multiplied by a certain adoption rate.

To calculate the adoption rates for ICPS, assumptions were made based on the current barriers to implementation. The kiln can easily be built in Kenya, but may be too expensive for many charcoal producers who are used to not paying for the fuel wood and currently use readily available earth to make kilns. Another barrier is the immobility of retort kilns, which would now require charcoal producers to gather the collected fuel wood and transport it to the kiln. Policy interventions could overcome some of these barriers, but the unregulated nature of the sector likely will mean low initial compliance with policy and regulations. The potential impact of these barriers was a critical consideration in forming the adoption scenarios.

8.5.3 Calculation of abatement costs

The highly informal nature of the charcoal production sector in Kenya meant it was not possible to determine if and how much charcoal manufacturers pay for the woody biomass they use as input for the manufacturing process. Therefore it was not possible to calculate marginal abatement costs for the option. Instead, an estimate of investment costs is given and marginal abatement costs from a comparable study are cited.

8.5.4 Data availability and uncertainties

The data available was limited to supply side data on charcoal consumption, rather than end-user data and consumption behaviour. It was therefore assumed that all charcoal consumed in Kenya is also manufactured in Kenya. There was also little data on the current use of retort kilns, and it was assumed that 100 percent of charcoal production was carried out using earth mound kilns.

8.6 Low-carbon Development Options

Improved charcoal production through more efficient kilns will lead to reduced emissions. The conversion of wood to charcoal is a small but decisive factor in the charcoal value chain. Generally, traditional kilns are used, which result in low conversion efficiencies. A wide range of interventions in many Sub-Saharan African countries have tried to overcome this challenge by promoting more efficient retort kilns for charcoal production, but the adoption rate has been limited. The reasons for this are mainly found in the informal—and often illegal—nature of charcoal production. Higher material costs, increased labour input and lack of awareness are disincentives to charcoal burners adopting improved technologies in situations where they are not rewarded with increased prices or where the risk of discovery may require abandoning the production site.[10]

In 2009 Kenya used a total of 12,000 kilotonnes of oil equivalent of woody biomass directly as fuelwood or feedstock for conversion to charcoal, representing 67 percent of total primary energy demand. The use of improved charcoal production systems such as simple retort kilns could be promoted, but additional regulation and enforcement would be needed for success.

The results of the analysis are discussed below in six categories:

- Low-carbon Scenario;
- Mitigation potential;
- Costs;
- Development benefits;
- Climate resilience; and
- Feasibility of implementation.

Figure 8.4: An example of an ICPS in the Rift Valley in Kenya[11]

Source: Adam, J.C. 2009. "Improved and more environmentally friendly charcoal production system using a low-cost retort kiln (Eco-charcoal)," Renewable Energy*, January.*

8.6.1 Scenario

It is assumed that the emissions can be reduced by 75 percent through the use of retort kilns, when compared to traditional charcoal production methods using earth mound kilns. The adoption rate of this technology is assumed to be 50 percent in 2030 because of policy interventions promoting the use of ICPS. This conservative assumption was chosen because of expected higher material costs, increased labour input, lack of knowledge and immobility of charcoal producers. In addition, even in a scenario where in 2030 regulation to truly reflect the cost of fuelwood exists it is unlikely to reach the poorer and more remote rural households that use fuelwood on open 'three-stone' fires.

8.6.2 Mitigation potentials

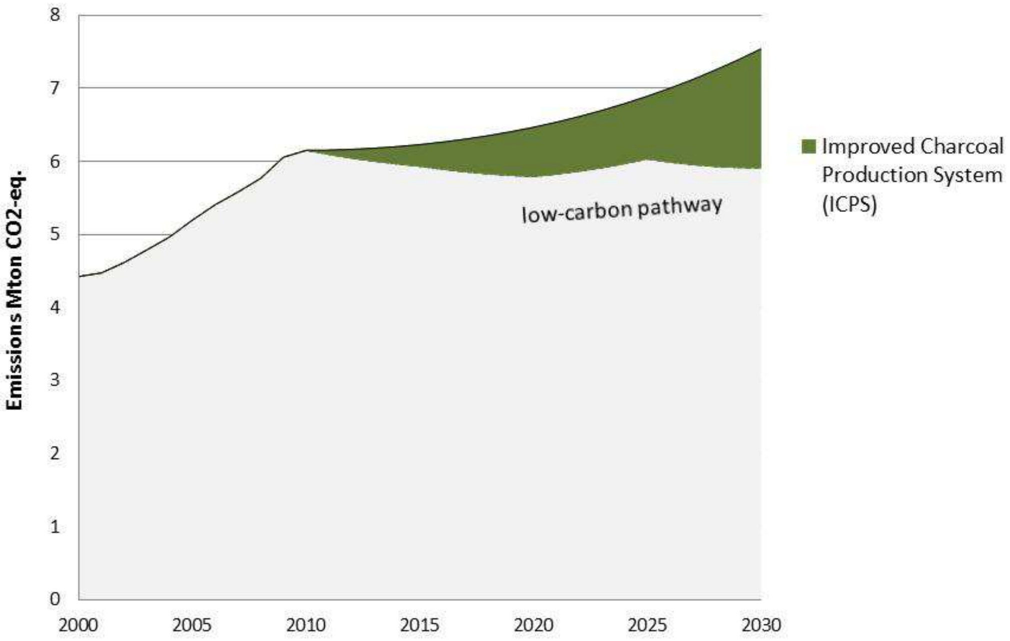
Figure 8.5 shows the abatement potentials for this improved charcoal production option. Emission reductions are 1.6 $MtCO_2e$ per year in 2030 assuming 35% unsustainable biomass use.

8.6.3 Costs

The investment cost of a low cost retort kiln is roughly $375.[12] The cost-effectiveness of deploying such an improved kiln highly depends on how much a charcoal manufacturer pays for the woody biomass used as input material for the manufacturing process, and if he can achieve a premium sales price for higher quality charcoal produced with the improved technology.

Data on abatement costs in the sector vary widely. A 2010 study in Tanzania found marginal abatement costs of US$ 70 per tCO_2e for improved charcoal production.[13] Other sources quote payback times of only five months for improved charcoal kilns, which implies negative abatement costs.[14]

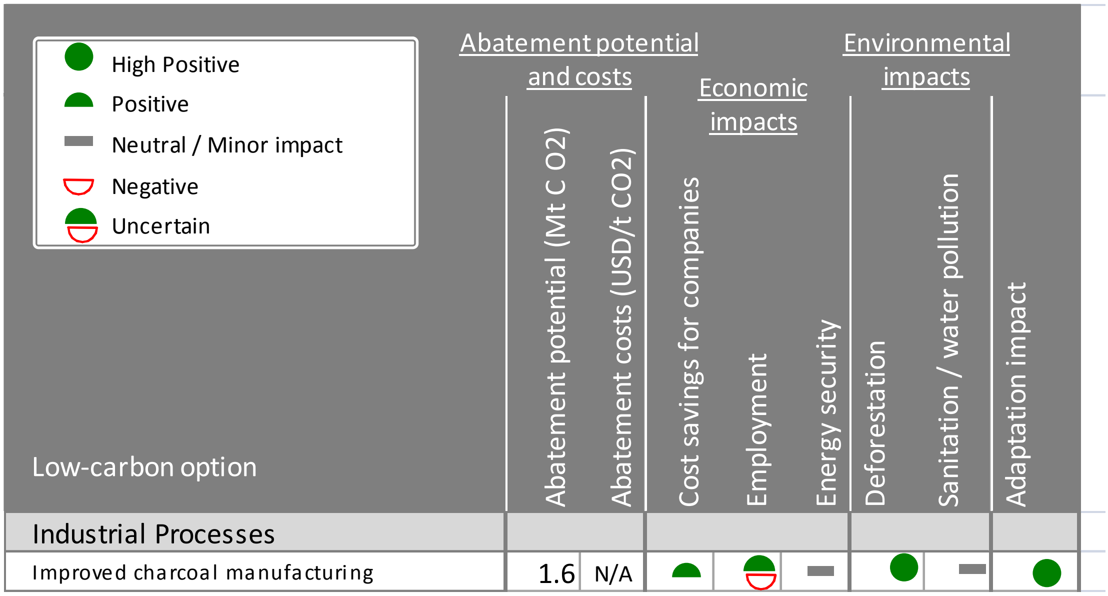
Figure 8.5: Low-carbon development option mitigation wedge in the industrial process emissions sector ($MtCO_2e$) assuming 35% unsustainable biomass use



8.6.4 Development impacts

Figure 8.6 shows the development impacts related to improved charcoal production. Broad implementation of improved charcoal production processes could have a significant positive impact on rates of deforestation, as less wood is required to produce the same amount of charcoal. There would also be potential benefits to government in the form of tax payments if the sector became more formal. It is also assumed that the profitability of charcoal production would increase with improved kilns (even though many retort kilns are relatively simple technologies).

Figure 8.6: Development impacts of improved charcoal production



● High Positive
◓ Positive
▬ Neutral / Minor impact
◡ Negative
⊖ Uncertain

	Abatement potential and costs		Economic impacts			Environmental impacts		
Low-carbon option	Abatement potential (Mt C O2)	Abatement costs (USD/t CO2)	Cost savings for companies	Employment	Energy security	Deforestation	Sanitation / water pollution	Adaptation impact
Industrial Processes								
Improved charcoal manufacturing	1.6	N/A	◓	⊖	▬	●	▬	●

Improved manufacturing processes are only likely if the sector is formalized. It is uncertain what impact such a development would have on the work and employment situation in the sector. The elimination of the middleman structure could have a positive overall effect on income generation in the sector. But individual producers who do not have access to sufficient capital to deploy improved production processes may be negatively impacted.

The charcoal industry may be able to use the invasive tree species *Prosopis juliflora* (locally known as "mathenge") as a substitute for local species. For example, charcoal producers associations have been formed in Garissa County to foster sustainable charcoal making, including the promotion of the use of mathenge.

8.6.5 Climate resilience

Charcoal production will not be directly susceptible to the possible impacts of climate change. However, improving charcoal production methods could increase Kenya's climate resilience because intact forests have higher water retention, and increased biomass cover lessens climate impacts.

8.6.7 Feasibility of implementation

The feasibility of implementation of improved charcoal production is dependent on the ability to regulate the market to reflect the true market value of fuelwood. The low-carbon development option provides large efficiency gains and short payback times of only five months have been reported for specific cases,[15] but the barriers associated with fixed kilns dominate. The most prominent barriers are the higher material costs and immobility. As fuelwood gets scarcer, wood will have to be harvested in increasingly remote areas, where the immobility of retort kilns will be a barrier.

8.7 Potential Policy Measures and Instruments

Fuelwood producers may be reluctant to invest in efficient retort kilns because currently they currently have near zero investment costs for both the wood collected and conversion materials. Policy measures exist to avert unregulated and illegal production, such as subsidies or payment schemes that reward efficiently produced charcoal. However, since these products would need to fetch higher prices in the market – rendering them uncompetitive when compared to illegally produced charcoal – a subsidy scheme can only be successful if regulation is simultaneously enforced on illegally produced charcoal. Hence a combination of subsidies and regulation is necessary to prevent negative impacts on the 700,000 people employed in the charcoal sector.[16]

A potential subsidy approach includes the use of results-based finance; a financial mechanism that purely rewards production per specified unit. When applied to the charcoal production sector, charcoal producers could be financially rewarded for the use of efficient charcoal production techniques, and paid per tonne produced. It may prove challenging, however, to introduce a monitoring scheme to verify the production practices and production quantities. In the long run the effects could include increased employment opportunities and improved regulation of the sector.[17]

8.8 Conclusion

This low-carbon scenario analysis demonstrates how improved charcoal production methods can lower GHG emissions compared to the reference case. More efficient charcoal production can have large sustainable development benefits. A main benefit is the reduction in the amount of wood needed for charcoal production, which decreases deforestation and, as a consequence, increases climate resilience. In addition, there can also be benefits for charcoal producers and government from formalizing the sector, but this is very dependent on the ability to enforce regulation.

Annex 1: Low-Carbon Development Option Fact Sheets

Improved Charcoal Production

This mitigation option considers a shift from the use of traditional earth mound kilns, which generally have an efficiency of 10 to 22 percent (calculated using oven-dry wood with zero percent water content) to an increased use of improved charcoal production systems (ICPS), using retort kilns with an efficiency of approximately 30 to 42 percent.[18]

Current situation: The large majority of charcoal production in Kenya relies on traditional earth-mound kilns.

Low-carbon scenario: The low-carbon scenario assumes a 50 percent penetration of charcoal production methods with 75 percent lower process emissions than the traditional earth-mound kilns by 2030.

Development benefits and priorities

Development benefits:

- Reduces the amount of fuel wood necessary per tonne of charcoal produced.
- Reduces the pressure on woodlots and forests.

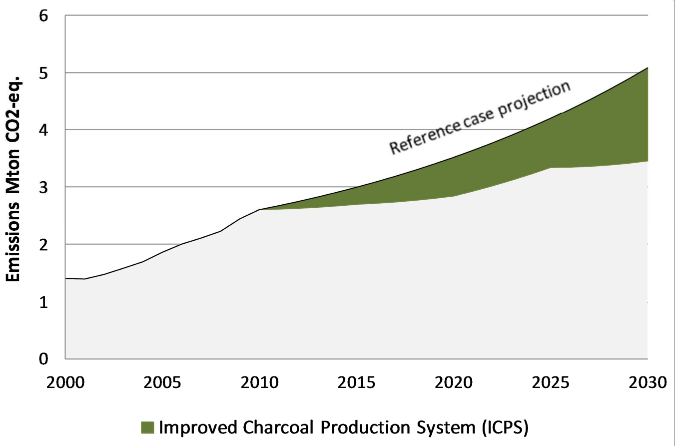
Alignment with Government of Kenya priorities: Vision 2030 and the Scaling- up Renewable Energy Program note that the overreliance on wood fuel is a challenge for Kenya.

Links to adaptation: Not directly affected by climate change; but indirectly, increased levels of desertification could result in increased pressure on available woodlots, forcing a shift to a substitute fuel. Improved charcoal production methods increase climate resilience by decreasing pressure on forests.

Abatement potential and costs

Greenhouse gas abatement: These efficiency improvements amount to an abatement potential of 1,628 $ktCO_2e$ per year in 2030. Note: this wedge includes emissions from biomass of which 35 percent is non-renewable.

Costs: Investment costs for an improved low-cost retort kiln are assumed to be roughly US$375.



Scenario	2010	2015	2020	2025	2030
Reduction in process emissions from improved kilns versus traditional earth-mound kilns	-	75%	75%	75%	75%
Adoption rate	-	10%	20%	30%	40%
Abatement potential ($ktCO_2e$)	-	296	674	858	1,628

Feasibility of implementation

Several interventions have been tried in many Sub-Saharan African countries to overcome barriers to the adoption of improved charcoal production methods, but adoption rate has been limited. The main reason is the informal—and often illegal—nature of the charcoal production industry. In addition, higher material costs, increased labour input and lack of knowledge are disincentives for charcoal burners to adopt improved technologies.[19]

Endnotes

---

[1] Energy for Sustainable Development. 2007. *Situation Analysis of Charcoal Dynamics, Energy Policies and Possibilities of Switching to Alternatives*. Dar es Salaam: WWF-Tanzania Program Office.

[2] Government of Kenya. 2007. *Vision 2030 - A Globally Competitive and Prosperous Kenya*. Nairobi: Government of Kenya

[3] Intergovernmental Panel on Climate Change (IPCC). 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Hayama: Institute for Global Environmental Strategies on behalf of the IPCC.

[4] Ministry of Environment and Natural Resources. 2002. *First National Communications of Kenya tit eh Conference of the Parties to the United National Framework Convention on Climate Change (UNFCCC).* Nairobi: Republic of Kenya, Ministry of Environment and Natural Resources.

[5] IPCC. 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Hayama: Institute for Global Environmental Strategies on behalf of the IPCC.

[6] IPCC. 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Hayama: Institute for Global Environmental Strategies on behalf of the IPCC.

[7] Ministry of Environment and Natural Resources. 2002. *First National Communications of Kenya tit eh Conference of the Parties to the United National Framework Convention on Climate Change (UNFCCC).* Nairobi: Republic of Kenya, Ministry of Environment and Natural Resources.

[8] Adam, J.C. 2009. "Improved and more environmentally friendly charcoal production system using a low-cost retort-kiln (Eco-charcoal)," *Renewable Energy*. January.

[9] Pyrolysis is one of the processes in charring, which produces gas and liquids but leaves a solid residue richer in carbon.

[10] Africa Renewable Energy Access Program. 2011. *Wood-Based Biomass Energy Development for Sub-Saharan Africa*. Washington, D.C.: International Bank for Reconstruction and Development and the World Bank.

[11] Adam, J.C. 2009.

[12] Adam, J.C. 2009.

[13] Global Climate Adaptation Partnership, Stockholm Environment Institute and Dew Point for UK Aid. 2010. *Opportunities for Low Carbon Growth in Tanzania: An assessment of future emissions growth and low carbon reduction potential.* Submission to the Development Partners Group.

[14] Adam, J.C. 2009.

[15] Adam, J.C. 2009.

[16] Sepp, S., 2008, *Promotion of Sustainable Charcoal Production Through Community Level Approaches: Experiences and Lessons Learned from Selected Sub-Saharan African Countries*, Discussion paper.

[17] Africa Renewable Energy Access Program. 2011.

[18] Adam, J.C. 2009.

[19] Africa Renewable Energy Access Program. 2011.