5) Assessment of a low carbon pathway for Kenya

There is the potential to implement no regret (win-win) measures across many areas of economic activity in Kenya, which are available at negative cost now, and improve economic efficiency, as well as delivering low carbon and development objectives. They can also provide important benefits from reducing (fossil) energy imports, enhancing energy security, improving air quality and health, reducing pressures on natural resources, and potentially improving adaptation capability by exploiting synergies.

Low carbon options are important to ensure future growth in Kenya avoids getting ‘locked’ in to high emission pathways, and to allow maximum potential for capturing financing opportunities now and in the future. In advancing all of these areas, there is an important role for domestic policy (taxation, regulatory, incentives etc) to encourage low carbon technology development, diffusion and deployment. This also includes the reform of fossil fuel subsidies and low electricity tariffs. Curbing deforestation is also part of this low carbon pathway, and is now the subject of potential new financing flows (reducing emissions from deforestation and forest degradation in developing countries (REDD)) and also provides protection of natural habitats and ecosystem services.

In this section of the report, a number of the most promising low carbon options have been considered that could put Kenya on to a lower carbon development and growth pathway, focusing on those sectors where emissions are projected to be significant. In addition, there is also some discussion about the issues of implementation (particularly barriers) and some of the policies that may be required to ensure such options are taken up.

The key priority options include:

- Electricity sector decarbonisation, including decentralized technologies
- Reducing transport fuel consumption through improved vehicle efficiency
- Introducing efficient public transport system
- Improving the efficiency of the biomass stove stock
- Industry efficiency improvements
- Reducing agriculture emissions through livestock and cropland management
- Reducing forestry emissions through forest protection and afforestation

In assessing these measures, their marginal abatement cost (cost-effectiveness) and emission reduction potential are estimated, and the wider benefits. To do this the study has estimated:

- The indicative unit marginal abatement cost of potential measures, comparing the potential emissions reductions of a measure against the potential annual emission of carbon, thus expressing options in terms of their cost-effectiveness, or $/t$CO_2$ abated.
- Assessing the potential opportunity for the options looking at current activity levels and projections through to 2020.
- Combining these to build up an indicative marginal abatement cost curve, i.e. looking at the attractiveness of options in terms of their cost-effectiveness, and assessing the potential total reductions they could achieve through implementation.

Note that the mitigation potential and costs used are indicative, to demonstrate where key savings can be made. The potential is derived from initial projections that we consider to require significant additional work, and marginal cost estimates are not fully Kenya specific. Despite this uncertainty, the assessment can provide policy makers with some of the key options, the order of magnitude of savings and indicative investment requirements.

Framework for assessing options for a lower carbon future

As implied throughout this report, low carbon options will not be introduced to reduce emissions alone. Investment will be driven by the need to improve economic productivity and deliver growth, improve transport infrastructure and reduce inefficiency in energy and materials used. In this development and economic context, emission reductions are effectively a co-benefit of other policy drivers, and the introduction of these options is driven by self-interest, economic and development objectives. However, the introduction of carbon financing has the potential to increase the relative attractiveness of these options and to help finance their introduction.

In particular, options should:

- Further the goals of development, including poverty alleviation and economic growth
- Promote greater energy security, particularly in reducing reliance on high price fossil / electricity imports
- Enhance environmental sustainability
- Meet objectives of, or at least not conflict with, adaptation strategies
- Provide opportunities for investment through carbon financing

A range of questions to aid assessment of wider benefits are listed below.

Criteria	**Assessment questions**
Economic development	Are economic development objectives, as set out in the Vision document, enhanced through uptake of measure?
Poverty alleviation	Is the option going to help reduce poverty e.g. through enhancing access to energy?
Climate change adaptation	What are the linkages? Is the introduction of measure synergistic to adaptation objectives or does it involve conflicts? How climate resilient is it?
Other social benefits	Does the option increase productivity, reduce time spent on basics (water, fuel collection), provide gender opportunities, improve housing, access to education etc?
Energy security	If relevant, does the measure promote greater energy security or diversity?
Technology modernisation	Is option promoting new technology uptake / transfer?
Other environmental co-benefits	Does option protect habitats, reduce air pollution, preserve natural resources?
Financing and scaling	What are the opportunities for financing and scaling opportunity up?
Barriers to update	What are the key barriers to uptake? Are they easily overcome?

A possible framework for appraising options is shown in Figure 24, taking account of the cost-effectiveness of a given option, and the wider policy considerations (right-hand side).It is also important that cost-effectiveness numbers are also scrutinized against a number of other factors that could have a bearing on the feasibility of a given measure, or how appropriate it is:

- Capital intensity. Many options may require high upfront capital investment. Such investment may be difficult to raise, and therefore this issue needs to be considered.
- Fuel price sensitivity. The cost-effectiveness may be highly sensitive to changes in fuel prices, particularly where cost reduction is primarily based on fuel savings.
- Carbon intensity. Changing carbon intensity of electricity can drastically change the cost-effectiveness of an option. For example, options that save electricity are likely to disbenefit from reducing carbon intensity in the generation sector.

- Local experience. Previous experience of option implementation and associated expertise can affect the C-E of an option, in terms of lowering costs and ensuring robust installation and maintenance which can affect emission reduction performance.

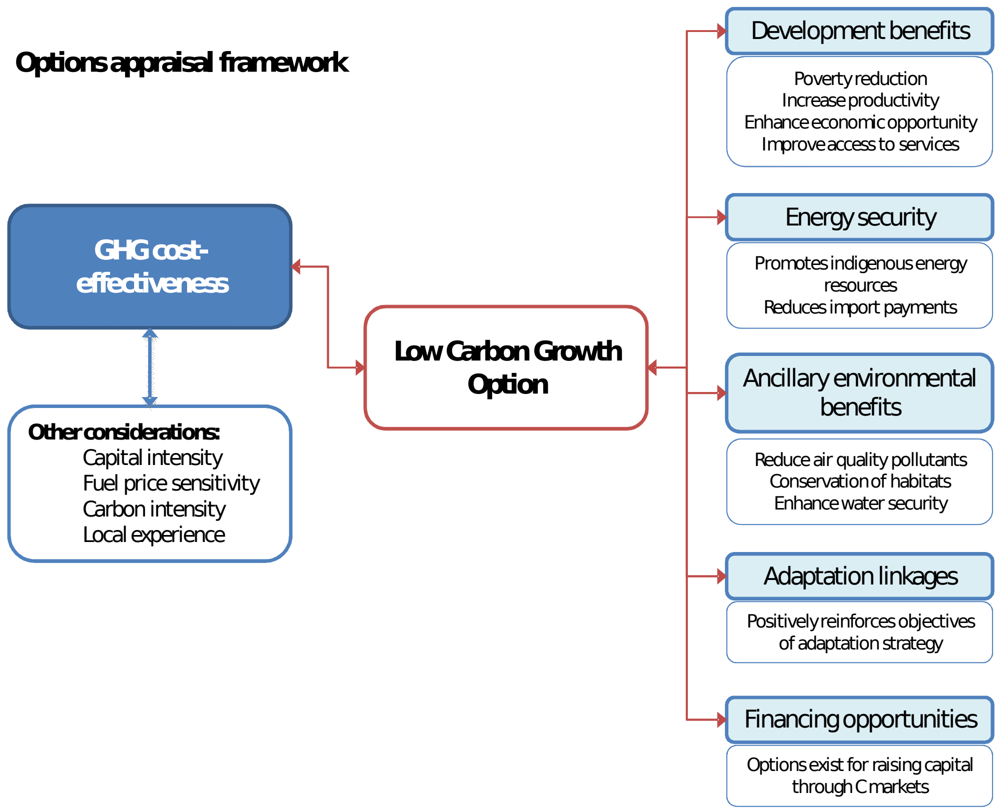
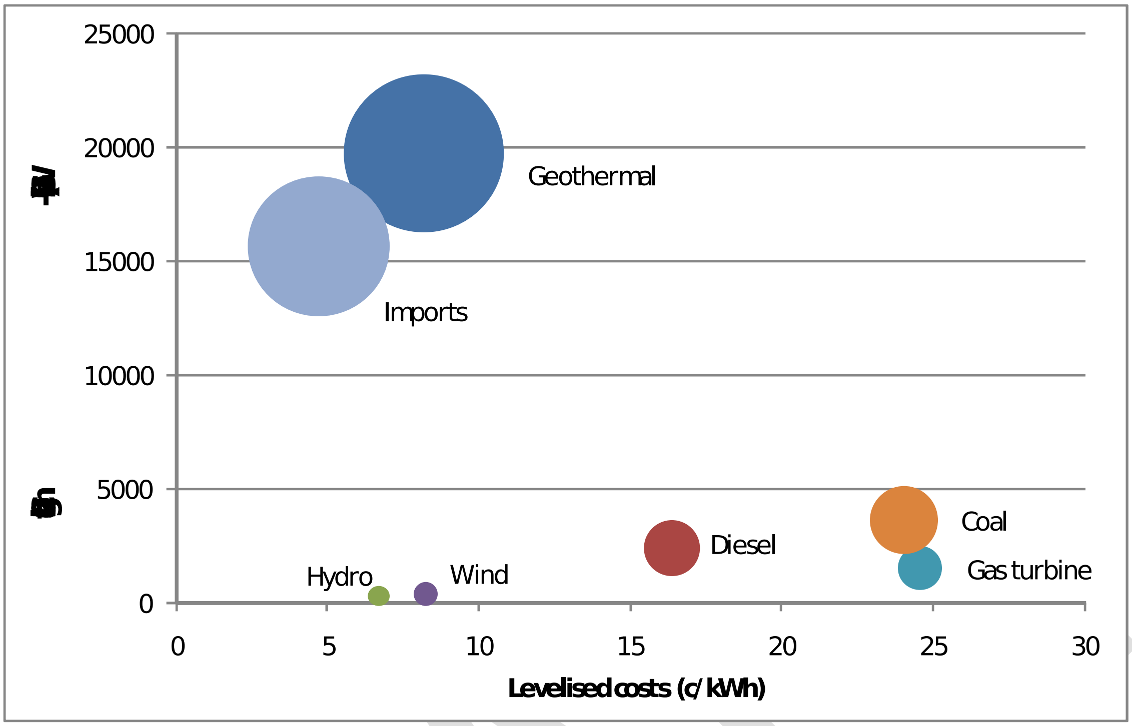


Figure 24. Options appraisal framework for low carbon growth options in LICs

Electricity generation

Kenya's electricity system is relatively low carbon. The immediate plans will lead to a further reduction in the carbon intensity, but the introduction of coal will reverse this trend by around 2020. To further reduce the intensity of the system, renewable generation could replace some of the planned future coal and diesel generation, although a proportion of this may be needed to balance the grid. There could also be some clear risks with this strategy, if any replacement concentrates the mix further towards one single technology (particularly hydro), especially in light of the potential effects from future climate change. However, clear benefits from such a policy would be a reduction in fossil imports, and potentially lower costs of generation, reduced air pollution impacts (coal in particular is a very high emitter of pollutants), and greater security of supply.

The low carbon future generation mix as projected in the LCPDP is illustrated in Figure 25 below. This shows the cumulative generation over the next 20 years from new investment versus the levelised cost of generation (not the electricity price). It shows that low carbon imports and geothermal will be the main generation types, and that these are considerably lower cost than fossil alternatives. They are also extremely cost-effective in carbon mitigation terms when compared to the average or marginal generation alternative. Due to the very high imported fossil prices and the availability of renewable generation, a low carbon future for this sector makes economic sense. It is highlighted that the costs of the fossil fuels are far to the right of the figure, i.e. they have the highest levelised costs.



* Coal operating at 20% plant utilization; hence the higher levelised costs
* Cost of capital set at 12% as per the LCPDP analysis
* Renewable generation costs derived from ESMAP (2007); thermal plant costs sourced from LCPDP and deflated to 2005 cost basis
* Base Crude Oil Price of US$100, Coal Price 135 US$/M Tonne (in LCPDP)

Figure 25. Cumulative generation (GWh) between 2009-2029 versus cost of generation (c/kWh)

Despite the obvious economic benefits, a key challenge remains the raising of investment to scale up to these levels of installed capacity, and the associated grid infrastructure and connections. Therefore, further market re-structuring may be needed to encourage private sector investment. Other important challenges remain the vulnerability to climate impacts from reliance on imported hydro generation (see main impacts study), and associated energy security issues from regionalizing supply.

The potential of options shown above does not feature significantly in the cost-curve analysis as it forms part of Government projections for the sector, informed by the central Vision 2030 growth assumptions. However, uncertainties are significant in this long term plan, as illustrated in the projection section (3), where it was demonstrated what a 30% reduction in imports might result in with respect to emissions.

Distributed or off-grid generation is not fully captured in the projections of the LCPDP. These could have an important role to play, particularly in the provision of electricity to rural areas where grid distribution is not feasible or economically viable. In 2020, the forecasts for electrification show that around 35% of households will be connected; this therefore leaves a significant potential for micro-scale generation.

The ESMAP (2007) report draws some interesting conclusions about two types of distributed provision – mini-grid and off-grid. For off-grid systems, it concludes that renewable energy is often more economical than conventional generation for off-grid (less than 5 kW) and mini-grid (5-500 kW load) applications. Technologies such as wind, mini-hydro and biomass-electric – can deliver the lowest generation costs, critically assuming availability of good renewable resources. Micro-hydro *can deliver electricity for US¢10-20/kilo watt (s) per hour (kWh), less than one-quarter of the US¢40-60/kWh for comparably-sized gasoline* *and diesel engine generators*. The costs of supplying electricity by a mini-grid may lead to significant increases in the overall costs of generation. This will depend on the size of the network and the power load.

Kenya has good biomass and hydro resources which could potentially be exploited for off-grid and mini-grid generation. However these generation technologies (at this scale) may be significantly more expensive than centralised plant, and investment without subsidy or grant makes purchase very difficult, particularly at the household level.

A number of options have been included in an indicative cost curve for Kenya in 2020 (see Figure 26). This cost curve is to illustrate a range of options and their potential and costs. For electricity generation, the following have been considered:

- Wind (centralised)
- Solar PV (centralised)
- Geothermal (centralised). This is 3 additional plants to what is forecast in the baseline.
- Hydro (mini-grid)
- Wind (mini-grid)
- Solar PV (mini-grid)

Table 11 provides information on the mitigation costs and potential CO_2 savings in 2020 if these options were introduced. Sector-based savings could be in the region of 80%, with these options replacing 13% of baseline generation. Renewable options tend to have lower mitigation costs as seen in other cost curve examples due to the high price of fuel in diesel generators, and the higher capacity factors of renewable options (due to very good solar / wind resources). In addition, the capital costs of renewables are not current year costs but factor in learning effects across these technologies.

Table 11. Comparison of generation costs in 2020 for centralised and decentralized electricity options and marginal abatement costs of alternative renewable technologies

Technology	No. of plant / schemes	Plant capacity	Generation cost	Mitigation cost / tonne	Total CO2 saving	Generation
		MW	*c/kWh*	*$/tCO2*	*% 2020 sector emissions*	*% 2020 baseline GWh*
Diesel plant		5	16			
Geothermal	3	70	10	-19	42.8%	6.6%
Wind (centralised)	15	10	5	-80	15.3%	2.3%
Solar PV (centralised)	30	5	24	47	11.5%	1.8%
Diesel generator		0.10	20			
Micro-hydro	500	0.10	12	-42.8	3.8%	0.6%
Micro-Wind	1000	0.10	21	2.7	5.1%	0.8%
Small PV system	3000	0.025	39	87.4	3.8%	0.6%

* All costs in USD 2005
* Current year PV capital costs have been reduced by 30% to reflect reductions by 2030.
* 10% discount rate used
Primary sources: ESMAP (2007) for mini-grid technologies; KPLC (2008) for centralised grid technologies

For decentralized technologies, the proposed numbers of schemes do not take barriers of uptake / scaling into account. Rather they are indicative of the costs and emission reduction potential of providing rural electricity generation by renewable rather than diesel generation. To put this into context, 500 micro-hydro schemes could provide electricity to over 1 million people, assuming that each scheme reaches 400 households.

Whilst micro-hydro is cost-effective, there are issues around finding suitable locations that offer relatively secure running water all year round. UNDP (2006) mentioned scale-up potential of 100 schemes, although other estimates of potential have been put much higher. Another important point is that capital costs also vary depending on location and labour costs. In a paper published on the Practical Action website *Micro-hydro power: an option for socio-economic development* (by Dr Smail Khennas and Andrew Barnett), a cost range of $655-5630 per kW (USD 1998) was suggested. PV and wind are less economic, although costs of wind could be significantly lowered where reliable and stronger wind speeds are experienced. In addition, they are more capital intensive, meaning that raising investment becomes a more significant issue.

There are options that could lead to a lower carbon system than observed in the baseline by 2020, which Kenya could implement. Post-2020, increasing renewable options could also reduce some of the coal based generation that is projected. However, more analysis would be needed to ensure that Kenya is able to maintain a balanced and reliable grid system with an increasing renewable load.

There are of course risks of a higher carbon (and more costly) system in future years if climate impacts affect hydro availability. Due to low rainfall in Kenya since mid 2008, the electricity system carbon intensity has increased due to increased use of diesel generation plus load shedding (managed reduction in supply) has become more frequent. Kenya will continue to be exposed in future years, particularly through its import of hydro-generated electricity from other countries in the region, particularly Ethiopia; domestic and imported hydropower is projected to be around 40% in 2030. A recent ECA working group report (2009) looked at this issue for Tanzania, which relies on hydropower for 50% of electricity supplied. An analysis was undertaken that assessed the additional costs of reduced supply to the economy, use of more costly alternative generation and loss of generation revenues. Under a high climate impact case, GDP losses were put at 1.7% GDP due to shortfall in electricity versus 0.1% if no climate impacts were realised. The analysis then focused on how this shortfall could be averted, suggesting that efficiency improvements across the economy could achieve this.

The above analysis illustrates the importance of building in climate resilience aspects into any low carbon pathway. The ECA analysis suggests necessary resilience in the case of Tanzania could be met through negative costs measures. However, climate variability may result in much more extreme shortfalls in one year followed by more stable climate conditions in following years. So the problem may also be one of extreme variability rather than average rainfall reductions year-on-year.

Household / commercial sector options

Biomass will remain one of the primary sources for meeting energy needs in future years. In 2030, it is projected to still provide 60% of household energy requirements. There are a number of technology-based options that could be considered for displacing or reducing reliance in solid biomass-based energy including:

- Improved stove efficiency
- Solar cookers
- Biogas digesters (particularly on smallholdings where cattle are kept)

Much of the literature suggests that improved stove efficiency could achieve up to 50% reduction in household wood fuel consumption, and between 60-70% in a large institution (commercial premises, school etc) (GTZ (2004), GEF (2005), UNDP (2006), GTZ website).

Efficient stoves are extremely cost-effective, in the sense that they save a significant amount of money where wood fuel costs are incurred. GTZ (2004) states that for households up to 30% of monthly income can be saved, and if collection is involved between 10–20 hours saved per week, allowing time particularly for women to engage in productive labour. In Kenya, a very short a payback period of two and a half months was calculated for an improved stove as compared to a service life of three years. A more recent survey showed a lifetime of 8–9 years, which would triple the amount of savings realised. As illustrated earlier in this report, significant savings can also be made at the institution level (schools, hospital etc) through introducing improved stoves.

A study by Habermehl (2007) for GTZ in Uganda calculated the economic benefits of an improved stove programme, while the institution level information is taken from a Kenya case study of improved stoves for schools (implemented by RETAP under the GEF Small Grants programme). The data used in those analyses are reproduced below, to illustrate cost-effectiveness in carbon mitigation terms of options (which are exclusive).

Table 12. Fuel and emission savings from use of improved stoves, and cost-effectiveness for mitigation

Technology	*Annual fuel saving*	*Monthly fuel saving*	*Payback period*	*Emission saving*	*C-E*
	Kg	Kg	Months	t CO_2 eq	\$/tCO_2
Rocket Lorena Stove	22.48	1.9	2.1	0.143	-148.1
Charcoal saving	10.98	0.9	10.9	0.018	-395.2

Source: Habermehl (2007). Above data estimates are per stove, and use a 10% discount rate.

Technology	*Annual fuel saving*	*Monthly fuel saving*	*Payback period*	*Emission saving*	*C-E*
	Kg	Kg	Months	t CO_2 eq	\$/tCO_2
Institution stove	1000	83.3	18.0	12.234	-61.8

Source: GEF Small Grants Programme, Stoves for schools in Mt Kenya region. Above data estimates are per stove, and use a 10% discount rate.

The stove options are very cost-effective and require low capital investment. Payback period is rapid due to the fuel savings (note that the above estimates for household stoves include fuel cost saving on half of the overall fuel saved, as half is assumed to be collected) meaning that this type of measure is cost-effective even without all of the other significant benefits including:

- Reduced health impacts resulting from lower levels of indoor air pollution
- Reduced cooking time
- Reduced time spent gathering fuel
- Lower burden on forests

As discussed earlier in this report, penetration of stove programmes has been successful, and the latest energy policy statement suggests strong ambitions in this area. In this analysis, potential uptake of improved woodfuel stoves is assumed for 5 million households in rural areas, and for charcoal stoves, 1 million households. Take up for 10,000 institutions is assumed. Note that these are not maximum potential numbers but rather illustrative of what could be achieved and at what cost.

These assumptions lead to savings potential of around 20% in 2020, all of which is at negative cost. Clearly, the assumed price of biomass fuels is a critical assumption here, a parameter that is likely to vary in different parts of Kenya (based on local market supply).

Transport sector

Transport emissions are going to be one of the key drivers of rising GHG emissions in future years in Kenya. This is because of significant increases in private car travel demand as incomes rise. Clearly this also has serious implications for urban spatial planning and environmental quality, especially given population and urbanisation trends.

There are two significant issues for Kenya that are considered in this analysis: - improving the fuel efficiency of the vehicle fleet (due to the very high percentage of second hand cars) and considering mass transport options in urban areas.

On fuel efficiency, Kenya has a significant second hand vehicle market. UNEP (2006) estimated over 50% of the vehicle stock of 700,000 was 15 years or older, and over 70% 10 years or older in 2004. A significant proportion, ~25%, is over 25 years. The potential for improved efficiency has been considered for HDVs, LDVs, and cars in 2020, particularly as these vehicle types account for 90+% of total vehicles (in 2004). These older cars also tend to have higher emissions of air pollution, higher noise levels, and lower safety standards. Options for hybrid vehicles have also been considered.

The above five options considered are presented in Table 13, with saving potential and cost. The first three options remove (de-register) stock that is over 15 years old.[43] The additional capital required for these options are estimated as new vehicle price minus the assumed cost of two second hand cars (70% of new vehicle price), as it is assumed that two second hand vehicles would need to be purchased within 15 years. Note these assumptions about costs of alternative second hand cars and replacement rate have a signficiant impact on cost-effectiveness. Options relating to LDVs appear more cost-effective due to the larger fuel savings based on a higher annual usage. The HDV option simply improves the efficiency of older vehicles by assuming a vehicle that is 10 years older.

Table 13. Emission and cost savings from vehicle efficiency improvements, and mitigation cost-effectiveness

Option	*Stock age*	*MAC*	*Road transport sector CO2 saving*
	Yrs	$/tCO2	%
Reduced older car stock (>15 years)	15-25	121.2	1.5%
	>25	-120.3	0.7%
Reduced older LDV (GSL) stock (>15 years)	15-25	66.6	0.4%
	>25	-189.6	4.1%
Reduced older LDV (DSL) stock (>15 years)	15-25	140.2	2.0%
	>25	-138.0	1.2%
Improve HDV efficiency	>15	-157.9	5.6%
Hybrid uptake (5% cars)		-58.2	1.8%

* 10% discount rate used
* Technology data assumptions sourced from UK MARKAL transport sector analysis

The fifth option shows 5% of new cars being purchased as hybrids rather than the conventional gasoline

[43] Note that we assume a 15 year old car in 2030 to have the efficiency of a vehicle in 2015.

ICE. This measure is relatively cost effective due to the lower price differential between hybrids and ICEs by 2020, and the relative efficiency improvement versus an ICE vehicle.

A Bus Rapid Transport (BRT) option has also been considered for Kenya; although one is being planned in Nairobi, it does not feature in the baseline. This option is primarily illustrative, to indicate where it is positioned in the range of measures in terms of cost and potential. Costs have been taken from Kahn Ribeiro (2007), citing Wright and Fulton (2005), of around $60/tCO_2$. Potential is premised on an additional 10% of Nairobi's population (40% of Kenya's urban population in 2020) taking up this option, moving away from older car stock to efficient buses.

All of the options below are included in the illustrative cost curve in Figure 26. There are a range of other technologies that could improve the efficiency of the fleet (including advanced technologies, such as electric vehicles) plus other options for reducing reliance on petroleum products e.g. biofuels. It is important that all such options are fully considered, with consideration of all of the costs and benefits. A more efficient road transport fleet is likely to have the following benefits in addition to reducing carbon:

- Reducing reliance and expenditure on oil imports
- Reducing business and private costs of travel, and increasing competitiveness of the economy
- Reducing air pollution, particularly in urban areas
- Improving road safety due to an increase in newer vehicles

One potential negative impact is that legislation to reduce the availability of older vehicles may have a distributional impact on lower income groups, by impacting on the affordability of travel due to large upfront costs of vehicle purchase.

In addition to increasing efficiency, it is imperative for expanding urban areas that planned transport systems are put in place to ensure mobility of the population can be maintained and urban environmental quality not compromised. This is very challenging and requires significant upfront costs but is critical for meeting travel demand and ensuring quality of life for a growing urban population.

Industry sector

The projections for the manufacturing sector are based on current year oil consumption, growing at a rate similar to that suggested for the economy with some autonomous energy efficiency improvements. Hence, they are relatively simplistic. The potential for energy efficiency improvement in 2020 is based on a project supported by GEF (1998) which in trying to understand how the programme could be scaled undertook some assessment of efficiency potential in SMEs. This analysis has been used to estimate potential for energy savings, and marginal abatement costs. The analysis suggests that on average there is about 16% potential savings in oil use; if this was applied to 40% consumption across all industry sectors, this would equate to over 250 Gg CO_2, or 6% of sector emissions. Marginal costs (based on a 15 year programme) are estimated to be $20/tCO_2$.

Much more work is required in this sector to understand efficiency potential in different subsectors of manufacturing. In addition, there may be a range of different technology options for larger industries that may improve productivity of the economy whilst also providing carbon benefits.

Agriculture sector

Agriculture projections are extremely uncertain, particularly because the inventory estimates (GoK 2002) are not recent and incomplete (compared to other country inventories). A simplified approach, due to high uncertainty of agriculture sector emissions, has been to use mitigation cost and reduction potential estimates for Africa from the comprehensive USEPA study (2006) on non-CO_2 mitigation options and apply them to the Kenya situation. Options for livestock management, particularly focusing on enteric fermentation, could reduce emissions by 2.1% at \$15/tCO_2 or by 0.5% at \$0/tCO_2. For cropland management, to reduce N_2O emissions in particular, we have used the following % reductions: 13.5% at \$15/tCO_2 or by 10.6% at \$0/tCO_2.

Whilst this approach is basic, it has been used provide some preliminary understanding of the extent of reduction potential at given costs for generic agriculture emission categories. At higher costs, mitigation does not increase significantly; McKinsey analysis supports this finding by estimating average abatement costs of around \$5-10 for agriculture sector in Africa (Grantham Institute 2009). On mitigation potential, it is difficult to compare the Grantham analysis with that produced by the USEPA due to different baselines and different analysis years.

Forestry sector

Kenya plans not only to preserve its forest cover but embark on a large-scale afforestation / reforestation programme. The Government has developed some initial thinking on the types of activities required, and the investment requirements. Costs are put in the region of \$385 million per annum (for 20 years), to increase forest cover from the current 3% of land area to 10%.

Therefore, we have not undertaken any additional analysis here to look at costs and potential. However, it is worth noting a number of points when considering such options from an economic perspective:

- The benefits are clear – preserving biodiversity, safeguarding tourism, improving security of fuel wood supply, improving prospects for forest based industries, retaining natural water management, and making habitats more resilient to some of the impacts of climate change.
- A potential cost is the opportunity cost lost from not using the land for another type of economic activity. Agricultural commodity prices and land rents are going to have a big impact on such costs.
- Raising the necessary investment is going to be challenging; REDD is an emerging mechanism for financing the safeguarding of existing forests. Financing will need to be found for afforestation – a current example if a project the Green Belt Movement has which is funded by the World Bank BioCarbon Fund.
- Rapid development if delivered at the projected rates would lead to significant economic pressures on the current forests but also on the land that might be designated for new forest area.

From a purely mitigation perspective, the emerging consensus is that measures to reduce forest loss and degradation, and reforestation, are relatively low cost. Cited in Nabuurs et al. (2007), Sohngen and Sedjo (2006) estimate that for 27.2 US\$/tCO_2, deforestation could potentially be virtually eliminated. Over 50 years, this could mean a net cumulative gain globally of 278,000 $MtCO_2$ relative to the baseline and 422 million additional hectares. At least 60% of this could be done at a carbon price near to 13 US\$/tCO_2. Relative to other regions (except South East Asia, Africa has most potential at these lower carbon prices.

Additionally, modelling results presented Nabuurs et al. (2007) suggest that 70% of mitigation potential identified could be implemented at a carbon price of between 1-20 US\$/tCO_2. Analysis by McKinsey (2009) supports the fact that forestry measures tend to be relatively low cost to those observed in other sectors.

More assessment is required for this sector to understand the costs of reducing deforestation / increasing afforestation for Kenya, particularly in the context of increasing opportunities for financing. Momentum is building in the discussions around a REDD+ mechanism prior to Copenhagen, as set out by the recent working group report on phasing funding over the next 5 years (IWG-IFR 2009); it will be important for Kenya to better understand its potential for access such financing, and how this can link in with the Government's own strategy for afforestation and forest protection.

An indicative cost curve for Kenya

An indicative cost curve for Kenya is provided below for 2020. It does not represent total potential in 2020 but includes the example measures described above. The primary purpose is to demonstrate that Kenya can move to a lower carbon pathway without significantly impacting on growth; in fact, many of the measures would make the economy more productive and competitive. Many lower carbon options therefore promote rather than undermine the ambitions of growth. This is particularly the case concerning energy efficiency measures, which reduce fuel costs.

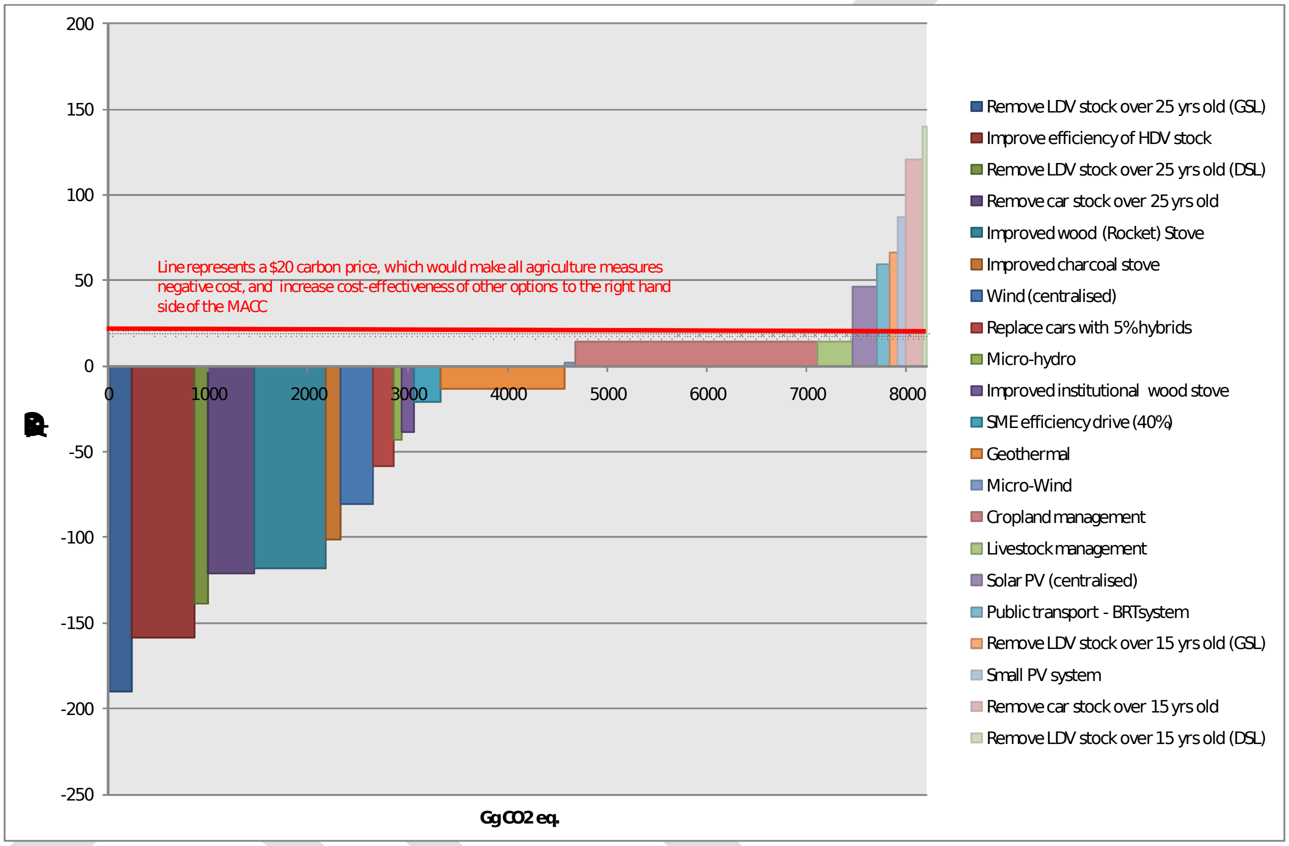


Figure 26. Indicative MAC curve of selected abatement measures for Kenya in 2020[44]

All future cost and benefits are discounted at 10%, using the net present value.[45] The first measure listed in the legend is the most cost-effective, shown as the bar further left on the MACC figure. Subsequent measures are listed in order of cost-effectiveness. The cost curve identifies that significant 'no regrets' potential is available (almost 50% of stated potential), particularly from improvements in transport vehicle efficiency, and performance of domestic stoves. The agriculture sector options are low cost (<$15 /t$CO_2$), resulting in no regrets / low cost options accounting for over 80% of stated potential.

The carbon credits that could be available for emission reductions are not included in the cost curve analysis. If they were, the negative cost potential would increase, and least cost-effective options would appear more attractive, as shown by the red line illustrating a $20 carbon price. Therefore, the above MACC represents a less optimistic situation, where additional financing is not available. This is encouraging, given the number of low or negative costs measures in the absence of a carbon price.

[44] Fossil prices consistent with those presented in Kenya's LCPDP for electricity generation measures. For transport fuel prices, current petrol / diesel prices have been used.(~100 KSh / litre). Biomass prices based on those cited by Habermehl (2007)

[45] Agricultural and public transport measures use costs derived directly from literature and therefore the discount rate is not known.

The emission reduction potential shown in the above MAC curve for 2020 is compared against the 2020 baseline for energy using sectors (Figure 27). These sectors have the potential to produce savings of 22% relative to the baseline. Of the potential savings, over 80% can be realised at negative or low cost.

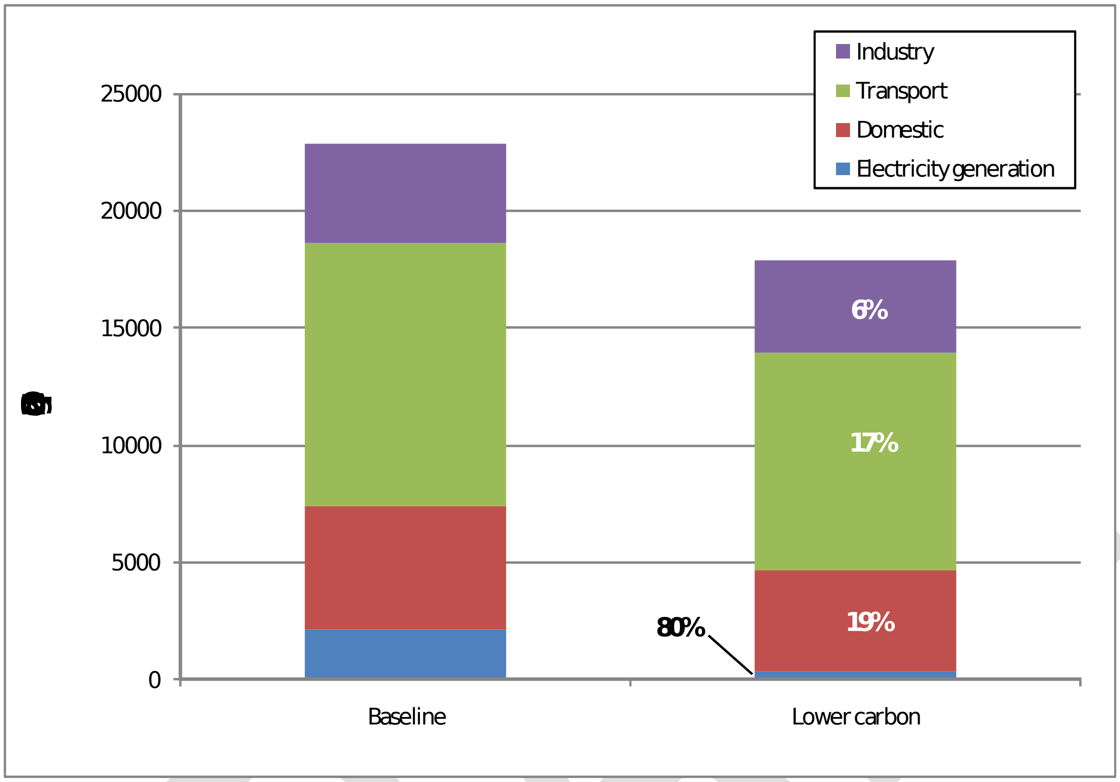


Figure 27. Kenyan emission in 2020 under the baseline and *lower carbon* case

* The % labels in the *Lower carbon* case denote % reduction by sector relative to baseline

The inclusion of agriculture sector emissions results in an overall reduction of 13%. This is lower than the 22% reported above due to the high level of the emissions from this sector.

Pertinent issues with the above MACC approach

The above MACC analysis needs to be considered in view of a number of other issues:

- **The MACC does not represent full potential**. Specific subsectors (non-road transport) and sectors (waste) have not been included. For sectors considered, only specific examples have been included. Therefore, significant additional potential is likely to be available.
- The MACC (for most measures) does not include policy / transaction costs which may be significant for implementing some of the measures listed. Project Catalyst estimate transaction costs in the region of \$1-6 /tCO_2 globally (Grantham Research Institute 2009).
- The MACC is for a single year, 2020, chosen because it represents around 10 years from current time, a period of time when progress of moving to a lower carbon pathway could be achieved. It is likely that with rising emissions post-2020, more expensive options, particularly in the transport sector, will be needed.
- Specific types of measures (which may be cost-effective) are more difficult to quantify and have therefore not been included. These include non-technical options e,g. driving behavior improvement, and issues associated with urban planning, which are very important in the context of Kenya.

- There are a number of drivers, important for Kenya, which are not included in the projections e.g. the potential effects on agricultural air freighted export markets from international emission reductions, or the effects on the long-haul tourist potential for Kenya with international emission reductions on aviation

Wider issues with the use of MACCs are outlined in the Box below.

Wider issues concerning the use of MACCs

There is no doubt that MACCs have provided an important role in helping explore mitigation options, and identifying those opportunities that are most cost-effective. However, there is both a danger of misinterpretation of and over-reliance on this approach. Misinterpretation comes because of the absence of information on underlying assumptions. Large amounts of cost-effective potential can be observed and provide an impression that this is easily attainable, without noting the many caveats and simplifications that have been made.

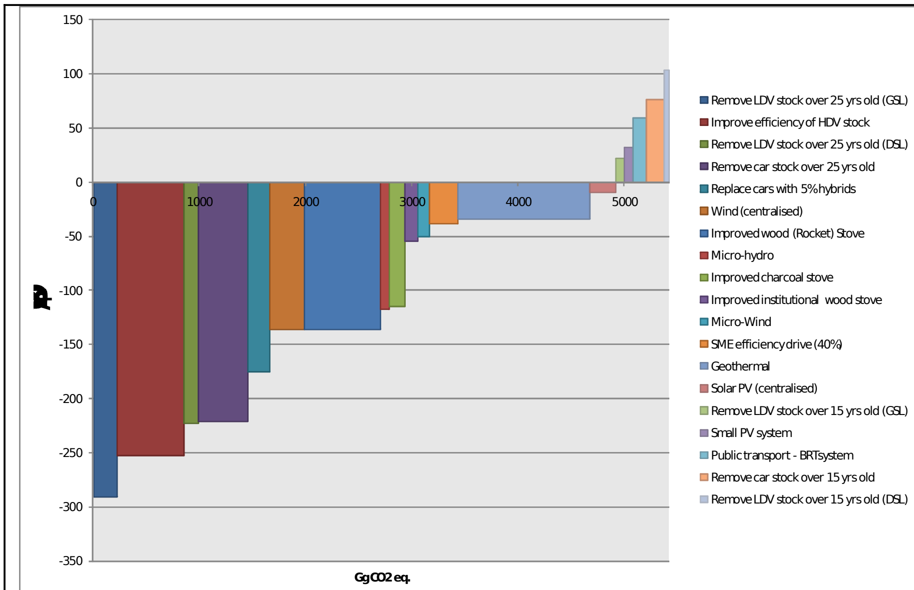
Over-reliance because the MACC approach is relatively simplistic. Additional analysis may often be needed to compliment the MACC approach. Indeed it is often the case that MACC are derived from more complex models, as a simplified representation. The following notes of caution need to be made for when using and interpreting MACCs:

- Static snapshots of mitigation potential in a given year. Therefore, it is of limited benefit in helping understand when investments should occur, for example, or whether additional options will be available in subsequent years. If a MACC time series is available, care is then needed to ensure that the baseline in subsequent years is adjusted to account for any additional take-up of measures.
- Limited feedback between sectors. Integrated system modellers often cite the lack of interaction between sectors as a significant problem with MACCs. In an energy system, what happens in one sector might impact on electricity demand which in turn affects the upstream sectors. None, or at least very little of this is captured in MACC analysis. Some MACC analyses do account for changes in electricity sector intensity.
- An associated issue is the interaction between measures. Introducing one measure first could have an impact on the cost-effectiveness of the second measure and so on. This may be particularly true of building measures.
- Few MACCs integrated the full cost of the measure in the analysis. Hidden and missing costs (e.g. implementation, transaction costs) are often omitted but can have a significant bearing on a given measure. In other words, full costing of measures could also lead to a better representation of the barriers to uptake. [46] As MACCs tend to represent technical measures, significant costs associated with implementation are usually overlooked.
- MACCs often take account of overlaps between the range of alternative options but not always. A MACC may list three power plant options; however, if one is introduced it may be the case that the other two are not needed. Therefore simply aggregating options in a MACC to get total potential is not always correct.

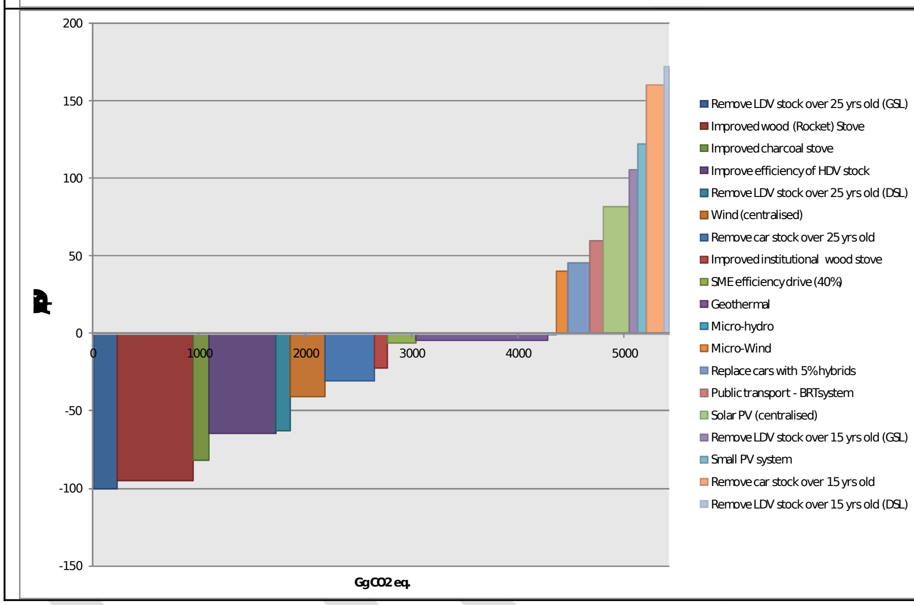
An additional sensitivity has been undertaken to highlight the importance of the discount rate chosen. While the above MACC estimates are based on a 10%, the impact of a higher commercial discount rate and lower societal based rate (as used in the UK) are provided for illustrative purposes below. Note that the agriculture measures have been removed, as they have not been calculated but rather derived directly from literature review.

The lower discount rate (commonly used in McKinsey work represents a ‘societal view’ of costs and benefits, highlighting the measures that will be in the public interest to implement. A private sector perspective can be quite different, with investment decisions factoring in much higher rates. Higher rates make options with high upfront costs and future streams of benefits (e.g. many energy efficiency investments) appear less attractive. This moves the MACC upwards, and changes the order of options on the basis of cost-effectiveness. Conversely, a low rate will make such options more attractive. This is reflected in Figure 28.

[46] Some economic analysis (although not found in the review) also use higher cost of capital (or CRF) known as a hurdle rates to reflect the barriers to uptake of perceived higher costs, consumer choice or the quick payback period that consumers expect.



4% discount rate



20% discount rate

Figure 28. Indicative MAC curves of selected abatement measures for Kenya in 2020 using alternative discount rate assumptions

Carbon financing requirements

Kenya is going to need to invest heavily in infrastructure and technologies if it is to grow to the extent set out in the Vision 2030. There are emerging opportunities that will enable financing of such investments where the carbon benefit can be demonstrated.

CDM as has been the primary carbon financing mechanism that the developing world has had access to. However, the benefits of this scheme have not been realised for African countries. Africa holds less than 3% of CDM projects; of these, most are in South Africa (APF 2009). Barriers to this mechanism include high transaction costs, low institutional and technical capacity and small sized projects. Institutional capacity needs to be strengthened in order that other aspects of CDM, that allow for small-scale projects or programmes (multiple projects) to be included under the mechanism. There is also a need of course for Kenya to suggest changes to current carbon financing under the CDM so that any emerging scheme is as beneficial as possible. A number of different mechanisms are being discussed and therefore it is vital that Kenya and associate countries look at what might be most beneficial for raising finances.

The potential for carbon financing under non-UNFCCC administered funds also needs to be realised, such as World Bank Climate Investment Funds, plus the emerging REDD / REDD+ schemes that may be important for Kenya in financing forest protection measures and afforestation plans. Again, it is vital that Kenya positions itself to fully inform the ongoing discussions about how mechanisms might work, and strengthens the institutional capacity to ensure that opportunities are taken.

Grantham Research Institute (2009) describes a range of barriers that may need to be overcome in Africa to access potential mitigation financing. These include limited capabilities to efficiently deploy funding, limited capacity / capability to meet MRV requirements, and the perceived investment climate for internal and external investors. They also highlight that for certain measures (e.g., fuel efficient stoves or REDD) financial support will need to go to a wide range of communities and individuals to have an impact, and policies and institutions will be needed to support such distribution.

The same report discusses how to enable access to carbon markets for Africa, including *tailoring market mechanisms to Africa's opportunities; and designing a phased approach to market access to allow Africa build its capabilities*. In particular, market mechanisms should include *specific opportunities such as REDD; accommodate small scale projects; and guarantee further capability building*. The report notes that financing will initially be done through public financing routes such as mitigation funds, but could then shift to private funding through offset markets in the longer term.

Summary

This analysis shows that there are significant opportunities for further reducing GHGs while promoting and ensuring growth rates are maintained. Whilst these have been assessed, it is important to stress that more work is required to understand the potential of such options, due to the uncertainties in the projected baseline.

The measures shown in the above cost curve are listed below, showing what might be the policy driver for introducing a given option, and the co-benefits of the measure if indeed the measure was being appraised for carbon mitigation.

Option	***Policy driver***	***Co-benefits (as a GHG mitigation measure)***
Expanding use of renewables (centralised)	Expanding capacity to meet future needs based on strong resource base	Reduce reliance on / payments for foreign fossil imports More cost-effective across many types Leverage carbon finance to fund investment Potential to build regional expertise, and export No air quality pollution
Decentralised generation from renewables	Rural electrification	Lower cost than alternative fossil generation Limit requirements for expensive grid expansion Sustainable energy for local economic growth No air quality pollution
Introducing improved stoves	Reduce biomass demand	Reduce indoor air pollution, and therefore health impacts Reduce fuel costs Protecting fuel Saving economic / leisure time (wood collection)
Improving efficiency of road transport fleet	Reducing reliance on fossil fuel imports	Reduce reliance on / payments for foreign fossil imports Reduce costs of vehicle use Reduce air pollution Reduce road traffic accidents (due to newer cars)
Planned public transport scheme for Nairobi	Meeting urban transport demand	Reduce congestion Reduce air and noise pollution levels Save travel time / enhance productivity Reduce road traffic accidents
Tackling energy inefficiency in SMEs	Reducing industry fuel costs, increasing competitiveness	Reduce fuel costs, enhance competitiveness Enhance energy security Reduce air pollution
Improve livestock and cropland management	Improve agriculture productivity and reduce land degradation	Protect / enhance arable land quality Safeguard rural livelihoods Increase economic productivity of sector
REDD / Afforestation	Protect forestry-dependent economy and energy supply security	Protect biodiversity, and dependent sectors Ensure security of wood fuel supply

It demonstrates that many of the options are important and consistent with objectives of sustainable economic growth. The costs analysis suggests that many of the above measures are also cost-effective, and can save money for the economy rather than add significant additional financial burden. Further work is required to develop other options and provide a more comprehensive picture of the different opportunities, building on this emerging picture of a lower carbon future.