LOW-CARBON AFRICA: LEAPFROGGING TO A GREEN FUTURE

POVERTY

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Country case studies by:

Kenya: Practical Action Consulting

Ghana: KITE

South Africa: Economic Justice Network

Ethiopia: Ethio Resource Group

Rwanda: Climate and Development Centre, Smith School of Enterprise and the Environment, University of Oxford

Nigeria: International Centre for Energy, Environment and Development (ICEED)

Full-length country case studies are available from:

christianaid.org.uk/low-carbon-africa

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Partner organisations

PRACTICAL ACTION Consulting

Practical Action Consulting (PAC) is the consulting arm of the international non-governmental organisation Practical Action, which has been a leader in the field of development consultancy for more than 40 years. Practical Action uses technology to challenge poverty, working with poor people around the world.

SJS CLIMATE ASSOCIATES

SJS Climate Associates is an independent research consultancy specialising in the inter-linkages between poverty, environment, climate change, economics and social issues.

EcoEquity

EcoEquity is a small, activist think-tank that has had a significant impact on the international climate justice debate. It has done this primarily, but not exclusively, through the Greenhouse Development Rights project.

PACJA PANAFRICAN CLIMATE JUSTICE ALLIANCE

The Pan-African Climate Justice Alliance (PACJA) fully endorses this report and will advocate for the leapfrog fund – outlined on p35 – and other recommendations presented in this report for Africa and internationally.

KITE

KITE is a Ghanaian not-for-profit development organisation and a leading actor in the energy, technology and environment sectors in Ghana and the West Africa subregion.

Economic Justice Network

The Economic Justice Network (EJN) is a project of FOCCISA, the Fellowship of Christian Councils in Southern Africa. FOCISSA is an ecumenical organisation working with 11 national councils of churches in southern Africa. EJN works to harness the resources of the southern African region for all of its people, with a view to bringing about economic justice.

Ethio Resource Group

Ethio Resource Group (ERG) is a consultancy group based in Addis Ababa, which works on energy policy and renewable energy technology installation.

Climate and Development Centre, Smith School of Enterprise and the Environment, University of Oxford

The aim of the Climate and Development Centre is to help developing countries and their development partners understand climate impacts, and identify opportunities and design strategies for effective climate adaptation and low-carbon development.

International Centre for Energy, Environment and Development

The think-tank International Centre for Energy, Environment and Development (ICEED) provides ideas that link energy and climate change policy reforms to prosperity for Nigeria's poor.

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OVERVIEW

The scandal of poverty, suffered by billions of people around the globe, could soon become far worse. It is being exacerbated by the effects of climate change, which are already having an impact in some parts of the world, with an increase in severe tropical cyclones, drought, falling crop productivity, rising sea levels and shrinking glaciers.

To date, poverty eradication has largely come at a price, with progress going hand in hand with massive carbon emissions. Those used to a carbon-intensive way of doing business say the choice is plain: policy makers can either chose to lift people out of poverty or they can tackle climate change. They can't do both simultaneously, for progress and clean air are mutually exclusive.

Sensitive to the energy needs of such governments, the World Bank has refused to stop funding fossil fuel projects, despite the way in which this will lock countries into a dirty development path. In its defence, the Bank cites arguments from developing country governments that it would be hypocritical for rich countries to 'pull up the ladder' after their own dirty development has been secured. Why, goes the argument, should South Africa be denied coal power by countries that relied on it themselves? As a result, one of the biggest institutions with the potential to catalyse cleaner development has washed its hands of the responsibility.

Christian Aid believes the 'choice' between addressing poverty or addressing climate change is a fundamentally false one. We see in our work with partners all around the world that it is the poorest and most vulnerable communities that are already bearing the brunt of climate change. Addressing poverty must therefore include addressing climate change.

But there is a second powerful reason why the two challenges must be faced together. In this report, we draw on evidence from six sub-Saharan African countries to show the enormous opportunity that exists for developing countries to leapfrog ahead in the journey to sustainable development.

Put simply, they have no need to pursue the dirty development route. In case after case, we see that the poorest people are not best served by large-scale, carbon intensive projects. Instead, the measures that will deliver most to address energy poverty can also be those that would set countries on the much-sought alternative path to low-carbon development.

Africa has a big opportunity to leapfrog and transition to a low-carbon development path and at the same time still expand access to energy services. It is possible to lift Africa out of energy poverty without increasing emissions. But it will need financial and technological support to rise to the occasion. Africa, in other words, can be a low-carbon leader.

The energy challenge

- Kenya's per capita electricity consumption is 156 kilowatt-hour (kWh) per year, compared to a global average of 2,751kWh. In Ethiopia, the average electricity consumption is just 35kWh.
- Rwanda's total installed electricity capacity is 85 megawatt (MW), equivalent of one small power station in Europe. About 90 per cent of people in Rwanda have no electricity.
- Wood and charcoal provide 73 per cent of total energy consumption in Nigeria and 81 per cent in Ghana.
- In sub-Saharan Africa, cooking on open fires fuelled with wood or charcoal results in 359,520 premature (<5 years) child deaths and 23,212 (>30 years) female deaths per year.

(These figures are taken from the full version of the case studies contained in Annex 1: christianaid.org.uk/low-carbon-africa)

This report presents the case for a low-carbon Africa that is able to deliver clean and sustainable energy to millions of energy-poor people across the continent, and to drive a productive green economic expansion for the region to deliver a higher sustainable standard of living well into the future. Energy diversity, local resources and sustainable long-term supply from low-carbon energy will help to deliver modern energy to the people, services and industry where it is needed, and to stimulate greater economic growth and energy security in the region.

Delivering low-carbon energy is a key development challenge. Without significantly expanding the provision of energy services, Africa will not be able to meet those poverty-eradication indicators the Millennium Development Goals (MDGs), to say nothing of its broader sustainable development ambitions.

It will not be able to make clean cooking fuels and lighting widely available, or to ensure food and water security. It will be unable to provide education and healthcare or begin in earnest to move towards becoming a region of middle-income countries with significant global economic weight.

This report gives examples of the potential low-carbon energy in six sub-Saharan African countries: Kenya, South Africa, Ghana, Ethiopia, Rwanda and Nigeria. These countries share common features, such as high levels of energy poverty and dependence on biomass (wood and charcoal) for domestic needs, power shortages, unsustainable dependence on imported fossil fuels and lack of access to finance to invest in energy security. Nigeria and South Africa in particular continue to be bound to economic growth based on unsustainable fossil fuels, with limited plans for reducing this high carbon dependence.

However, all six countries have a huge potential for renewable energy and for improving energy efficiency, and a potential to leapfrog over dirty or unsustainable energy practices and 'brown' technology to move towards a green development pathway.

South Africa is the largest economy and most influential country in sub-Saharan Africa, and yet more than 30 per cent of its population still have no access to electricity, while its economic growth is based on unsustainable use of coal to subsidise energy intensive industry and mineral extraction.

At present, energy consumption throughout sub-Saharan Africa (excluding South Africa) is roughly equivalent to that of New York State, with nearly half a billion people – almost 70 per cent of the population – without access to electricity.

Across Africa there is a massive dependence on imported fossil fuels, which consume a very high portion of the region's export earnings. Even Nigeria, the region's largest exporter of crude oil, has to import refined fuels. Fluctuation of oil and gas prices further complicate the task of delivering a secure energy supply in the region. The focus on delivering centralised conventional power through thermal power from oil, gas and coal or from large-scale hydropower (projects of more than 100MW) has not effectively delivered either energy access for poor people or the rate of economic growth that sub-Saharan African countries aim for.

Africa currently has the highest energy intensity in the world; it uses far more energy for every dollar of Gross Domestic Product (GDP) than any other region.[1] Africa's inefficient energy system is characterised by energy that is imported, expensive, environmentally unsustainable and dependent on coal, oil, wood fuels and natural gas. Regular power outages, inadequate and unreliable distribution networks and high energy costs are features common to the energy sector across sub-Saharan Africa.

While some sub-Saharan African countries have a significant potential for large-scale hydropower, drought and fluctuating rainfall have meant that it can be unreliable as a main source of energy. States such as Kenya and Ghana that currently rely heavily on large hydro have experienced significant power shortages in drought years.

Realising the renewable potential

There is a huge potential for renewable energy across the continent, which is largely untapped. This report demonstrates that geothermal, small-scale hydro, solar, wind, tidal and local biomass fuels, including agriculture wastes, all offer significant potential for delivering both basic needs and for unlocking economic growth. Building in energy efficiency will be an important element of developing a low-carbon Africa to increase productivity and reduce fossil fuel dependence.

In the United Nations Framework Convention on Climate Change (UNFCCC) climate negotiations, sub-Saharan African nations have traditionally given priority to finance for adaptation, given that they will be suffering climate impacts to a degree that is out of all proportion to their historical contribution to the climate problem or their economic capacity to respond. Energy insecurity at a national and at a household level is closely linked to vulnerability to climatic shocks. Low-carbon development can maximise the benefits of mitigation finance by increasing the resilience of these countries and communities to climate and economic shocks.

African countries will have to put in place strategies, regulations and capacity-building to stimulate low-carbon development and to attract private sector investment, innovation and markets. Kenya and Ghana are ready to act now, with forward-looking low-carbon policies and strategies. South Africa and Nigeria will need to rethink their current fossil-fuel-based economic approach if they are to move effectively to a green future. A major barrier that all countries face is very limited access to finance.

Africa will need reliable and substantial financing to realise its potential and to deliver low-carbon growth. It is estimated that the continent will need about 20 billion US dollars per year to deliver its basic energy needs to all its people by 2030, and US$30-35bn per year to deliver a higher level of low-carbon development. But so far sub-Saharan Africa has seen very little mitigation funding from global climate finance or the carbon market.

There is a huge climate finance gap. The support that developed countries have offered for all climate change actions (mitigation and adaptation) for all developing countries is totally inadequate. Fast-start finance agreed at Copenhagen in 2010 is just US$10bn per year up until 2012, with a long-term goal of mobilising US$100bn per year by 2020.[2] Delivery of climate finance is not linked to what is actually needed or to where it is most urgently needed. To date, climate finance delivered has reflected the political preferences of developed countries, and the 'low-hanging fruits' opportunities offered by the higher emitting, middle-income countries, particularly India and China.

The time has now come for Africa to demand its fair share of mitigation finance to expand its access to clean and sustainable energy services.

This report argues that Africa should get its fair share of mitigation funds to realise its low-carbon development potential. With its abundance of resources and its sustainable development ambitions,

Renewable development in Africa

Low-carbon energy is already happening in Africa:

- In Kenya, the Mumias Sugar Company (MSC) is using sugarcane bagasse (waste from sugar production) to generate 35MW of electricity, with 10MW for internal consumption by the factory and 25MW exported to the national grid.
- In Rwanda, the National Domestic Biogas Programme (NDBP) is part of an effort to encourage people and businesses to move away from using wood fuel for energy and move instead towards biogas, which is better for health, sanitation and the environment. It is estimated that 110,000 families have the potential for using biogas.
- The Nigeria Electricity Supply Company (NESCO) has been operating a network of small hydroelectric power stations with total installed capacity of 21MW. The NESCO system operates as an independent network serving a number of industrial customers and communities, and also sells to the national grid.
- In Ethiopia, the Solar Energy Foundation (SEF) Solar Home Systems meet the lighting and audio-visual requirements of households in rural areas. SEF piloted this concept in one village in 2008 and has since replicated the model in four other villages in different parts of Ethiopia. So far it has provided electricity to 3,740 homes and businesses.
- Toyola Energy Limited in Ghana is one of the most successful and sustainable charcoal cook stove businesses in the world. The company has trained about 300 artisans and a total of 154,000 stoves have so far been sold. The Toyola stove is projected to reduce charcoal use by 26,000 tonnes per year, thereby saving trees and cutting carbon dioxide emissions by 150,000 tonnes.
- In South Africa, the Kuyasa Thermal Efficiency Upgrade in Low-Income Housing aims to fit 2,300 low-income households with solar water heaters in order to provide hot water on demand, insulated ceilings to improve the thermal efficiency of the household units, and two compact fluorescent light bulbs (CFLs) to provide energy efficient lighting.

(These figures are taken from the full version of the case studies contained in Annex 1: christianaid.org.uk/low-carbon-africa)

Africa has a real comparative advantage when it comes to renewable energy development. This potential can be realised through the right interventions to support market development in the regions and access to targeted financing. Christian Aid proposes the establishment of a 'leapfrog fund' from global mitigation finance to support Africa towards a low-carbon economy – that is to pursue energy access and sustainable development through a clean development model. The Green Climate Fund, which is being established by the UNFCCC, should include a dedicated window for this purpose.

Primary messages

- Energy access is a vital component to poverty reduction and a crucial factor underpinning the success or failure of the MDGs. Africa will not be able to meet the MDGs, let alone its economic development ambitions, without significant expansion of energy services.
- Concerted efforts are needed to provide clean, basic and productive energy services to sub-Saharan Africa. The development benefit of basic energy services there is so great and so urgent, there is no excuse for further delay. Productive uses of energy services are needed to boost the region to middle-income status.
- Increasing energy access in sub-Saharan Africa will have a nominal impact on global emissions, and pursuing low-carbon development will not only minimise its already modest carbon emissions, but will also provide opportunities for climate change adaptation in environmental, livelihoods, and health terms.
- Future economic growth in sub-Saharan Africa will depend on improved and efficient energy services for households, industry and transport, and the significant dependence on biofuels will need to be replaced by modern energy services (preferably renewables), taking an approach that supports the poor.
- Successful low-carbon energy interventions in sub-Saharan Africa have relied on community participation, local capacity-building, appropriateness of the energy service/technology, as well as an enabling legal and governance environment.
- Poor governance, regulation and accountability have led to failures in previous energy sector interventions in sub-Saharan Africa. A bias towards large-scale energy investment has inhibited the manufacturing sector in the region, and disincentives such as the perceived cost of low-carbon energy technologies have prohibited market penetration and private sector investment.
- Sub-Saharan Africa has a vast and largely untapped renewable resource bank, which if harnessed will bring socio-economic benefits in support of poverty reduction, economic growth and employment. Hydropower, geothermal, wind, solar and sustainably sourced biofuels are all potential sources of renewable energy there.
- Funding constraints are severely limiting Africa's renewable energy potential, despite the financial commitments made by industrialised countries. Global public engagement and political will relating to climate change will be needed for these funds to materialise.
- There is potential for large, medium and small-scale low-carbon and renewable energy initiatives, which could be further enhanced by technology transfer, bilateral and multilateral investment, participatory markets approaches and local capacity-building.
- Well-designed policies that tackle under-investment in low-carbon technology development, ambiguous carbon pricing and market and governance failures will likely bring down costs.
- **Achieving total access to modern energy services in sub-Saharan Africa would require investments of about US$20bn. Quantifying the cost of low-carbon development in the region is more difficult, but could equate to about US$30bn per year until 2030.**
- **African countries need to put in place strategies, regulation and capacity-building to stimulate low-carbon development and to attract private sector investment, innovation and markets.**
- **Based on its energy needs, along with the requirement to reduce greenhouse gases emissions, the Green Climate Fund should include a dedicated window for this purpose. This should be a leapfrog fund for low-carbon energy access.**

(These figures are taken from the full version of the case studies contained in Annex 1: christianaid.org.uk/low-carbon-africa)

1.0 CURRENT ENERGY CONTEXT

Christian Aid/Gideon Mendel

Women carry firewood near Saula, southern Ethiopia

Energy production and consumption are very significant contributing factors to global greenhouse gas (GHG) emissions. In Africa, transport, agriculture and forests all contribute to the continent's currently relatively small carbon footprint, and these have to be considered in delivering its full low-carbon potential. However, for this report we have decided to focus on energy and the importance of energy access to the continent's development and potential for a green economic future.

'We cannot solve climate change without an energy revolution… Some 70 per cent of the world's global emissions were said to result from the power sector. Africa cannot develop without ensuring that all people have access to energy – thus the need to focus on providing sustainable energy'
Kandeh Yumkella, United Nations Industrial Development Organization (UNIDO) director-general, speaking at African Energy Ministers meeting in Johannesburg, September 2011

1.1 The significance of energy to development in Africa

Currently, about 41 per cent of the 1.4 billion people in developing countries lacking access to electricity live in sub-Saharan Africa. Energy poverty at the household level is assessed by the International Energy Agency (IEA) through two major indicators: access to electricity and dependence on traditional biomass fuels for cooking. Statistics compiled by the IEA clearly highlight the region as a global hotspot for energy poverty: just 30.5 per cent of the population have access to electricity, leaving an estimated 585.2 million without, while 80 per cent of the population rely on traditional biomass for cooking.[3]

1.1.1 Energy and development

The vital role of energy in poverty reduction and development in Africa has been demonstrated through slow progress in achieving the MDGs. It is increasingly recognised that these eight international development goals, which 193 United Nations member states and at least 23 international organisations agreed to achieve by 2015, are unlikely to be met by 2015 on current trajectories.[4]

The MDGs are characterised by operational inadequacies that suggest that essential features of the Millennium Declaration were lost in the process of translating it into the goals. Inequality, sustainability and democratic and participatory governance are three themes of the Millennium Declaration that are significantly underrepresented across all MDGs,[5] and this has hampered progress towards achieving universal energy access.[6]

It is now widely recognised that without access to modern energy services, such as electricity and modern fuels, it is highly unlikely that any of the MDG objectives will be achieved.[7] Even the most natural-resource-rich communities can be economically poor because a lack of mechanical power prevents productive use of local resources. A lack of access to modern energy services impedes poverty alleviation, education, gender equality and healthcare, and limits employment and livelihood opportunities.[8] Moreover, when energy prevents progress towards one MDG, the complex inter-linkages between all MDGs mean the negative impacts and barriers are widespread.

Text box 1 (on p8) outlines how access to energy can promote progress towards the MDGs.

The World Health Organisation (WHO) has published some alarming figures linking widespread biomass use in sub-Saharan Africa to pneumonia in children and chronic obstructive pulmonary disease in adults. It is estimated that cooking on open fires in poorly ventilated or inefficient stoves fuelled with biomass results in 359,520 premature child (<5 years) deaths and 23,212 (>30 years) female deaths in the region per year.[9] Without international action to reduce the burning of wood, charcoal, animal dung, crop residues and tree leaves for cooking and heating, the total number of child deaths from pneumonia and adult deaths from chronic obstructive pulmonary disease will continue to soar.

Text box 1: Access to energy services can help to achieve the MDGs[10]

To halve extreme poverty: Through facilitating livelihood activities beyond daylight hours, access to energy services facilitates economic development.

To reduce hunger and improve access to safe drinking water: Given that 95 per cent of staple foods need cooking before they can be eaten and accessibility to clean water is facilitated through water pumping systems, access to energy services supports food and water security.

To reduce child and maternal mortality; to reduce diseases: Energy services increase reliability of healthcare systems, for example through lighting operating theatres and refrigerating vaccines. Transportation to health clinics is facilitated with access to energy.

To achieve universal primary education; to promote gender equality and empowerment of women: Traditional division of labour in many households means women must invest time to walk large distances to source and carry health-damaging loads of firewood (in some parts of Tanzania women walk 5-10km per day with loads of up to 30kgs.)[11] Also, poor-quality lighting prevents children from learning after dark, while education is also affected by current energy practices as parents remove children from school to help with household labour and to care for those with ill-health.[12]

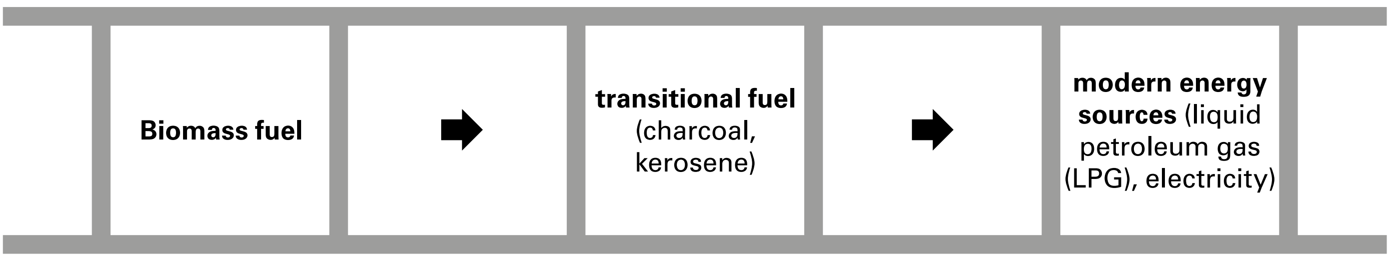
Environmental sustainability: Using energy efficiently and promoting cleaner energy sources can support sustainable resource use in the local environment. Reducing emissions through energy helps to protect global environmental services through limiting human's impact on the climate.

It is essential to reduce reliance on biomass in urban as well as rural areas; while the highest populations of those reliant on biomass are situated in rural areas, 60 per cent of households in urban areas of sub-Saharan Africa still use biofuels for cooking. Of great concern is the urban shift from fuel wood to charcoal because unlike the former, the latter is most often produced from forest resources. If not kept under control, the toxic combination of high population density, low income and/or severe climate conditions presents great risks for forests and vegetation through charcoal consumption in urban areas.[13]

Choices about energy consumption and fuel type are strongly influenced by poverty and other factors affecting household livelihoods. A household that conventionally consumes transitional fuels such as charcoal or kerosene might move back along the energy ladder (see Text box 2 below) and consume more biomass fuel during brief periods of low-income, or during festivals or other events that require cooking for large groups. Improved cook stoves can provide an effective intermediate technology to improve efficiency of biomass cooking, although deviations from the normal cooking requirements can lead households to revert to traditional fuels and technologies.

Similarly, inaccessibility to modern energy sources 'entrenches poverty, constrains the delivery of social services, limits opportunities for women, and erodes environmental sustainability at the local, national and global levels'.[14] Recognising the significance of energy to poverty reduction and acting to achieve universal energy access is crucial to reducing child mortality, improving maternal health, and providing universal access to primary education

Text box 2: Households move backwards and forwards along the energy ladder depending on poverty and other livelihood factors[15]



and essential care to those suffering with HIV, AIDS and other infectious diseases.

1.1.2 Energy and climate change mitigation

The world cannot afford to disregard environmental sustainability in the challenge to address energy and development.

Recent analyses by US and UK Government and Meteorological Office scientists, who examined data from 10 different indicators of global temperature change, show that global temperatures have been rising since the 1850s.[16] From separate data, the US National Oceanic and Atmospheric Administration concludes that June 2010 was the hottest month on record, with temperatures in 17 countries reaching record highs.[17] As set out in the latest report of the Intergovernmental Panel on Climate Change (IPCC), the global average temperature rise of 0.4 degrees Celsius over the past two decades can very likely be attributed to the rise in atmospheric GHG levels, principally from continued deforestation and fossil fuel burning.[18]

Achieving worldwide, universal access to energy services at a basic MDG-level of development at the 'IEA's recommended threshold of 100kWh per person per year, even if delivered through the current fossil fuel-dominated mix of generation technologies, will increase GHG emissions by around 1.3 per cent above current levels'. (The UN Secretary-General's Advisory Group on Energy and Climate Change (AGECC), p9)

This would not dramatically increase human's contribution to climate change.[19] All of this said, it must also be emphasised that meeting basic human needs does not constitute 'development' in any meaningful sense. Communities whose basic needs are met continue to strive for improved welfare and sustainable development. The levels of energy service delivery – basic, productive and modern society needs – are summarised in Figure 1.

Figure 2 indicates the the quality of energy available to different income groups, showing a direct link between income poverty and energy poverty.

The literature on the energy requirements and emissions implications of Level 2 development (see Figure 1) is not nearly as mature as that examining the energy requirements of MDG-level energy access, but conceptually and politically

Figure 1: Incremental levels of access to energy services[20]

Level 1
Basic human needs

- **Electricity** for lighting, health, education, communication and community services (50-100 kWh per person per year)
- **Modern fuels and technologies for cooking and heating** (50-100 kgoe of modern fuel or improved biomass cook stove)

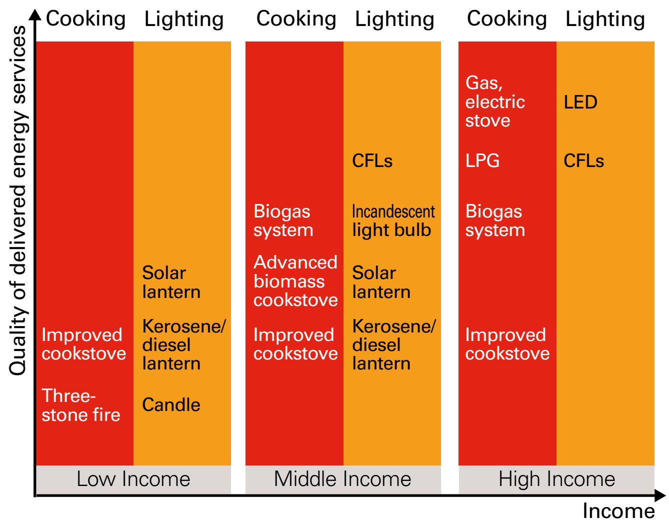
Level 2
Productive uses

- **Electricity, modern fuels and other energy services** to improve productivity e.g.,
  - Agriculture: water pumping for irrigation, fertilizer, mechanized tilling
  - Commercial: agricultural processing, cottage industry
  - Transport: fuel

Level 3
Modern society needs

- **Modern energy services** for many more domestic appliances, increased requirements for cooling and heating (space and water), private transportation (electricity usage is around 2000 kWh per person per year)

Figure 2: The quality of energy services and household income[21]



World Energy Outlook 2010 © OECD/International Energy Agency 2010, figure 8.2, page 241 the notion of Level 2 energy requirement is still entirely critical. If Africa is going to develop beyond the basic needs stage, energy supplies will need to increase by an order or magnitude above that implied by MDG-levels of consumption, or perhaps even more.

There is a global agreement to limit human-induced warming to below 2°C in order to manage dangerous climate change and many developing countries argue that the only safe level is below 1.5°C warming. Despite recognising the high uncertainty attached to translations of temperature risk into a target figure for GHG emissions, the University of Oxford recently published this very clear scientific message:[22]

'The risk of a dangerously high temperature at any level above the present (387 ppm CO_2; approximately 420 ppm CO_2 equivalent) is relatively high.[23] GHG emissions must be reduced, in order to manage this risk downward at the fastest rate that can be achieved.'

The link between energy and climate change cannot be disentangled in the case of fossil fuels. It is highly important that measures to address the current energy situation in Africa (explained in more detail in Section 1.2) and the rest of the developing world include an accelerated deployment of low emissions technology at supply and demand side. As outlined in Section 2.0, there is significant potential for sub-Saharan Africa to achieve renewable and low emission fossil-fuel-based technologies on the supply side and energy-efficient end-use facilities on the demand side.

As African countries continue to exploit their fossil fuel resources there is increased urgency to improve the efficiency of productions and use; for example the scandal of gas flaring (burning the natural gas released during oil production as if it were a waste product) in the oil fields of Nigeria, a country where 95 million rely on traditional use of wood energy for cooking.

1.1.3 Energy and climate change adaptation

In addition to the social benefits of universal access to modern energy services, low-carbon development brings environmental and economic opportunities for sub-Saharan Africa that can support climate change adaptation.

Sub-Saharan Africa contributes a negligible share to global GHG emissions; it is estimated to be less than four per cent of the global total. Europeans emits roughly 50-100 times more and North Americans 100-200 times more GHGs than Africans, when one compares the average per capita GHG emissions in the typical African country with the typical European country.[24] The top-right of Figure 3 (p11), the chart displaying 2009 CO_2 emissions for selected countries in Africa, demonstrates the uneven distribution of emissions, particularly between North Africa and sub-Saharan Africa, and between South Africa and the rest of the sub-Saharan region.

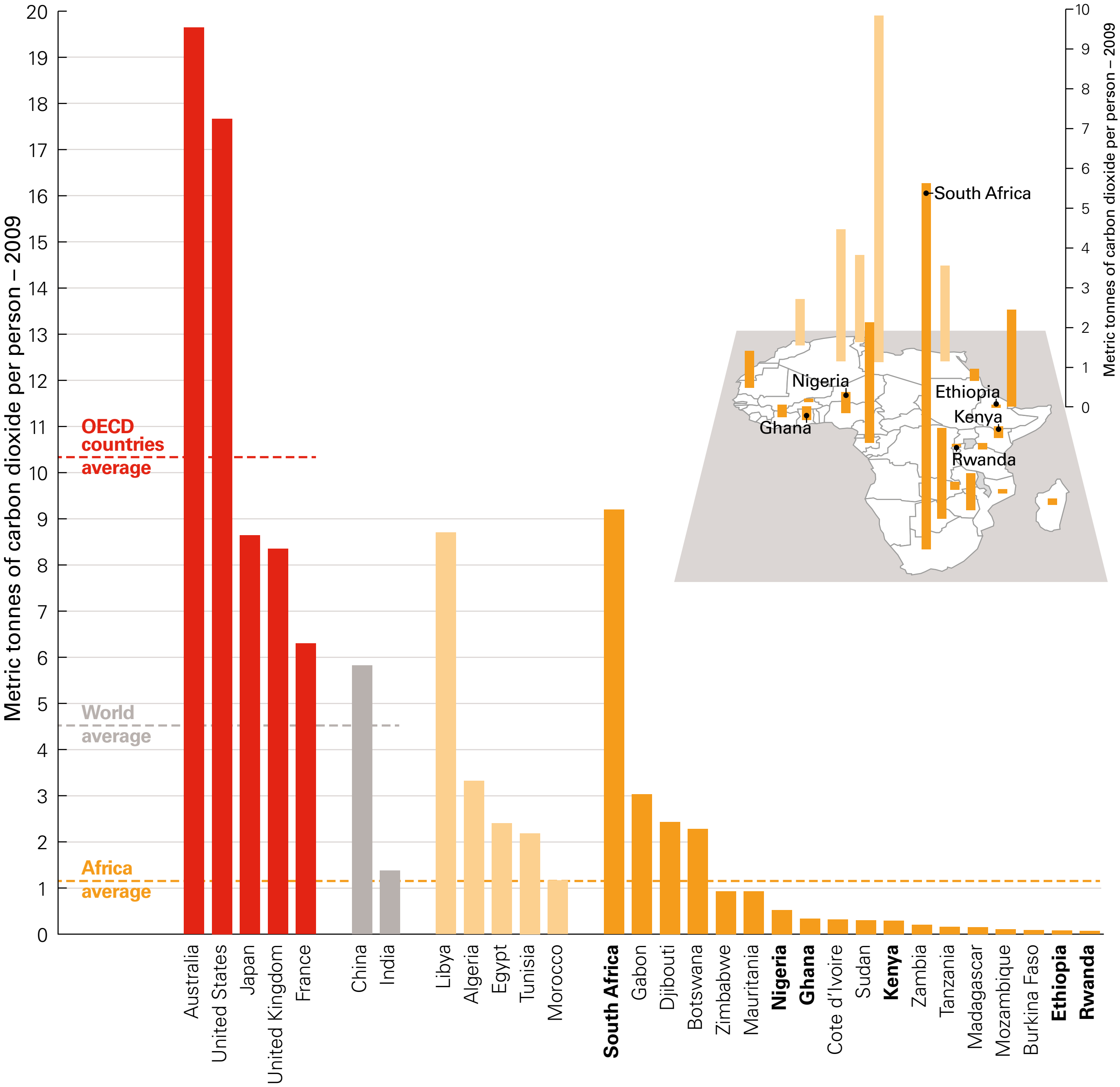
Nevertheless, sub-Saharan Africa is one of the most vulnerable places to climate change in the world. Reviewing evidence from a range of peer-reviewed literature,[25] the Centre for Climate Change Economics and Policy (CCEP) presents this list of the major climate change impacts that might affect the region:[26]

- drop in agricultural yields
- increase in the number of people at risk of water stress
- increase in the exposure to malaria
- rising sea levels that may severely affect mangrove forests as well as coastal fisheries, and lead to severe flooding.

The wide range of environmental benefits attached to low-carbon development and modern energy services, such as reduced deforestation due to a move from wood fuel to efficient cook stoves, can enhance resilience of vulnerable people to climate impacts. For example, sea level rise and storm surges are less likely to flood an exposed coastal community if householders have refrained from exploiting the mangrove forests for wood fuel.

Cleaner energy sources can also enhance the adaptive capacity of households to climate change. The co-benefits of cleaner energy sources are numerous: with reduced need to walk large distances to collect firewood, women and their children may have more time in the day to engage in productive activities such as trading, household duties or educational activities. Increasing the amount of time for such tasks can support gender equality in the home, and the wider socio-economic benefits associated with empowering marginalised groups, for example improved access to community decision-making processes. Additional household income can be used to prepare or respond to the above

Figure 3: African major sources of GHG emissions, per capita, and comparisons with emissions from other countries.[27]



climate change impacts, for example through purchasing medicines for malaria treatment or nourishment if crop yields are expected to fail due to prolonged or intense drought.[28]

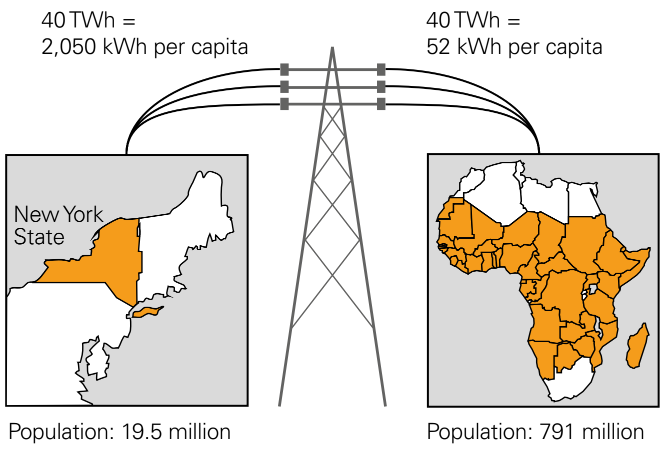
While diversification of energy sources through renewables can make a country's energy system more resilient to climate change, there is one caution – countries dependent on hydropower, such as Kenya and Rwanda, suffer with increased power blackouts when electricity output is reduced during drought.

1.2 Current energy situation in Africa

Africa currently has the highest energy intensity in the world, defined as the ratio of a country's domestic energy consumption to its GDP. Africa's high energy-intensity ranking reflects a pattern of energy use that does not translate into economic development; a pattern typified by energy that is imported, expensive, and environmentally unsustainable, and characterised by energy sources including coal, oil, wood products and natural gas.

The IEA estimates that when South Africa is excluded, annual residential electricity consumption in sub-Saharan Africa is the same as electricity consumption in New York State. That is to say, the 19.5 million people in New York consume the same amount of electricity, approximately 40 terawatt-hour (TWh), as is shared between the 791 million people of sub-Saharan Africa. Universal access to electricity is widely believed to be the region's greatest energy challenge.

Figure 4: Comparing electricity consumption in New York State and sub-Saharan Africa, excluding South Africa[31]



Notes:
- IEA, UNDP [United Nations Development Programme], UNIDO, 2010, *How to Make Modern Energy Access Universal?*.
- Boundaries do not reflect official endorsement or acceptance from IEA. World Energy Outlook 2010 © OECD/International Energy Agency 2010, figure 8.6, page 248.

1.2.1 Growth, energy security and low-carbon development

Most African governments have developed economic plans for the next few decades and many have high ambitions. Nigeria's vision for 2020 seeks to place the country among the top 20 world economies by 2020. Rwanda – a state currently ranked 152 out of 167 on the human development index – plans to be ranked as a middle-income country by 2020.

In recent years, Africa has achieved strong economic performance; real GDP rose 4.9 per cent per year during 2000-2008, more than twice its rate in the 1980s and 1990s, and the rate of growth is projected to increase.[29] Power supply has not kept pace with the high rates of growth, and energy demand constantly outweighs supply across the continent. Additionally, there are risks that a fossil-fuel-dependent economy will hamper sub-Saharan Africa's economic potential because of poor energy security, including instability of fossil fuel supply, fluctuating fuel prices and the high levels of foreign exchange needed to import fuels. Setting Africa on a path to sustainable, low-carbon growth is absolutely imperative to reduce the current widespread energy insecurity resulting from the supply-demand imbalance.

The high rate of annual population growth (2.5 per cent in 2010),[30] and the pressing need to reduce high levels of poverty and address development and environment issues present a complex challenge for sub-Saharan African countries: increasing economic growth without negatively impacting progress on development or the environment.

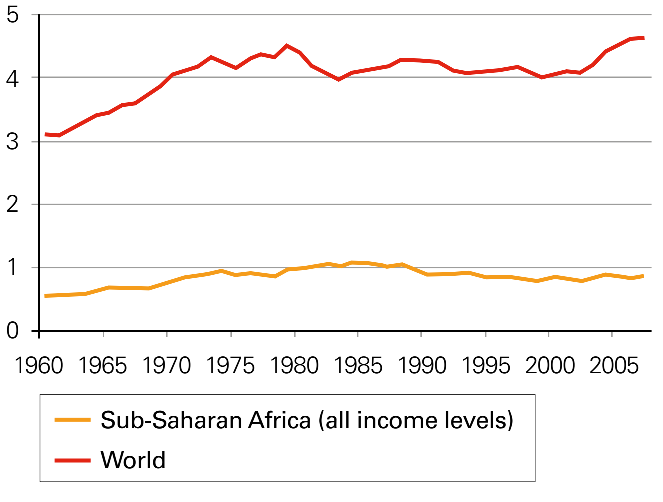
One of the largest driving factors for the region's current rate of investment in low-carbon technology is the risk of

Text box 3: Natural resource scarcity as a driver for Kenya's increasing investment in renewable energy[32]

To reduce the threat of resource scarcity crises constraining national 'Vision 2030' growth ambitions to transform Kenya into a 'middle-income country providing a high quality of life to all its citizens by the year 2030', Kenya has invested heavily in renewable energy since the drought in 2008. Investments include a 300MW wind farm in the northwest of the country and more than US$91m in the expansion of geothermal plants. Additional investments of US$500m are expected over the next five years to promote agro-fuel production.

natural resource scarcity impeding achievement of national economic growth plans. Text box 3 (p13) demonstrates Kenya's significant investments in the renewable energy sector since intense and prolonged drought severely reduced hydroelectric output in 2008.

Figure 5: Annual CO_2 emissions from sub-Saharan Africa (metric tonnes per capita) from 1960-2007, compared to the global average[33]



1.2.2 Industrialisation and current high carbon growth

Sub-Saharan Africa has an extremely small record of CO_2 emissions in comparison to the rest of the world. As displayed in Figure 4 (p12), the region's annual CO_2 emissions in 2007 (about 0.9 metric tonnes/capita) were still significantly below the global average (about 5.0 metric tonnes/capita).

At the current rate of industrialisation, sub-Saharan Africa's emissions are expected to increase between 2010 and 2030, at a rate that will depend on levels of economic growth in the region, particularly if countries such as South Africa continue to base their economic development on energy-intensive sectors powered by coal.

Increasingly, yet slowly, renewable energy and low-carbon technologies are being integrated into high carbon emitting sectors, including manufacturing, transport and residential. There is a huge opportunity now to ensure that growth in Africa is delinked from high carbon emissions and that low-carbon growth becomes the norm.

1.2.3 Energy efficiency in sub-Saharan Africa

Compared to renewable energy technologies, less progress has been achieved in sub-Saharan Africa to improve energy efficiency. There is a significant lack of energy efficiency programmes and high levels of energy waste have been recorded along the energy chain including energy extraction, processing and end-use consumption.[34]

In addition to energy savings, there is great potential for the region's manufacturing sector to achieve benefits in terms of productivity, the environment and other areas through energy efficiency measures. However, the cost-effectiveness of potential energy efficiency measures is not accurately recognised because the related benefits are difficult to quantify. This gives the perception that efficiency measures are not cost-effective, reflected in the slow rate of uptake of energy efficiency measures in Africa.[35]

1.2.4 Energy access in sub-Saharan Africa

There is no clear consensus on what the term 'energy access' means. In accordance with the AGECC and the IEA, this report adopts the classifications in Figure 1 (p9), which shows incremental levels of energy services access, while recognising that the shift from traditional to transitional to modern fuels is rarely simple and linear.

In sub-Saharan Africa, just 31 per cent of the population have access to electricity.[36] The estimated 585.2 million people lacking electricity, more than two-thirds of whom live in rural areas (465 people in 2009)[37], are largely reliant on biomass and traditional energy sources to meet their livelihood needs.[38] Under the IEA's New Policies Scenario – a scenario for global energy that takes into account the agreements made at the Copenhagen climate conference in December 2009 and promises made at the G20 to phase out subsidies for fossil fuels – and in the absence of additional, dedicated policies for reducing energy poverty, the percentage of people relying on biomass for cooking in sub-Saharan Africa is projected to decrease in line with the rest of the developing world, by approximately 10 per cent in 2008-2030.[38] However, despite a projected increase in the electrification rate in 2008-2030, the absolute number of people in the region lacking access to electricity is expected to rise from 31 per cent in 2009 to 50 per cent in 2030; a stark increase in comparison with projections for the rest of the developing world. Sub-Saharan Africa could account for 54 per cent of the total world population lacking access to electricity in 2030 compared to 41 per cent in 2009.[39]

Moreover, reducing Africa's dependence on biofuel from 80 per cent in 2008 to 70 per cent in 2030 is inadequate if we are to achieve the health goals outlined in Section 1.1. It is important to note, however, that macro-figures such as these do not capture the uneven nature of energy access: physical proximity to grid electricity and LPG does not automatically translate into 'real' access for the poor unless the services and related appliances are available, affordable and appropriate. As displayed in Table 1 (below), if this projection became reality, the number of children in sub-Saharan Africa dying from pneumonia due to the use of biomass for cooking could not even be halved, while adult deaths from chronic obstructive pulmonary disease could even increase.

There is a strong message emerging from these figures: Africa requires international recognition that the energy situation is intolerable and urgent action to reduce reliance on biofuels, particularly among the poor, through increasing *real* access to electricity and other modern energy services.

1.3 What has worked in the past and why?

There are no fundamental technological barriers to achieving universal energy access in sub-Saharan African countries.[40] There is a good understanding of how to design and build energy facilities at the supply level (for example power stations) and demand level (for example small-scale off-grid renewables such as solar or wind power and fuel efficient

Table 1: Number of deaths from pneumonia and COPD in Sub-Saharan Africa due to the use of traditional biomass for cooking in 2008, 2015 and 2030

	Year	% population relying on biomass	Pneumonia: Children < 5 years	COPD: Female > 30 years	COPD: Male > 30 years	COPD: Adults > 30 years	Total deaths
SUB-SAHARAN AFRICA	2008	80%	359,520	23,212	29,090	52,302	411,821
	2015	76%	301,163	28,048	36,375	64,423	365,586
	2030	70%	190,400	38,450	52,905	91,355	281,755
TOTAL DEVELOPING COUNTRIES	2008	54%	602,923	505,126	341,374	846,500	1,449,423
	2015	51%	464,150	569,399	409,826	979,225	1,443,375
	2030	44%	261,249	726,224	536,671	1,262,895	1,524,144

Notes:
1. Table extracted from data provided by the IEA and WHO 2010, iea.org/weo/docs/poverty/Number_of_deaths_by_region_2008_2015_2030_WHO.htm
2. COPD is Chronic Obstructive Pulmonary Disease, a term used to describe chronic lung diseases that cause limitations in lung airflow. Included in the COPD diagnosis are 'chronic bronchitis' and 'emphysema' but these terms are no longer used. See who.int/respiratory/copd/en for more information.

Text box 4: Advancing modern energy facilities while building local capacity: the Rural Stoves West Kenya project[41]

The Rural Stoves West Kenya project, established by Practical Action (formerly ITDG) in 1990, has engaged more than 200 women from 13 women's groups in stove making and business management training. The 11,000 improved (cleaner and more efficient) cook stoves produced annually (known as Upesis) enable the women potters to make a profit in accordance with local rural wages. Women have become financially independent, increased in confidence and gained social status as a result of their entrepreneurial ventures. There are also benefits for those who use the Upesi stoves and the wider community. Purchasers of the stoves report that they are safer and more fuel efficient than traditional cooking methods, while other community members have increased household income by transporting materials for the stove production process.

A full case study including lessons identified from this project is available here: http://practicalaction.org/t4sl _ casestudy _ stoves

cook stoves). Similarly, there is a strong body of evidence about obstacles limiting energy access in the region and an understanding of what does and does not work. The known conditions for meeting energy demand efficiently vary by scale and type of initiative.

1.3.1 Community-level conditions for success

It is essential to raise awareness among and gather feedback from communities when planning and delivering interventions to the end-use of energy services.[42] Energy provision, and labour and household income often differ by gender in sub-Saharan Africa, so information collected to inform new energy initiatives must adequately reflect these gender (or other) divisions, in the interests and perspectives on energy provision and expenditure of household incomes, for projects to be effective.[43]

Stories of success at community level, such as the case of Kenyan women stove makers presented in Text box 4 (above), tend to reflect a combination of advancing modern energy facilities with the region's untapped energy resources, while building local capacity in a participatory and locally appropriate way.

1.3.2 Effective legal, governance conditions and market development

Projects that work at any one level, in only one direction (top-down or bottom-up), are more likely to fail than succeed. Many well-intended, local, bottom-up, grass-roots projects have failed and numerous top-down government interventions have been abandoned. For a sustainable renewable energy sector to be effective there must be a push for renewable energy from the supply side and a pull from the energy consumer's side.[44]

Good laws and consistent enforcement are crucial components of an effective policy intervention. As such, the most successful renewable energy policies are characterised by ease of execution, which facilitates the political will and capacity to implement them.[45]

Lessons from Brazil, Japan, Spain and Germany demonstrate that steady and meaningful renewable energy price reductions are best developed through the creation of transparent and steady markets: sustaining a realistic market (based on supply and demand) for the related products and services, increasing the affordability for small and medium-size enterprises (SMEs) to enter the market, and providing conditions for optimisation of the comparative employment, research and development opportunities brought about by SMEs. Research in Kenya and Sri Lanka has shown that promoting demand through awareness raising, and working with local producers and service providers to facilitate improvements in value chains, can generate more effective, efficient and affordable services or products.[46]

1.3.3 Success in improving energy efficiency

The highest potential energy efficiency gains are in the industry, transport and the residential sectors. This is reflected by the target sectors of most existing sub-Saharan African energy efficiency programmes.[47] Examples of energy efficiency measures include installing solar water heaters in residential areas, which have achieved up to 40 per cent savings on household electricity bills, and the introduction of high efficiency light bulbs. Utilising renewables in the production of combined heat and power, for example in bagasse-based cogeneration (combined heat and power plant) and geothermal energy, is another initiative that has been implemented successfully.[48]

The infrastructure sector, including roads, ports, airports and power, has driven more than 50 per cent of Africa's recent economic growth. To limit sub-Saharan Africa's impact on global climate change, it is essential that energy efficiency and low-carbon measures are integrated in its current and future infrastructural plans.[49]

1.4 Challenges to overcome

National governments have traditionally played a big role in decision-making in the energy sector across sub-Saharan Africa. A lack of local private capital and the influence of utilities' activities on the economy traditionally provided reason for national authorities to intervene in their country's energy sector. However, government involvement has been characterised by poor management, corruption and draining of public money.

Despite widespread power sector reform in the late 20th century, the power sector in the region still seems to be dominated by state-owned monopolies, and there is a lack of policies to support the poor and prevent disproportionate benefits to the better-off.[50]

Across Africa, as with many developing areas, decisions on energy investment are made by the elite for the elite and protect its immediate economic interests. Decisions on energy strategy – for example, on which technologies to support and on who implements a project – often have the vested interests of the ruling classes at heart. An example of this can be seen in energy-rich South Africa, where the power sector is geared towards delivering very low cost electricity to the extractives industries, while the tariffs for townships have been raised substantially to meet the rising cost of power production. In other sub-Saharan countries it is clear that choices are being made that prioritise energy to urban centres and industries, while up to 90 per cent of the rural poor cook on primitive wood fires and have no prospects of accessing modern energy.

Different sections of the elite compete to control the energy sector, so that green policy for renewable energy may be overruled by industrial policy. For example, gas and oil extraction dominate the Nigerian energy sector, while low-carbon energy plans have been hindered by a lack of coordination between policy and implementation. As a result, gas flaring continues in a country where more than 90 million people have no modern energy. In other countries, effective monopolies block green energy providers' market entry.

For future reforms, energy provision must be viewed from a poor person's perspective, so that the industry is restructured to prioritise equitable access to energy, make funds available for policies that support the poor and provide clean and efficient energy to improve health and the natural environment. It must also look beyond electricity alone, and include more efficient and sustainable delivery of fuels, such as wood and charcoal, and the delivery of decentralised energy.

1.4.1 Governance, regulation and corruption

Effectively planned economic reform contributes to the larger-scale process of achieving good governance. Large swathes of land in Africa are rich in natural resources such as timber and fossil fuels. The management, award and taxation of concessions in these areas tend to lack transparency, risking leakage of government money away from national development priorities. Corruption at both national and local levels has significantly hindered energy access in sub-Saharan states, particularly for the poor, who pay a disproportionate amount of household income on energy provision and continue to be affected by energy price increases.

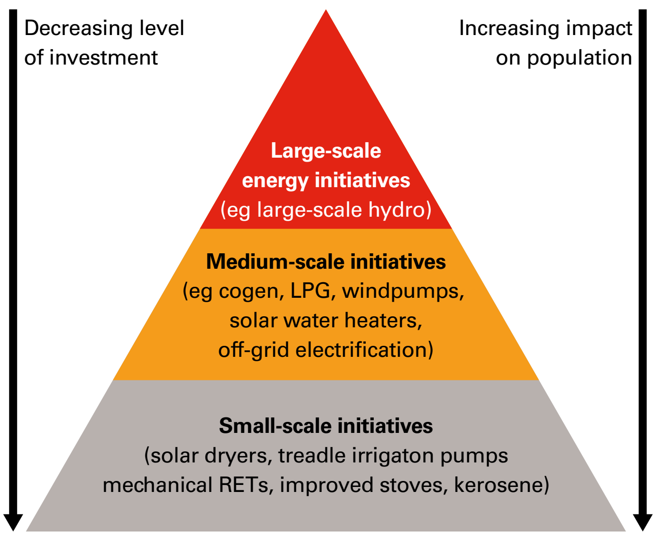
Regulation and good governance is vital to creating a competitive environment between private sector players. Such competition is necessary to drive forward research and development of renewable energy technologies, and improved energy efficiency measures. Primarily, the affordability of electricity and modern energy services to the poor must be maintained and increased through effective government regulation that ensures cost savings from energy efficiency and that other measures are shared equitably between suppliers and consumers.[51] Reforms must also encourage decentralised production and supply of power; grid services are not always effective solutions, and minigrids servicing communities from renewable energy sources may be an alternative, particularly in sparsely populated or geographically hard-to-reach areas, where the costs of traditional grid-infrastructure provision is prohibitively expensive.

Universal access to energy is more likely to be achieved if strong regulation measures are implemented effectively, otherwise they are unnecessarily delayed. Unfortunately, lack of capacity among regulators, ill-defined social and environmental standards, and lack of awareness among non-energy specialists as to the role energy can play across sectors are still preventing the supply and affordability of reliable energy services to poor people in sub-Saharan Africa.[52]

1.4.2 Manufacturing

Despite the abundance of natural resources, Africa has the lowest productivity out of all continents of the world and this is largely attributed to its infrastructural shortcomings.[53] The rate of growth of sub-Saharan countries' sustainable energy sector is further constrained by an investment bias towards the large-scale energy sector, such as large-scale hydro and petroleum projects. As displayed in the energy pyramid in Figure 6 (below), there is a disproportionate investment balance between large- and small-scale energy initiatives in the region that does not effectively consider the relative needs of the population.[54]

Figure 6: Energy pyramid in Africa and the need for a better balance[55]



A factor limiting in-country manufacture of renewable energy technologies is ineffective market penetration. The main barriers to market penetration of new renewable energy technologies vary by technology. In the case of solar water heaters the initial cost barrier is only part of the problem. A lack of awareness of policy makers, plumbers and end users, as well as lack of trained installers, national standards and testing facilities, are some issues preventing the increased manufacture of the technology.[56] However, these barriers have been overcome in some countries, for example in the Mediterranean region – about 90 per cent of Cypriot homes and 80 per cent of apartments have solar water heaters – so it is possible.

Worldwide, the industrial sector produces more than one-third of global energy-related CO_2 emissions and is responsible for more than one-third of global primary energy consumption.[57] There is large scope to achieve low-carbon development through the sub-Saharan region's manufacturing sector, which is one of its largest GHG emitters. Low-carbon development will bring job opportunities, particularly as jobs in renewable energy are not limited to resource-rich areas; for example there are employment opportunities in the manufacturing and development of technological parts.[58]

Another common threat to the manufacture of renewable energy technologies in sub-Saharan Africa is the competition from China for low-cost products such as solar lanterns or improved cook stoves. While it may not be realistic at the moment to expect African countries to manufacture solar panels or other more specialised technologies, there is significant scope to assemble solar products for local sale, to manufacture small hydro or wind turbine and to produce biogas units and improved stoves. In such a way the sub-Saharan region can build capacity for higher-value energy products and avoid dependency on imported technologies. Manufacturing in Africa may have to be supported until it reaches an economy of scale to compete with imported products.

1.4.3 Engaging the private sector to deliver low-carbon energy

There is strong evidence that the private sector can play a significant role in delivering low-carbon development and increasing the use of renewable energy in sub-Saharan Africa. This could be multinational intervention and invention, but is more likely to be a local private sector innovation: which could range from women running micro-enterprises in rural areas to medium-scale business capital to promote renewable energy. The private sector can bring investment, manufacturing capability and effective market delivery mechanisms. However, many countries in the region are currently viewed as high-risk areas for investment, while multiple renewable energy technologies are seen as in their early stages of development. The risks for private investors include:

- no well-formed, effective business chains
- limited financial and technical capacities of companies
- a lack of secure national policy framework or strategy
- regulations that do not support independent power producers of suppliers
- lack of institutional capacity to support private sector engagement in the energy sector
- perceived risk of new technology innovation
- poorly developed markets
- lack of finance to support development of the market, particularly in poor areas.

Some African countries are taking the initiative to create a better environment for private sector engagement. Ghana's Energy Sector Development and Access Project (GEDAP) seeks to create the enabling policy and regulatory environment that would help attract private sector capital.

Start-up capital can be used to pilot new technology innovations, to reduce financial risk of starting a business and to increase the capacity of the local private sector.

1.4.4 Economic issues

Attracting more capital to increase access to modern energy services is one of the largest challenges facing sub-Saharan Africa's energy sector. From exploration and extraction of fossil fuels to electricity generation and distribution, African governments have traditionally struggled to raise the funds to meet total energy demand. Today, in the context of global, national and local environmental and social challenges – including the need to mitigate climate change and achieve growth in the face of natural resource scarcity – even higher amounts of capital are required for countries to develop and market sustainable, low-carbon and renewable technologies.

Private sector investors have been discouraged from investing in the region's energy sector because the country risks are often perceived to outweigh the potential benefits. New public-private partnerships offer a promising change in investment trends, helped by the global drive towards low-carbon and renewable energy generation and Africa's abundance of natural resources. Investors such as the World Bank that are well positioned to invest also continue to drive forward unsustainable energy production there. An overview of Christian Aid's No More Dirty Power campaign is displayed in Text box 5 (below).

1.4.5 Common past mistakes of many energy projects and policies

The following are examples of errors regularly made in energy projects and policies:

- prioritising technology development over delivering energy as a service to the poor

Text box 5: Christian Aid's World Bank: No More Dirty Power campaign

Despite a large and vocal campaign from South African civil society in spring 2010, the World Bank agreed to a loan of £2.2bn for South African energy giant Eskom to build a new unabated coal-fired power station. The new plant will emit an estimated 25 million tonnes of CO_2 per year, and damage the air, water and health of local communities.

Big industry will benefit from the electricity produced by the plant, but not ordinary South Africans, many of whom currently live without access to electricity or find the increasing electricity tariff unaffordable.

Representing the views of the Southern African Faith Communities' Environment Institute (SAFCEI), Bishop Geoff Davies stated: 'We believe the World Bank has no ethical position to continue financing the destruction of the planet's climate by funding coal generation… We believe a sustainable energy future is possible if we put power in the hands of the people.'

- failing to understand the links between energy and the livelihoods of the poor, including in relation to development and poverty reduction strategies
- lack of awareness on the part of non-energy specialists of the value energy plays in meeting other sectoral objectives (such as agriculture, health, education, manufacturing and so on). Under-representation of community energy requirements for cooking and space heating. Community centres, schools, medical centres and micro-enterprises all require modern energy services, in addition to households
- over-emphasis on energy-supply issues in relation to end-use benefits, represented in the funding bias towards large power projects over capacity-building at local level to install, operate and maintain small-scale systems
- one-directional planning of energy projects, often ignoring the need to involve communities in the planning process. Many projects have failed for providing energy services that are not socially acceptable, sustainable or appropriate to the unique needs of a given location.

The failure to include energy access as part of the MDGs was a fundamental failure in recognising its importance for poverty reduction. This can be rectified in the post-2015 framework to replace the MDGs.

2.0 LOW-CARBON AND RENEWABLE POTENTIAL

Christian Aid/Sam Faulkner/NB Pictures

Solar panels provide energy in the village of Wawan Rafi, Jigawa State, northern Nigeria

2.1 Renewable potential in Africa

While the costs of climate change to sub-Saharan Africa are significant, the sub-continent has vast renewable resources and the potential to chart a course for sustainable low-carbon growth. Harnessing its renewable potential will bring socio-economic benefits in support of poverty reduction, economic growth and employment as well as environmental protection.[59]

2.1.1 Hydro

Hydro power is the harnessing of the energy in falling water for either mechanical power (such as water mills), or, more likely these days, electricity. There are examples of very large-scale hydropower dams across the globe, such as the Three Gorges dam in China. Many large-hydropower projects have been criticised for poor consideration of social and environmental damage and forcible displacement of communities. Ten years ago, the World Commission on Dams established a set of guidelines for sustainable development of large hydropower,[60] which have yet to be adopted by many countries worldwide. Medium scale (20MW to 100MW) and small-scale hydropower (less than 20MW) offer more sustainable and decentralised alternatives to large scale.

- Installed hydropower capacity is about 20.3 gigawatt (GW) with a total generation of about 76,000 gigawatt-hour (GWh) per year.[61]
- Estimated technically feasible hydro potential on the African continent is around 1,750TWh.[62] However, it is important that this potential is developed in a sustainable manner that is compliant with the recommendations of the World Commission on Dams.
- Africa is currently using 20 per cent of its hydropower potential, with non-uniform regional distribution.
- Some regions are more resource-rich than others – a few countries contribute more than 65 per cent of total installed energy.[63]
- The Democratic Republic of Congo (DRC) and Ethiopia together account for more than 60 per cent of Africa's hydropower potential (40,000MW).[64]
- Despite abundant resources, small hydropower development is weak in comparison to large hydro.

2.1.2 Geothermal

Geothermal energy harnesses the underground heat that comes near the Earth's surface at geological faults. While it is a very effective source of energy, it is limited to countries with sufficient geological activity.

- Estimated geothermal resources on the African continent are around 14GW.[65]
- Only 0.6 per cent of Africa's geothermal potential has been exploited.[66]
- Currently, the only countries using geothermal for electricity in sub-Saharan Africa are Kenya (127MW) and Ethiopia (7MW).[67]
- Many countries in the region have rift valleys with significant geothermal project development potential.
- The most promising undeveloped rift systems are the East African Rift in Mozambique, and another in Uganda. Further research is required to explore possible geothermal potentials in Tanzania, Eritrea and Zambia.

2.1.3 Wind

Electricity generation from wind power is reducing rapidly in cost and becoming a viable alternative to conventional power for grid electricity. It can also be used off-grid for water pumping and battery charging.

- Africa's wind-energy potential is not currently well assessed, but there is limited rapid wind-energy development on the continent in comparison to other world regions.
- In 2007, Africa had about 476MW of installed wind-energy generating capacity; a significantly low proportion of the estimated sub-Saharan Africa-wide capacity (93,000MW).[68]
- The following 11 countries (by region) have the strongest wind resources in the sub-Saharan region:
  - East Africa: Djibouti, Eritrea, Seychelles and Somalia
  - West Africa: Cape Verde and Mauritania
  - Southern Africa: South Africa, Lesotho, Madagascar and Mauritius
  - Central Africa: Chad.

- As most African countries have fairly low wind speeds, there is greater potential for large-scale than for small-scale project development. However, new technologies are emerging to overcome current technological barriers at the local level.

2.1.4 Solar

Markets for solar photovoltaic (PV) systems are expanding across Africa, especially for lighting and communications. Solar thermal power (that is using the direct heat from the sun) also has its uses for water heating and power generation, as described below.

- The sub-Saharan African countries are well exposed to sunlight with some of the highest solar intensities in the world. PV applications have developed many benefits across the region, ranging from solar refrigeration for vaccines to improved access to learning environments from the provision of solar lanterns.
- Large-scale development is more costly than small-scale uses and still largely in a development phase in the region, and development at scale has been limited in some cases.
- Northern and southern Africa, particularly the Sahara and Kalahari deserts, have particularly promising conditions for concentrated solar plants for large-scale power production.[69]
- To date, only South Africa is generating solar thermal power (0.5MW) in the sub-Saharan region.[70]

2.1.5 Biofuels

Traditional biomass (burning wood, charcoal and agricultural waste) is the most common fuel used across the continent. However, more frequently now, modern biofuel technologies are starting to replace traditional fuels, and offering wide potential for power generation and transport fuels.

- If produced and used in a sustainable way, biofuels are a promising alternative energy source for Africa.[71] However, it will be necessary to set high standards for sustainable production of these to safeguard against negative social and environmental outcomes such as displacement of agricultural land for food security.
- The continent's tropical south-eastern region, particularly Tanzania and Mozambique, has the right investment climate, soil and transport infrastructure for a thriving biofuels industry.
- Countries with land suitable or very suitable for biofuels: South Africa (8.7 million hectares); Angola (22.1 million ha), Zambia (24.1 million ha), Mozambique (31.1 million ha).
- Bagasse is a promising by-product of sugar cane that can be harnessed for energy. There is significant potential to harness more than 26 million tonnes of bagasse produced in Africa.[72]

2.1.6 Regional power trading

As this section demonstrates, only a small fraction of sub-Saharan Africa's power generation capacity has been developed. Despite having vast renewable energy resources, at least 21 of the 48 countries in the region have a generation capacity below 200MW. Large distances between cost-effective energy resources and major centres of energy demand are greatly to blame for the resulting high cost of power production (US$0.18–US$0.25 per KW) in countries too poor to raise the billions of dollars to develop the sector.[73] Despite 80 per cent of Africa's population residing in the sub-Saharan region, only 25 per cent of the energy generated in Africa is generated there.[74]

If the sub-Saharan countries were capable of increasing investment in the regional pooling of energy resources, the cost of energy production, which is twice as high as in some other world regions, could be reduced significantly. The Infrastructure Consortium for Africa estimates that regional power trading, if pursued to full economic potential, could:[75]

- reduce the annual cost of power system operation and development by US$2bn per year
- achieve cross-border transmission returns from around 25 per cent for most power pools and up to 120 per cent for the Southern African Power Pool (cross-border electricity market in southern Africa)
- enhance the economies of 16 countries in the region through improved access to imported energy
- achieve savings of between US$0.01-US$0.07 per kWh of energy produced.

2.2 Initiatives, plans and strategies in Africa

The African Development Ministerial is 'determined' to develop a 'Low-Carbon Growth and Sustainable Development Strategy in Africa, focusing on the different mitigation and adaptation needs and priorities of African countries within the course of 2011'.[76] The process was discussed and agreed upon at the Third Tokyo International Conference on African Development (TICAD) in May 2011, where participants also reiterated 'the importance of making their utmost efforts to bring a successful outcome' at the 17th Conference of the Parties (COP17) to the UNFCCC due to be held in Durban, South Africa, at the end of 2011.

2.2.1 International initiatives to fund energy and climate change mitigation in Africa

Africa hopes COP17 will exceed the progress made with the Cancun Agreements established following the 16th COP in December 2010, which set out additional funding for climate change adaptation and mitigation in developing nations. Current funding pledges include US$30bn from 2010-2012, with a commitment to increase this to US$100bn per year by 2020, from developed to developing countries.

The agreement was also made at COP16 to establish a new Green Climate Fund (GCF) and this should open up new funding opportunities for sub-Saharan Africa to address climate change adaptation and mitigation needs. However, there are many questions hanging over the governance and the sources of finance for the new fund, which provide uncertainties for the region, including:[77]

- how will funding be raised by industrialised countries?
- how much funding will come from public/private/ multilateral/bilateral sources?
- how much of the US$100bn per year by 2020 pledged to developing countries at COP15 in Copenhagen should be channelled into the GCF?
- given that developed countries already seem likely to fail in providing the committed 0.7 per cent of GDP by 2015 in support of the MDGs, what assurances are there that climate aid pledges will be delivered, and that pledges will be 'new and additional' to current pledges for development aid?

Progress towards achieving Africa's renewable potential is significantly limited by funding constraints. One of the greatest uncertainties is how promised funds will be raised by industrialised countries, other than that funding will 'come from a wide variety of sources, public and private, bilateral and multilateral, including alternative sources of finance'.[78] Further doubt arises from past experience, which shows that without high levels of public engagement and greater awareness on the issue and risks posed by climate change, there will be little political feasibility in the transferring of large sums of money to the developing world, particularly in view of the dire fiscal situation currently characterising developed nations.

There is also a question over how much of this fund will be directed to low-carbon development in Africa – to date, climate mitigation funds and carbon market finance has largely bypassed sub-Saharan Africa. The GCF may also prioritise projects that achieve leverage of private sector investments (that is using public sector money to encourage increased private sector investment); this will require very careful planning and delivery of funds to encourage private sector investment in the region.

There is great hope that Africa will have an influence and receive positive answers to many of the above questions when decisions are made about the proposed structure of the GCF at COP17 in Durban in 2011 and during 2012.

2.2.2 Feed-in tariffs for renewable energy

In 2009, South Africa became the first African country to introduce a feed-in tariff (outlined in Text box 6, p24) for renewable energy. The World Wind Energy Association (WWEA) expects this form of decentralised investment to mitigate strongly energy challenges in sub-Saharan countries through allowing small and large investors to contribute to the take-off of renewable energy.[79] Feed-in tariffs also bring benefits at community level through increased electricity generation, for example from community wind-farms, and jobs created as a result of increased technology demand.[80]

Germany's electricity feed-in law is the most successful policy to eliminate barriers to renewable energy development in the country. Through requiring utility companies to purchase electricity from renewable sources and establishing a minimum price, the legislation created

Text box 6: Overview of the feed-in tariff and quota systems[81]

Feed-in tariffs are pricing systems that regulate electricity grid operators by obliging them to accept electricity generated from renewable energy, and pay fixed minimum prices. As prices are differentiated according to technology, size and location, feed-in tariffs prevent market domination of the cheapest technology and prevent sole exploitation of the locations with the most abundant natural resources (such as sunshine belts). There is a guaranteed payment schedule of about 20 years, allowing investor confidence that projects will give a long-term return, which is formalised by a standard contract between the grid-feeder and the grid-distributor.

Quota systems are the opposite of pricing systems because governments fix a realistic target instead of a price. This target represents a minimum share (quota) of energy that must come from renewable sources. While the European Union (EU) has set a quota for renewables that it is aiming towards, there is less experience with electricity quota systems compared to the feed-in system, and no known examples of quota system implementation in sub-Saharan Africa.

certainty for investors as well as economies of scale, which has led to large-scale cost reductions.[82]

Since the announcement of South Africa's feed-in tariff system in 2009, more than 100 renewable energy proposals amounting to more than 500MW have been received by the country's Department of Minerals and Energy. However, the South Africa case study in Annex 1 raises scepticism about the effective implementation of the feed-in tariff by the government and the utility ESKOM.

2.2.3 The Clean Development Mechanism and Nationally Appropriate Mitigation Actions in Africa

As of July 2011, less than two per cent of all registered Clean Development Mechanism (CDM) carbon market projects were situated in Africa.[83] Worldwide, less developed countries – as very low emitters in comparison to the emerging economies – have not attracted projects due to two main reasons. First, 'low-hanging fruit' opportunities are offered by higher-emitting nations, which excludes those in Africa. Second, potential emissions-saving opportunities in Africa tend to come from smaller projects, which discourages investors because the high administrative costs in setting up and implementing CDM projects eats into a higher proportion of the project costs than for larger projects.

Disappointment following the lack of financing and clean technology brought to Africa through the CDM presents a challenging context for the design and implementation of Nationally Appropriate Mitigation Actions (NAMAs). First introduced in the Bali Action Plan of 2007, and redefined in the Cancun Agreements of 2010, NAMAs are new instruments 'aimed at achieving a deviation in emissions relative to business-as-usual emissions in 2020'. They are designed to be proposed by developing countries in the category of 'voluntary emission reduction measures'.[84]

To date, international negotiations have failed to provide a specific definition of NAMAs and to decide the level of GHG reductions to be accomplished by different types of these, and how they should be subject to international measurement, reporting or verification processes. Also, investor interest and confidence in NAMAs are almost certainly likely to be affected by uncertainty of the negotiations under the UNFCCC, including the establishment of the Kyoto second commitment period.

The biggest funds for mitigation projects in developing countries are the World-Bank-managed Climate Investment Funds. Two of the funds are for low-carbon technology: the Clean Technology Fund (CTF), which currently has pledged a total of US$4.4bn for climate mitigation in middle-income countries, and the Scaling Up Renewable Energy Programme (SREP), which has pledged US$340m to support investments in a small number of low-income countries for energy efficiency, renewable energy and access to modern sustainable energy. From sub-Saharan Africa, only Nigeria and South Africa are eligible for funds from the CTF, while Ethiopia and Kenya are pilot countries for the SREP. There is considerable concern that four years since the funds were set up, very few low-carbon projects have yet to be implemented.

2.3 What is possible in the future for energy

Assuming minimum electricity consumption required at household level for basic needs is 250kWh per year in rural areas and 500kWh in urban areas,[85] under the New Policies Scenario, sub-Saharan Africa will need to have an additional generating capacity of 462TWh in 2030 to meet minimum requirements.[86] The current total installed generation capacity of the 48 countries in the region is just 0.068TW – no more than that of Spain (2008 figures). This total falls to just 0.028TW – equivalent to that of Argentina – when South Africa is excluded.

While on-grid connections are likely to generate the greater part of the required supply (see Table 2 below), the high cost of grid extension will mean that decentralised generation in the form of mini-grid (a small power generator such as micro-hydro, wind or biofuel plant) supplying a few communities through a small grid system) and isolated off-grid (such as individual solar home systems) connections are vital components of the total incremental electricity output.[87]

This on-grid/off-grid/mini-grid pathway to achieve minimum electricity consumption by 2030 must be complemented by a range of initiatives that increase access to modern energy services, if sub-Saharan Africa is to meet its energy and development objectives. Table 3 (below) displays a broader mix of larger- and smaller-scale energy initiatives that present opportunities for the region to achieve its low-carbon and renewable potential.

Across all energy sub-sectors, there are options for sub-Saharan countries to realise the cost-effectiveness of energy efficiency possibilities and to exceed those potentials in the future. Effective energy efficiency policies and programmes are essential to facilitate this process.[88]

2.3.1 Large-scale renewable energy systems

International investments, in the form of technology, finance or capacity-building, will provide a major influence on sub-Saharan Africa's energy future through large-scale energy systems. The potential opportunities of large-scale hydro, geothermal, wind, concentrated solar power and biofuels are displayed in Table 4 (p26).

Technology transfer is the moving of low-carbon technological hardware from one country (for example, a developed one) to another (usually a developing one), in addition to the transfer of knowledge and skills required to operate, maintain and develop that technology. Renewable energy systems in the sub-Saharan countries offer more new work opportunities than fossil and nuclear energy

Table 2: Generation requirements for universal electricity access, 2030 (TWh)[89]

	Year	On-grid	Mini-grid	Isolated off-grid	Total
SUB-SAHARAN AFRICA	2030	195	187	80	462
TOTAL DEVELOPING COUNTRIES		379	399	171	959

Table 3: Potential low-carbon and renewable energy initiatives, by scale

Large-scale energy (usually grid connected)	Medium and small-scale
• Hydropower • Geothermal • Wind • Concentrated solar power • Modern biomass	1. Energy systems that produce electricity, based on PV, wind power and micro-hydro 2. Energy systems that produce thermal energy for heating, drying and cooking, including biogas

technologies, yet the full implications of this are yet to be realised.[90]

Energy infrastructures in the region are under-developed and there is significant opportunity to make the transition from accepting low-value, discarded technologies from the developed world to creating new jobs in sustainable energy technologies in-country. International involvement and investments, for example through joint implementation processes such as the CDM or the GCF, present a wide range of in-country benefits when combined with job creation in new renewable energy infrastructure.

Despite the opportunities, there is a risk that directing resources towards large-scale renewable energy production could prevent sub-Saharan Africa from reducing the weaknesses that currently characterise conventional, centralised generation systems. For example, because

Table 4: Potential opportunities of large-scale, sustainable energy systems in sub-Saharan Africa

Type	Potential opportunities
Geothermal	• There are significant opportunities for expansion of geothermal energy. • In 2008, the continent's first privately financed geothermal plant was commissioned in Kenya.
Wind	• Substantial shift towards wind in several countries during 2008. • Significant potential for large-scale wind power development across coasts, the extreme east, west and south. • New technologies are emerging. The windbelt technology is the first system to capture wind power without using a turbine and can be used from micro to macro level. While still being developed for large-scale application, windbelt technology is more efficient than turbines, especially for regions such as this that are characterised by lower wind speeds.
Concentrated Solar Power (CSP)	• Significant suitability for CSP energy. • If enough plants are constructed, CSP could provide enough energy for domestic needs. Power could also generate profits through power sales to Europe for a relatively low transmission loss (15 per cent).[91]
Hydro[92]	• Hydroelectricity potential is high and the region continues to attract investment in this area. • In Kenya, hydropower already supplies more than two-thirds of existing power capacity (677MW). • Uganda attracted US$49m of investment from the Emerging Africa Infrastructure Fund in 2008 for two hydropower projects.
Biofuels[93]	• Substantial shift towards biofuels in sub-Saharan Africa during 2008. • There are increasing sustainable energy investments in biofuels: cogeneration constitutes more than 40 per cent of electricity generation in Mauritius,[94] while ethanol-gasoline blends are currently used to cover fuel shortages in Ethiopia. Tanzania has attracted international investment for a 240-million-litre-per-year sweet sorghum ethanol facility and a 100-million-litre sugar cane plant. • Utilising the 8.7 million hectares of land suitable for feedstock cultivation, South Africa has channelled significant investment to the biofuels industry. The interest is spreading to neighbouring countries, which have each more than doubled the land area suitable or very suitable for biofuels. Angola now has 22.1 million hectares available, while Zambia has 24.1 million and Mozambique has 31.1 million.

they are small and more discrete than large-scale power stations, cogeneration plants are significantly less affected by high maintenance requirements, theft, sabotage, terrorism and political manipulation than conventional systems.[95] Moreover, centralised generation systems are less environmentally and economically sustainable, requiring expensive investments to extend services to meet rural demand.

2.3.2 Energy efficiency opportunities

There are significant energy efficiency opportunities that are yet to be harnessed in both conventional and modern energy technologies. In the manufacturing sector, the majority of quick wins are in motor-driven equipment, which consumes approximately 60 per cent of the sector's final electricity use. While gains are largely untapped, energy efficiency measures in motor systems including compressed air, pumping and fan systems are believed to be highly cost-effective, low-carbon development options.[96]

Increased efficiency and use of better technologies will enable more widespread use of promising cogeneration technologies. Producers can use such facilities to generate power to meet local demand or for profiting from sales to the national grid.[97]

2.3.3 Medium- to small-scale energy systems

Technology transfer and capacity-building can also create new opportunities for the in-country manufacture of medium- and small-scale low-carbon and renewable energy technologies, with strong employment and economic growth benefits.

Socio-economic opportunities brought about by low-carbon and renewable energy varies by the type of technology in question. For example, most new jobs associated with the in-country manufacture of solar water heaters appear to be created in the business side of selling, installing and servicing as opposed to the direct manufacture of the technology, which can be costlier and less secure.[98] Regardless of the technology, with each new job that is created, there is an economic multiplier that reflects the subsequent impact of the related indirect jobs created.[99]

There are two major types of smaller-scale energy systems that can be used to increase access to modern energy services in Africa. The first type is energy systems that produce electricity based on PV, wind and hydropower – for example mini-grid and off-grid electrification such as solar PV cells, wind belts, wind pumps and micro-hydro systems for milling and electricity production. The second type is energy systems that produce thermal energy for heating, drying and cooking – for example solar water heating, solar dryers, gassifiers and improved stoves.

Table 5 (pp28-29) outlines the potential opportunities to low-carbon development and universal energy access in the sub-Saharan countries, offered by these initiatives.

2.4 Estimated costs for universal access and low-carbon development

2.4.1 Development costs of delivering access to modern energy services

Access to a level of energy services sufficient to support delivery of the MDGs is and must be the beginning of the story. Various studies have examined the energy requirements of meeting the MDGs and these repeatedly reach two critically important conclusions.[100] First, such requirements would not be particularly costly; second, they would have only minor emissions impacts.

An MDG Energy Vision (developed as part of the Millennium Development Project) provides a schematic view of the energy requirements of the MDGs. The targets of the MDG Energy Vision are that by 2015:[101]

- 100 per cent of the world's urban and 50 per cent of its rural populations use modern liquid and gaseous fuels for cooking
- 50 per cent of the world's rural population use improved biomass stoves
- 100 per cent of the biomass used for cooking is produced in a sustainable way
- 100 per cent of the world's urban populations have a basic electricity supply to meet lighting and communication needs
- 100 per cent of the world's health facilities and schools have an electricity supply and use modern liquid and gaseous fuels to meet cooking and heating needs
- 100 per cent of all communities have access to mechanised power.

Table 5: Potential opportunities of small/medium-sized sustainable energy systems in sub-Saharan Africa

Type	Initiative	Opportunities
Systems producing electricity based on PV and wind power (for example, mini-grid and off-grid electrification)	Microbial Fuel Cells (MFCs)	• In the process of development specifically to meet the region's needs, MFCs could be used 24 hours a day (unlike solar or wind) to charge mobile phones and radios, and as a reliable source of light, replacing the need for kerosene lamps.
	Windbelts (non-turbine wind energy technology)	• In the process of development, the windbelt is a turbine-less wind-energy technology that is not subject to grid failures. It is socially beneficial, providing enough lighting for school or households and very suitable to Africa's low-wind speeds – it can run on as little as 5mph.
	Traditional small-scale wind turbines and pumps	• Traditional small-scale (<100KW) wind turbines can be used to pump water or for grinding grains and battery charging. There are opportunities for increased home use or for use as part of hybrid system.
	Small hydropower and micro-hydro	• Small hydropower (SHPs) (>10MW) can supply remote communities and catalyse development. Most African countries are already exploiting the benefits for rural communities.[102] • Social and commercial uses.
	Cogeneration	• Potential to expand cogeneration from agricultural waste.[103] • Cogeneration plants are significantly less affected by the high-maintenance, theft, sabotage, terrorism and political manipulation that characterise centralised, conventional power plants.[104] • Cogen for Africa initiative will stimulate more than US$300m in medium- to long-term investment in the industry through technology transfer, capacity-building and financial incentives.[105]
	Solar PV cells	• Capitalising on Africa's record of having the most intense solar radiation in the world, PV provides reliable, rural electrification, with benefits for employment and education after dark. • Can be used alone or via a grid system. • Individual cells can be combined to customise the system, according to the resource availability and energy needs. • Opportunity to provide technical jobs at a local level.

Table 5 (continued): Potential opportunities of small/medium-sized sustainable energy systems in sub-Saharan Africa

Type	Initiative	Opportunities
Systems producing thermal energy for heating, drying and cooking	Solar water heating, solar dryers, improved stoves	• Affordable, accessible, efficient, healthy. • Can help provide more opportunities for women through reducing time spent on collecting woodfuel and cooking.
	Small-scale biogas digesters	• Composed of methane and CO_2, which can be captured and used for cooking and heating, and reducing atmospheric GHG emissions. • Deters deforestation and environmental degradation, reduces air pollution and related health issues.
	Improved cook stoves	• Affordable, accessible, efficient, healthy. Potential energy savings in Africa from improved cook stoves include:[106] – rural household energy use: 116 million tonnes of oil equivalent (Mtoe) – efficiency improvements: 30-40 per cent – energy savings: 35-46Mtoe – maximum fuel-wood savings: 14Mtoe.

The IEA has developed a Universal Modern Energy Access Case (UMEAC), which quantifies the number of people who need to gain access to modern energy services and the scale of investments required by 2030. It also relates to the achievement of the MDGs through including an interim target in accordance with MDG 1.

The results from the UMEAC scenario can be compared to the scenarios set out in the *World Energy Outlook 2010* report, particularly the New Policies Scenario, which considers broad policy commitments that have already been announced and therefore represent no significant future changes to policy from today.[107] A comparison of the projected outcomes for the UMEAC scenario and the New Policy scenario are illustrated in Figure 7 (p31).

In its most recent report the IEA estimates the cost of delivering an 'Energy for All' scenario. At the regional scale, under the Energy for All scenario, cumulative investment of US$390bn during 2010-2030 would be required to electrify all households in sub-Saharan Africa by 2030.[108] Table 6 (p30) displays this investment requirement disaggregated into the periods leading up to the MDG 1 target year of 2015 and the universal access to modern energy services (which would require 100 per cent electricity access) target year of 2030. The estimations show that an additional US$118bn of investment would be required in the region during 2010-2015 to meet the required electricity access target for achieving MDG 1, and an additional US$271bn would be required from 2016-2030 to achieve universal access to electricity by 2030, equivalent to US$19bn per year for the 20-year period.[109]

In terms of access to clean cooking facilities, under the Energy for All scenario, an investment of US$22bn during 2010-2030 would be required to achieve universal access to clean cooking facilities in sub-Saharan Africa by 2030, or US$1.1bn per year.[110] This gives a total investment required for energy for all in sub-Saharan Africa of US$20bn per year.

If the target of achieving (global) universal access to modern energy services (including 100 per cent electrification rate and 100 per cent access to clean cooking facilities) by 2030 is to be met, the IEA estimates that, adding its New Policy scenario and its Energy for All case, it will take US$1tn by 2030. This is US$48bn per year.[111]

Table 6: Additional cumulative investment requirements for electricity access in the Energy for All scenario (US$bn)[112]

Region	2010-2015	2016-2030	2010-2030
Sub-Saharan Africa	118	271	389
Total Africa	119	271	390
All developing countries*	243	398	641
World**	243	398	641

*includes Middle-Eastern countries
** includes OECD [Organization of Economic Cooperation and Development] and transition economies.

The IEA figure is above the UNDP estimate that US$35-40bn of capital will be required for universal access to modern energy services to meet basic needs by 2030.[113]

However, the figure is relatively small in comparison to projected global energy investment over the next 20 years (US$26tn); meeting this Energy for All 2030 scenario would require a mere three per cent redistribution of the projected investment.[114]

The IEA is clear that 70 per cent of rural areas are best provided either with mini-grids (65 per cent of this share) or with small, stand-alone off-grid solutions (the remaining 35 per cent). There is greater dependency on mini-grids and isolated off-grid solutions, particularly in countries (such as Ethiopia, Tanzania and Nigeria) where there is a higher proportion of those lacking electricity in rural areas.[115]

2.4.2 The cost of delivering low-carbon development in sub-Saharan Africa

The required investment to achieve low-carbon development in sub-Saharan African states is more difficult to quantify than that which is required to achieve access to modern energy services. There is currently no internationally agreed definition of the term 'low-carbon development' and there are ongoing discussions among development agencies about how to strike the right balance in integrating adaptation and mitigation as part of the requirement to make low-carbon development practices climate resilient.[116]

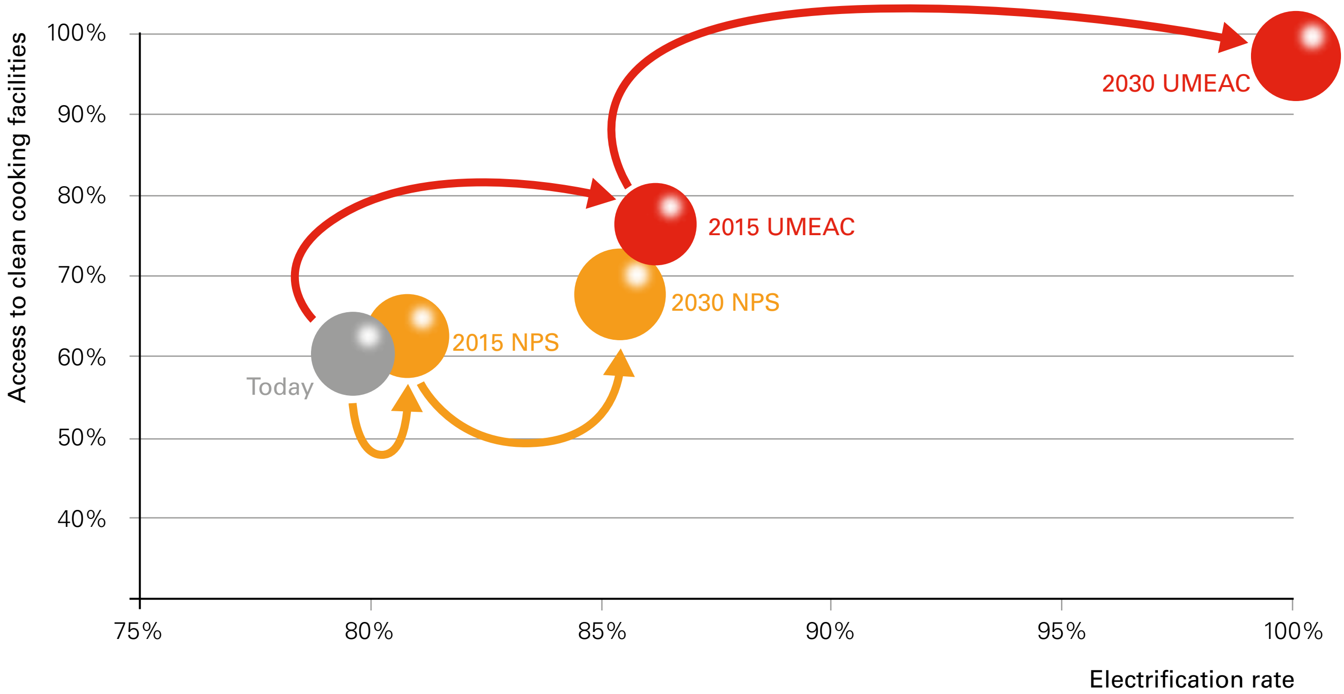
Many of the African nations cannot afford the high costs of climate change mitigation and adaptation, yet they are still disregarded in many climate change agreements and investments. In 2008, less than 10 per cent of total sustainable energy investments from developed to developing countries were directed to Africa (US$36.6bn).[117] However, despite annual investment being relatively less than in the rest of the developing world, total sustainable energy investment in Africa is increasing each year: the US$1bn invested in 2008 was a 10 per cent increase on investments in 2007.

There is a wide range of cost estimates for low-carbon development, but most are at the national or continental rather than regional level. Table 7 (p32) displays the business as usual emissions (BAU) for sub-Saharan Africa and its abatement potential (the emissions it would emit if it took carbon-cutting measures) for different time periods, as quantified by McKinsey in 2009. These BAU emissions and abatement potentials are translated into capital investments in Figure 7 (p31), showing that Africa would need to invest €12bn in 2011-2015 and €35bn in 2026-2039 to achieve its maximum abatement potential.[118]

These figures suggest that Africa accounts for about 10 per cent of all abatement costs in the developing countries. This is not the same as the climate finance costs, as many of the middle-income countries would be expected to meet many of their abatement costs through domestic investment, whereas the low-income countries of sub-Saharan Africa should expect abatement costs to be covered by climate finance. Limitations of the McKinsey study are that it is based on a level of emissions cuts over the next 40 years, which would give only a 50 per cent chance of staying below 2°C of global warming, and it is unclear what BAU scenario is used for African economic growth (likely to be based on current growth levels).[119]

In terms of the costs to reduce energy intensity through energy efficiency improvements, the UNDP estimates that

Figure 7: Access to modern energy services in the New Policies Scenario (NPS) and Universal Modern Energy Access (UMEAC)[120]



World Energy Outlook 2010 © OECD/International Energy Agency 2010, figure 8.20, p267.

on average an additional US$30-35bn of capital is required for low-income countries – which are largely in sub-Saharan Africa – and US$140-170bn for middle-income countries per year until 2030, over and above the IEA's New Policy Scenario. It is less clear what portion of this sum would be allocated to Africa specifically, though the continent currently has the highest energy intensity in the world, defined as the ratio of each country's domestic energy consumption to its GDP. Therefore Africa could be expected to gain substantial investment to meet this goal.

The most optimistic growth pathway for Africa appears to be that of the African Development Bank (AfDB). According to the chairman of the AfDB committee on climate change, Aly Abou-Sabaa, 'the cost of putting Africa on a low-carbon growth path with significant emissions reductions would be about US$22-30bn per year by 2015 and US$52-68bn per year by 2030'.[121]

However, the important thing to remember is that none of these numbers corresponds to scenarios that are actually designed to meet Africa's need to develop, and thereby eradicate poverty and improve welfare. Indeed, the projections typically compiled by institutions such as the IEA assume that Africa continues seriously to lag behind not only the industrialised countries, but also other developing regions.

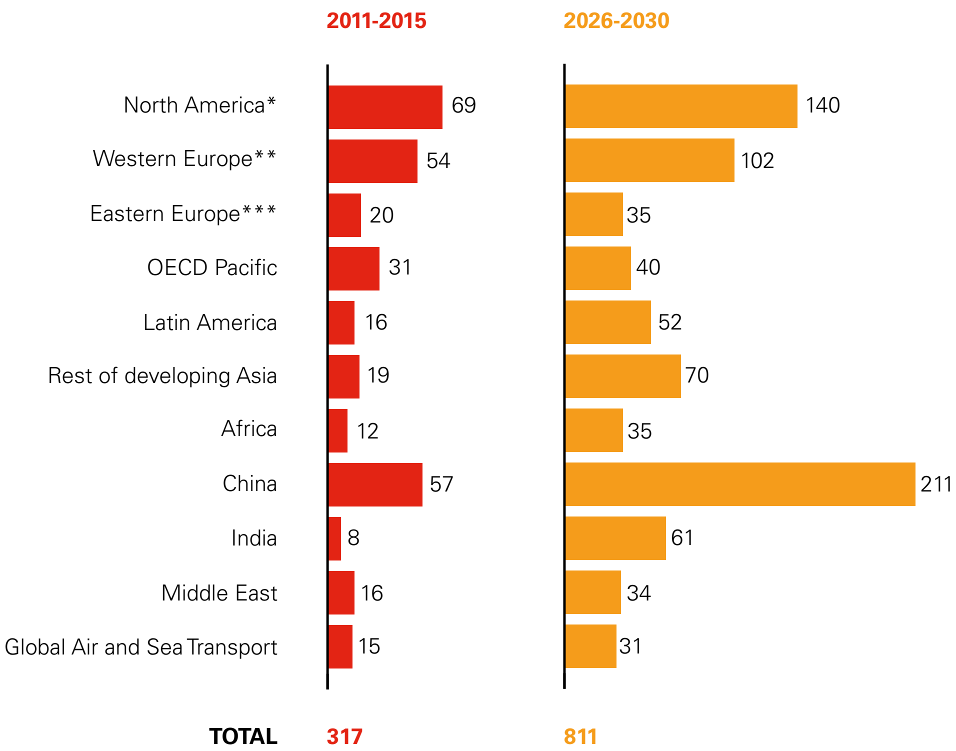
In the IEA's New Policies reference scenario, for example, Africa's per capita income rises at an extremely sluggish 1.1 per cent per year, which is less than half the rate in Latin America, and less than a quarter of the rate of Asia. By 2035, African incomes will have risen by about one-third, whereas Latin American incomes have nearly doubled, and Asian incomes more than tripled.

This is reflected in the levels of energy consumption assumed in this reference scenario. In Africa, total primary

Table 7: Low-carbon Africa – business as usual (BAU) and abatement potential (giga tonnes carbon dioxide equivalent, $GtCO_2e$ per year)[122]

		BAU Emissions			Abatement potential	
		2005	2020	2030	2020	2030
Africa	South Africa	0.4	0.6	0.7	0.2	0.5
	Rest of Africa	2.7	3.2	3.5	1.3	2.4

Figure 8: Capital investment by region incremental to business-as-usual for the abatement potential identified. (€ billion per year, annual value in period).[123]



Notes:
*United States and Canada
**EU27, Andorra, Iceland, Lichtenstein, Monaco, Norway, San Marino, Switzerland
***Russia and non-OECD Eastern Europe
Source: McKinsey Global Institute, *Pathways to a Low-carbon Economy*; Global GHG Abatement Cost Curve V2; Houghton; IEA; UNFCCC; US EPA.

energy consumption is actually increasing slower than population growth, meaning that per capita primary energy consumption actually declines by 0.7 per cent per year. By 2035, the average African rate of primary-energy consumption would be about 15 per cent lower than it is today.

Even the IEA's Universal Energy Access scenarios provide a very minimal level of energy services. The target level of electricity is enough to provide a rural household with enough electricity to power 'a floor fan, two compact fluorescent light bulbs and a radio for about five hours per day'. The total amount of electricity allotted per rural household for one year is equivalent to the amount consumed by the typical US household in approximately one week. The amount of cooking fuel (22kg of LPG) allotted per person for one year in the Universal Energy Access scenario is about the energy equivalent of a half-full tank of petrol in a typical US passenger car, or less than one week's worth of fuel.

Obviously, these low levels of energy availability do not support the Level 2 energy services necessary to enable the productive activities that would support improved livelihoods. Actually supporting such improved livelihoods would require a much more ambitious acceleration of investment in energy infrastructure than that implied by the investment figures given. Thus, IEA-style figures – the only ones available for green growth in Africa – in fact grossly underestimate the actual investment requirements corresponding to Africa's development needs. They cannot reasonably be said to support any right to sustainable development.

3.0 POLICY RECOMMENDATIONS – LEAPFROGGING TO A GREEN FUTURE

Christian Aid/Rachel Stevens

Bintou Kane sells soft drinks from her shop in Guralo Village, Mali. Before the village installed an electricity generator, with the help of Christian Aid partner the Mali-Folkecenter, Bintou had to travel every day to a nearby town to buy ice to keep her drinks cold. In future, the electricity generator will be run on biofuel from jatropha plants

'In addressing climate resilience, we need to develop renewable energy. Africa can leapfrog the rest of the world and adopt the latest, most efficient renewable energy technologies'
Jamal Saghir, Sustainable Development Director for the Africa World Bank, speaking at an African Energy Ministers' meeting in Johannesburg, September 2011

The fossil-fuel-based economy is not delivering the economic potential of sub-Saharan Africa. There is very poor energy security in the region, with instability in both the supply and the price of fossil fuels, and a huge draw on foreign export earnings to deliver energy demands. Conventional fuels are not delivering energy for the poor or meeting global climate change objectives.

This report has demonstrated that there is another option for sub-Saharan African countries. This is an economic pathway based on local, sustainable renewable energy, and energy efficiency. With the right international support and national policies to deliver this alternative, Africa could improve its energy delivery to reduce energy poverty and realise its economic ambition.

3.1 Challenges for African countries to achieving a big low-carbon transition

A transition to low-carbon energy will require political will from within countries and practical measures to lay a foundation to accept such a transformation. States such as South Africa and Nigeria, which have economies based on fossil-fuel exploitation, will need to question their current economic model's ability to deliver a sustainable and prosperous future for their people.

At national levels there are barriers to expanding low-carbon energy. Bureaucratic delay, poor institutions, unclear regulations and poor transport infrastructure are just some of the issues resulting in higher transaction costs for energy projects in sub-Saharan Africa than for the rest of the developing world.[124]

Limited technical expertise in operating and maintaining technology further heightens costs for investors. One potential option to mitigate these high costs would be to invest in research and development, with the aim of reducing the need for and associated cost of importing technical expertise from abroad.

Infrastructural investment is also a crucial component in structural transformation and export diversification in Africa's energy sector.[125] Investment in infrastructure attracts private investment, increases profits from private investment and creates an environment that enables trade to emerge.[126]

It will be essential to have a policy, regulator and an institutional environment that can nurture private sector delivery and market development. Creating economies of scale is likely to play an important role in technology-centred energy investment, to make the technologies more competitive and to drive delivery chains across the region. In particular this is important when competing with cheap imported technology from China. This will require support and nurturing a technology manufacturing base, from small-scale cook stoves to new innovations in solar and wind technology.

Getting the national policy, regulation and investment framework right; actions to increase the national capacity to deliver new technology approaches and to encourage private sector involvement; and the political will to make it happen will all support a green economic future for Africa.

3.2 Leapfrog fund – a fair share of mitigation finance for African people

An international, science-based, and equitable climate change agreement is needed along the lines agreed in the Bali Roadmap of the UNFCCC. Christian Aid believes such an agreement must be in keeping with the 1.5°C emergency climate stabilisation programme. The agreement must confront the twin problems of energy poverty and climate change facing poor nations.

Given that Africa is already suffering the impacts of climate change to a degree that is out of all proportion to its historical contribution to or economic capacity to meet the climate problem, it is due assistance for both adaptation and mitigation. Accordingly, Africa and developing countries in other regions must continue to fight for sufficient financial and technological transfers that are new, additional to overseas development assistance, adequate and predictable from developed countries to address the unavoidable impact of climate change and enable an effective transition to a low-carbon development pathway.

Christian Aid argues that Africa should get its fair share of mitigation finance through a special dedicated 'window' (ear-marked funding stream) to enable it to meet its energy requirements, not just at levels that fulfil basic human needs, but that enable the poor to develop cleanly.

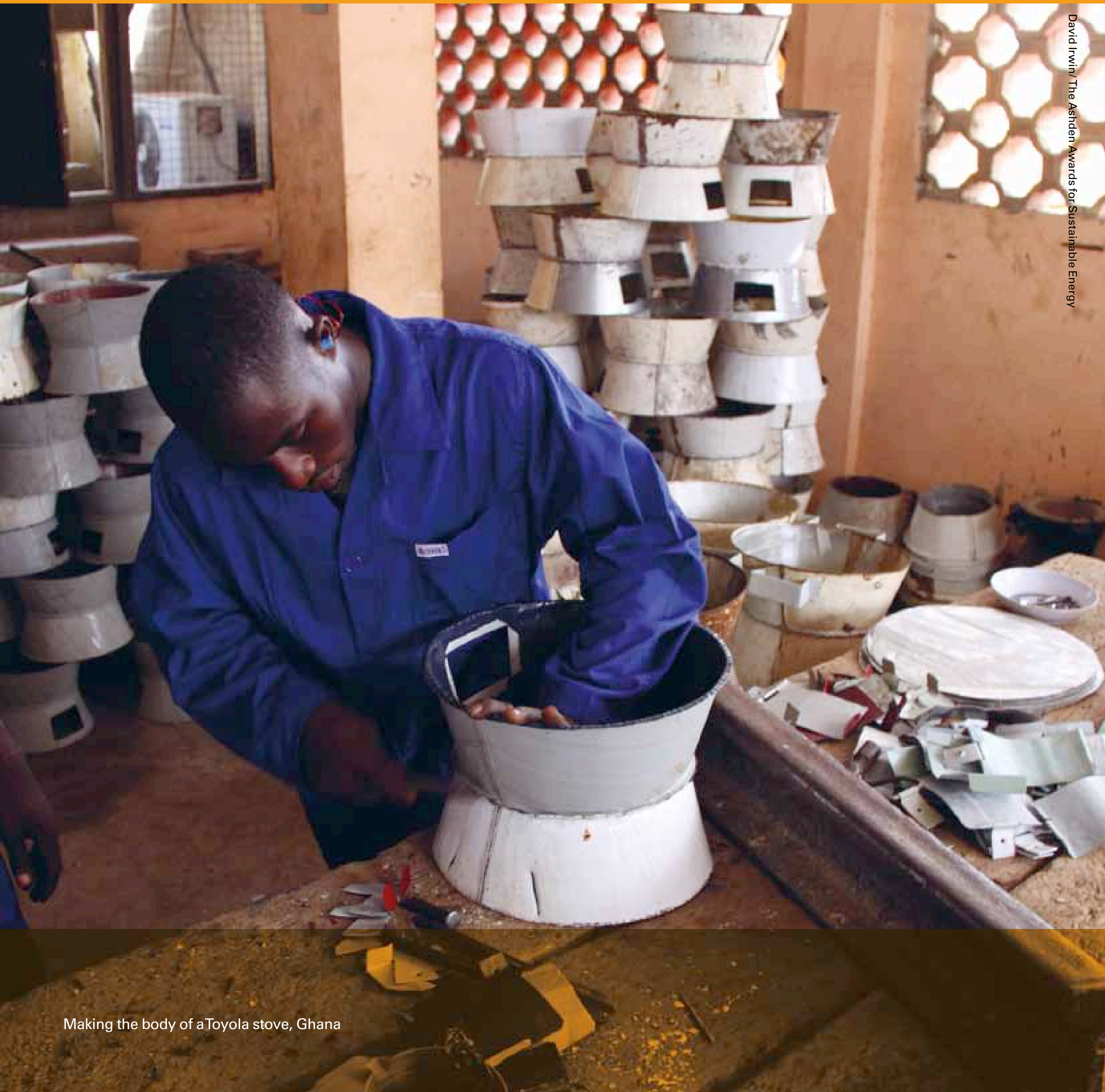
The support that developed countries have pledged so far (US$10bn per year, with a goal of mobilising US$100bn per year by 2020) was not linked to the actual needs of developing countries, but to the political constraints of developed countries, and there is no assurance whatsoever that developed countries will meet their emissions reductions obligations. If global warming is to be limited to below 1.5°C as demanded by the poorest countries then urgent international action is necessary to deliver the level of emissions reductions required to achieve this.

Christian Aid believes that is what is needed to address energy poverty and also stop poor nations from joining the league of big polluters as they enjoy rapid economic growth. Africa must continue to argue in a forceful and principled manner that even US$100bn would very likely be an entirely inadequate sum. This is and has always been a figure produced for political reasons, rather than one based on any robust (or even plausible) analysis.

Developed countries need to commit to deliver sufficient financing to developing countries that will be delivered through a special dedicated window under the Green Climate Fund, with democratic and equitable governance, that will enable African countries and other developing countries to pursue energy access and sustainable development through a clean development model. This should be a leapfrog fund for low-carbon energy access.

ANNEX 1: COUNTRY CASE STUDIES

SOUTH AFRICA
NIGERIA
KENYA
RWANDA
GHANA
ETHIOPIA



David Irwin/ The Ashden Awards for Sustainable Energy

Making the body of a Toyola stove, Ghana

SOUTH AFRICA

Prepared by: Michelle Pressend and Muna Lakhani, Economic Justice Network

The South African government's energy plan premises South Africa's energy future on a coal and nuclear strategy, with limited renewable energy targets. Though South Africa's Industrial Action Plan for 2010 to 2013 recognises that the current growth path is unsustainable, and significant emphasis must be put into building South Africa's productive capacity, the growth path is largely built on expanding the fossil-fuel based economy, in particular maintaining the dependence on coal-powered stations as well as expanding nuclear power.

As indicated in the New Growth Path Framework, released in 2010, ecological and social perspectives are divorced from sector priorities. Instead, the 'green economy' is seen as 'seizing the potential of new economies' in parallel with the traditional economic system, as opposed to changing the economic system, such that it takes into account social and ecological considerations.

The key barriers that hinder low-carbon development in South Africa include economic growth plans largely based on maintaining the minerals-energy complex; an energy strategy committed to coal and nuclear development; the lack of state finance to support renewable energy; continued state energy subsidisation for mining and related large corporations; and the ongoing support for large-scale capital and energy-intensive agricultural models.

Current energy situation

South Africa's domestic energy sector is dominated by coal, accounting for some three-quarters of the primary energy supply.[127] In South Africa, renewable energy accounts for approximately 7.98 per cent of primary energy supply. However, half the renewable energy comes from wood fuels (biomass) as opposed to renewable energy technology.

Eskom (South Africa's state energy production and supply company) supplies approximately 95 per cent of South Africa electricity, only one per cent of which has a renewable generation base.[128] Electricity generated from low-grade coal in South Africa is regarded as 'cheap energy' and South African electricity costs are generally considered to be among the lowest in the world. South Africa's reliance on coal has made it a major contributor to CO_2 emissions. The country is ranked the 11th largest emitter in the world.[129]

In recent years, South Africa has experienced periodic power outages (blackouts) because the current electricity supply could not meet demand. To address the electricity crisis, the government has opted to build new coal power stations and develop further electricity capacity from nuclear energy.

Residential demand for electricity use is 16.4 per cent of the total need, much less compared to industry and mining use at 62.7 per cent. According to government information, 'much of the energy in this sector is consumed in minerals beneficiation and mining (50 per cent) and manufacturing (20 per cent)'.[130]

South Africa faces severe socio-economic challenges. A large proportion of the population is 'energy poor'. About 30 per cent of the population do not have access to electricity and are dependent on biomass and paraffin to meet their energy needs. Government has introduced 'free basic electricity' of an amount of 50kWh per household per month for poor households.

An estimated 20 per cent of South African households were exposed to indoor smoke from solid fuels, exposure to which was estimated to have caused 2,489 deaths or 0.5 per cent of all deaths in South Africa,[131] and is responsible for the deaths of up to 1,400 children annually.[132]

Renewable potential

Climatic conditions in South Africa present immense renewable energy potential. It is widely accepted that South Africa has among the highest solar power potential in the world, estimated at 548GW[133] – an area of 730km^2 is required to meet the country's total current electricity needs.[134]

Regarding wind energy potential, the Hagemann atlas[135] estimates a potential of approximately 56GW of capacity. Likewise, hydropower varies – small-scale potential (<10MW) ranges between 69MW and 1,994MW.[136] Wave power is estimated at between 8,000 and 10,000MW.[137] Tidal current (as opposed to tidal flood) has, as yet, not been adequately quantified, despite two strong ocean currents – the Benguella and Agulhas Currents – running off the South African coast, though some estimates show base load potential for tidal currents is in the order of 10GW, utilising 15 per cent of the energy.[138]

It is clear that with the political will, South Africa is able to move towards a 100 per cent renewable energy future, with a concomitant benefit that most of the technologies mentioned above lend themselves to both decentralised and large-scale deployment, leading to an energy secure future for all.

Low-carbon plan

Some targets from the Industrial Action Plan and New Growth Path include:

- supporting 'green and energy saving industries' by committing to the installation of 1 million solar water heaters by 2014[139]

Low-carbon case examples

Kuyasa: Thermal Efficiency Upgrade in Low-income Housing

Kuyasa aims to retrofit existing low-income houses with solar water heaters in order to provide hot water on demand, insulated ceilings to improve the thermal efficiency of the household units and two compact fluorescent light bulbs (CFLs) each to provide energy efficient lighting.[140] The housing units referred to are approximately 2,300 units in Khayelitsha, Cape Town.

Some of the socio-economic impact and benefits are:[141]

- improved energy efficiency, and reduced household spend on energy
- reduced health burdens, health cost benefits due to increases in the ambient temperature and reduced reliance on heat sources holding fire-related dangers and negative respiratory health impacts and burns (currently there are 800,000 hospitalisation incidents annually related to fire and ingestion of paraffin)
- the installation of technologies and associated infrastructure also resulted in the project creating 100 jobs[142]

Kuyasa is a pilot project and in a sense provides the impetus and lessons learnt for extensive rollout of solar heaters for low-cost housing.

Small Business Enterprise: Integrated Biogas System at Three Crowns School[143]

Three Crowns Rural School in the Lady Frere district of the Eastern Cape has been the recent beneficiary of an integrated biogas system as its primary sanitation system, which provides a robust, low-maintenance sanitation solution for 170 staff and pupils. The treatment of waste water and other organic wastes through anaerobic digestion at Three Crowns has the additional benefit of producing methane, which can be used for cooking, water heating and other thermal applications. In the case of the school, the gas is piped to the kitchen facilities to be used for the cooking of school meals.

This makes biodigesters an ideal solution, as they can be scaled up or down to suit the immediate application. Another benefit of biodigesters is that use can be made of local labour, increasing local skills while keeping money within the local economy.

Darling Wind Farm[144]

The Darling Wind Farm is intended to be a learning platform for the development of the wind energy industry in the country by providing a financial, contractual, technical and operational framework for further independent power producer projects. The wind farm is located 10km north of the town of Darling in the Western Cape of South Africa, an area that gets strong and consistent winds. Construction on the project started in September 2007 and the first wind-generated energy was produced in May 2008.

In one year, the four wind turbines installed (each 1.3MW) produce 8.6GWh or the equivalent of the yearly consumption of some 700 average South African households.

The project is in line with the Government's vision in respect of climate change and pollution mitigation, and efforts to create a new industry and help the local population to benefit economically. Over 20 years, the Darling Wind Farm is expected to save 142,500 tonnes of coal, 258,100 tonnes of CO_2 emissions and 370 million litres of water.

There are plans to add six more 1.3MW turbines to the farm, bringing the capacity up to 13MW, providing there are no significant impacts found from the existing turbines.[145]

- targeting 300,000 additional direct jobs by 2020 to 'green' the economy. The potential for job creation rises to far more than 400,000 by 2030.

Nonetheless, a key assumption made by both the *Long-term Mitigation Strategy* document and the *Climate Change Green Paper* (2010) is that the development paradigm of South Africa will not shift significantly from its current model,[146] predicated on 'cheap' energy for large-scale industrial consumers, in fact, with an expansion of problematic industries such as aluminium smelters.[147]

The government has introduced the Renewable Energy Feed In Tariff (REFIT) as a basis on which technologies would be deployed, as guaranteed prices to Independent Powers Producers (IPP). Nevertheless, the uptake has been slow, given that the process of application for the REFIT, as well as access to the grid, is problematic.

Potential for leapfrog

To put South Africa on a low-carbon path will require greater public investment in renewable energy so that it is accessible and affordable to all, and not just those who can afford market-related prices. Government should subisidise the local production of renewable energy, because it also creates new livelihoods and jobs for the rural and urban poor, especially women.

First and foremost, it is critical that the South African government ensures that the correct policy frameworks are in place, so that funding can be directed to give genuine support to sustainable interventions. Therefore funds for renewable energy and energy efficiency must shift the boundaries to ensure broader systemic changes that address the wellbeing of all towards a socially and ecologically just society.

Supporting and implementing micro-power and following a localised and distributed generation model will prove most resilient,[148] while also keeping energy costs within limits – the rapidly increasing price of electricity for domestic users is problematic. Energy efficiency in South Africa has been inadequate. Though the electricity utility has been appointed to improve this, it has proved to be ineffective.

A leapfrog fund has the potential to initiate a just transition towards requiring a less energy-intensive economy, made possible through renewable energy and ecologically friendly buildings. For this transition to take place, a climate response requires a bottom-up approach and needs to be at the core of national development strategies. If this is not done, we risk the status quo remaining, with a few uncoordinated projects in the short term, but ecological and human disaster in the longer term.

The national government will need to provide an overarching policy framework for the evolution of a genuine low-carbon strategy.

NIGERIA

Prepared by: Ewah Otu Eleri, Okechukwu Ugwu and Precious Onuvae, International Centre for Energy, Environment and Development (ICEED)

Current energy situation

Nigeria is blessed with abundant sources of energy, including oil and gas, hydro, biomass and solar energy. In 2010 electricity production from all sources was 23.4GWh, while per capita electricity consumption was 129kWh. In the same year, only 40 per cent of the population had access to grid electricity.[149]

Nigeria is Africa's largest oil-producing country and accounts for nearly a third of the continent's crude oil reserves. It ranks second in natural gas after Algeria. Petroleum export is the mainstay of the Nigerian economy.

Nigeria's current crude oil reserve is 35.5 billion barrels. The country also has significant tar sand, coal and lignite, bitumen and uranium deposits. Despite this, Nigeria is experiencing energy deficits in a number of areas, including oil, electricity and biomass, mostly due to inefficient technology and management (oil and electricity), and high demand and over-exploitation of natural resources (biomass).

Growth of Nigeria's industry sector is severely hampered by lack of energy, particularly electricity. According to the Manufacturers Association of Nigeria (MAN), between 2000 and 2009, about 857 major firms either closed shop or suspended operations due to poor energy supply.[150] Nearly all major companies in Nigeria provide their own electricity through diesel generators. The high cost of energy supply has been a key factor in limiting the competitiveness of Nigerian industrial production and the growth of unemployment.

Energy poverty takes the form of inadequate quantity, poor quality and low access, despite the abundant endowment of energy resources. For example, more than 90 million people (60 per cent of the population) have no access to electricity services. Many more depend on traditional biomass sources for cooking, which are quickly becoming a scarce resource.[151]

Renewable potential

Nigeria has abundant renewable energy resources, especially solar, hydro and biomass. However, apart from biomass, which constitutes over 70 per cent of total energy consumption, and large hydropower, the share of renewable energy in the nation's overall energy supply mix is small.

According to the National Energy Master Plan of 2006, current exploitable large hydropower resource is 11,250MW and small hydropower is 3,500MW. However, only a fraction of these potentials have been exploited.

Located along the tropics, Nigeria receives significant solar radiation. Solar radiation for the country is estimated to be 3.5-7.0kWh/m^2 per day – several times the current energy demand of the country. However, there is very low usage of solar energy in the country.

Low-carbon plan

There is no national policy or strategy for low-carbon energy development in Nigeria. However, the Federal Government has developed a number of policy documents and strategies aimed at growing Nigeria's energy sector along a low-carbon pathway.

The National Electric Power Policy of 2001 provided for electricity supply for the rural areas (off-grid and mini-grid systems) from renewables. It proposed joint electricity and natural gas capacity expansion in order to utilise flared gas for electricity generation.

The National Energy Policy of 2001 emphasised the need for adequate energy supply for domestic, commercial and industrial utilisation, and provided for intensive development of joint electric power and gas supply to at least 75 per cent of the population by 2020.

The Renewable Energy Master Plan (REMP) of 2005 suggests measures, including adoption of a renewable portfolio standard, creation of innovative fiscal and market incentives to grow renewable energy industries, and preferential customs duty exemptions for imported renewable energy technology components.

The National Policy and Guidelines on Renewable Electricity of 2006 are meant to expand the market for renewable electricity to at least five per cent of total electricity generation by 2016 and a minimum of 5TWh of electric power production, excluding large hydropower.

The National Biofuels Policy of 2007 aims at firmly establishing a thriving biofuel industry, utilising agricultural products as a means of improving the quality of automotive fossil-based fuels in Nigeria.

Most of these policies have not been implemented effectively because of poor technology, lack of political will, and especially lack of funding.

Leapfrog potential

While grants are central in the demand for financial transfers under the leapfrog fund, other forms of financing, including loans and guarantee schemes, will also be needed. This

Low-carbon case examples

Pan Ocean Gas Utilisation Project

This project has the objective of eliminating gas flaring at the Ovade-Ogharefe oil field operated by Pan Ocean Oil Corporation in a Joint Venture Partnership with Nigerian National Petroleum Corporation (NNPC). This will save about 7,280 tonnes of CO_2 equivalent per day.[152] The project also seeks to discourage the prevailing practice of using diesel generators for homes and industries in Nigeria by replacing them with cleaner natural gas, which can deliver approximately 520MW of electricity per day.[153]

The project activity will capture and process associated natural gas that is currently flared and would be flared in the future. It will reduce the GHG concentration, promote sustainable development and contribute to environmental sustainability.

It has contributed to environmental sustainability in the project region through gas flare reductions, and the installation is expected to employ 35 to 45 skilled staff and about 150 unskilled positions when fully operational.

This project serves as an important step in using CDM to address this crucial environment issue. It also shows the ability of local Nigerian companies and society to participate in CDM and sustainable development.

Despite these positive possibilities, there are capacity and funding restraints, as well as the risk that the benefits of investments in gas infrastructure may bypass the poor.

The Save 80 Efficient Fuel Wood Stoves

The purpose of the project is to disseminate of up to 12,500 efficient fuel wood stoves (SAVE 80) and heat-retaining polypropylene boxes (called Wonder Boxes) in different states located in the Guinea Savannah Zone of Nigeria, at subsidised prices. These stoves save more than 80 per cent of wood use, and are therefore attractive in areas where wood is particularly scarce. Today, SAVE 80 is the most efficient household wood stove available in Nigeria, despite its high cost. The project is implemented by the Nigerian Developmental Association for Renewable Energies (DARE), and two German partners.

The stove needs only about 250g of small brittle sticks of wood to bring six litres of water to the boil, 80 per cent less than traditional fire places. By bringing wood consumption drastically down, it will slow down deforestation in the Guinea Savannah region and allow for natural recovery of forests and/or reforestation to take place.

Each of the 12,500 stoves saves about 2.7 tonnes of CO_2 annually, creating about 31,000 tonnes of offset credits annually in the carbon market. This has the potential to generate US$310,000 each year, at the price of US$10 per tonne of CO_2.

The Save 80 project has great social and environmental development potential, but faces some major challenges, including the high cost of purchasing stoves and the lack of political and financial will to expand the market for the stoves.

NESCO Hydropower

The Nigeria Electricity Supply Company (NESCO) has been operating a network of small hydroelectric power stations since 1929 in Kurra near Jos.[154] As a private company, its main aim was to make profit out of the investment and also ensure increased generation and distribution of electricity efficiently in Jos to the satisfaction of its customers.[155] The NESCO system operates as an independent network serving a number of industrial customers and communities, and also sells to the national grid. NESCO provides the main source of power for the city of Jos, with a population of about 900,000 people. The system has a total installed capacity of 21MW.

Benefits from this hydropower system include job creation at the plants and related employment opportunities, increased tourism to the area to see the dam and the electricity generated by the system.

However, despite these opportunities, small hydropower development is fraught with a number of risks, including policy and investment risks, as well as the fact that the availability of hydropower can be intermittent as a result of fluctuations in rainfall. Climate change can exacerbate this fluctuation in rainfall patterns.

will help to expand opportunities for scaling up energy access and climate-friendly technologies and adaptation mechanisms. Below are some examples of how a fund can play an important role in Nigeria's low-carbon development.

The leapfrog fund can play a catalytic role in mobilising local and international investments by providing various forms of investment guarantees, including: policy insurance, loan guarantees, foreign exchange liquidity funds, pledge funds and so on. The aim will be to take the risk out of lending to projects that reduce emissions and stimulate growth and/or are compatible with building resilience in vulnerable communities.

The fund could bridge the high costs of investing in small-hydro, solar, and other small-scale renewable sources by providing funding to close the gaps in the costs of these technologies.

It could help facilitate innovative financial solutions to address the needs of the poor through micro lending and climate-based micro insurance schemes.

The leapfrog fund can help stimulate innovation and technology sharing. Many technologies are costly and have minimal local input in their production. A fund that helps local research, development and production will be essential. Such a fund can also support south-south and north-south cooperation.

Finally, the fund can address the specific situation of vulnerable groups, particularly women, through financing community-based schemes that promote adaptation and mitigation while growing the economies of the poor.

KENYA

Prepared by: Kennedy S Muzee, Practical Action Consulting

The *Kenya National Climate Change Strategy* paper recommends that Kenya pursue an energy mix that greatly relies on carbon neutral energy sources to increase the country's energy security and helps in mitigating against climate change. Accelerated development of geothermal energy, wind, solar and renewable biomass will help ease the huge energy demand in the country.

Worryingly, Kenya's energy scene is characterised by high large-hydropower and thermal electricity generation, which have more than once exposed the country to energy insecurity owing to recurrent droughts and the volatility of international oil prices.

To guarantee sustainable energy supply, there is a need to transition towards newer and cleaner energy technologies, which critically means reducing emissions while lifting poor people out of energy poverty.

Current energy situation

Energy services in Kenya include biomass, petroleum, hydro and geothermal power, and renewable sources such as solar, wind, small hydropower and biomass residue. There is an over-reliance on biomass, especially in poor and rural homesteads, and a dependence on imported petroleum.

The consumption of modern energy is very low. At 156kWh per capita, Kenya's electricity consumption is very low compared to the global average of 2,751kWh per capita. The total installed capacity increased from 1,361MW in 2009 to 1,471MW in 2010, with the effective capacity under average hydrology (that is when there is not a drought) increasing from 1,310MW to 1,416MW.[156] This is approximately 16 times less than the installed capacity of Argentina, which has a similar population size.

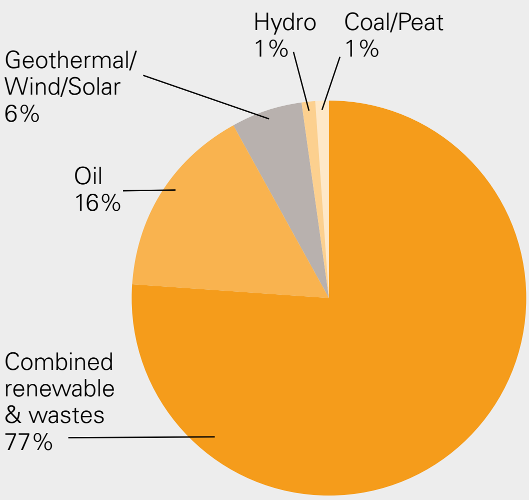
The number of electrical connections has risen five-fold, from a low of 265,413 customers in 1990 to a high of 1,463,639 in 2010, representing a 451 per cent increase. However, access to electricity is still very low with rural access averaging below 5 per cent, while urban access is estimated at 51 per cent.

The figure below illustrates the total primary energy supply.

Renewable potential

Kenya is endowed with significant amounts of diverse renewable energy sources, including biomass, solar, wind, geothermal, biogas, mini/micro-hydro, and bagasse cogeneration.

Figure 1: Share of total primary energy supply in 2008[157]



Source: IEA, 2011

Solar: Kenya receives an estimated 4-6kWh per square metre (m^2) per day of solar radiation, equivalent to about 300Mtoe per day.[158] However, only a tiny fraction of this resource is harnessed for commercial and household activities.

Solar thermal: Approximately 5,000m^2 of collector area for solar water heating systems are installed annually in Kenya. Individual households as well as public and private institutions stand to benefit from installation of solar water heaters to reduce on cost of electricity. This is made more feasible with most areas in the country receiving more than six hours of sunshine daily.

The potential of pico-, mini- and micro-hydro systems is estimated at 3,000MW nationwide, with only six small, mini- or micro-hydro plants in operation in the entire country, which have a total capacity of 13.64MW. To date, only one site has been able to supply 0.3MW of electricity to the national grid – a mini-hydro at the Imenti tea factory.[159] With only less than one per cent of pico-, mini- and micro-hydro exploited, there is great potential of this resource.

Wind: Kenya has one of the best wind speeds in the world averaging between 3 and 10 metres per second (m/s), with northern parts recording speeds of up to 11m/s. Estimated installed capacity from wind-generated power is 5.1MW. Northern Kenya and the area along the Kenyan coastal line are considered ideal for the setting up of wind farms.

Wind pumps: Approximately 350-400 wind pumps are in operation, mainly in the arid and remote parts of Kenya. The wind pumps are applied in domestic water supply, irrigation and watering dairy cattle and ranching. There is great potential for adoption of wind-pump technology for irrigation purposes, contributing towards food security.

The potential for geothermal: is estimated at about 7,000-10,000MW, but only 202MW has been exploited. The Geothermal Development Corporation (GDC) has harnessed about 168MW of steam in Olkaria that will run the 280MW Olkaria IV geothermal power plant scheduled to be operational in 2013. It also plans to drill 1,400 steam wells to provide steam for the generation of 5,000MW of geothermal power by 2030 (gdc.co.ke). Kenya has so far exploited only two per cent of the total technical geothermal potential.

Biomass residue in the agriculture sector: There is great potential for generating electricity from agricultural residues such as bagasse and rice husks. Currently, only 38MW capacity is installed in Kenya's six operational sugar factories that use bagasse to generate electricity.[160]

Low-carbon plan

Over the past four years, Kenya has experienced significant economic growth, which has translated to vibrant industrial growth, resulting in increased demand for electricity. To meet this challenge, the country is expected to increase its power capacity by 1,586MW by 2014. To achieve this, KenGen intends to develop an additional capacity of 233MW by end of 2011 and a total of 553MW by 2014, while IPPs will provide more than 800MW of additional capacity in the same period.

The table below shows some of the planned renewable energy projects to mitigate against climate change risks – poor hydrology and environmental degradation – with other global macroeconomic factors beyond Kenya's control such as high international fuel prices.

Leapfrog potential

The current national energy supply in Kenya is inadequate. A paltry four per cent of the rural population has access to electricity. With more than 80 per cent of the population still using biomass energy inefficiently, there is a need to adopt newer and cleaner energy supplies.

Despite the demonstrated positive impacts of the renewable energy technologies highlighted by these case studies, their uptake and upscale has been low, owing to high investment costs. This is compounded by the absence of financing mechanisms through which individuals,

Planned electricity generation projects[161]

Developer	Project name and type	Capacity (MW)	Estimated commission date
KenGen	Geothermal well-head units	70	June 2011[162]
	Eburu (geothermal)	2.5	Dec 2011
	Ngong 3 (wind)	15	July 2012
	Olkaria IV (geothermal)	140	January 2013
	Olkaria I Units IV and V (geothermal)	140	
IPPs	Lake Turkana (wind)	300	July 2013
	Osiwo Wind – Ngong and Kajiado	50	
	Aeolus – Kinangop and Ngong (wind)	160	
	OrPower 4 (Olkaria III) (geothermal)	52	July 2014
Total renewable energy		**929.5**	

Low-carbon case examples

Bagasse Cogeneration Project

The Mumias Sugar Company (MSC) is using sugarcane bagasse to generate electricity for internal consumption by the company and export to the national grid through cogeneration. The project generates 35MW of electricity, with 10MW for internal consumption by the factory and 25MW exported to the national grid.

Cogeneration has the potential for replacing 503GWh of electricity generated from fossil fuels (Karekezi and Kithyoma, 2005).

With the availability of advanced cogeneration technologies, sugar factories can potentially harness the on-site bagasse resource to go beyond meeting their own energy requirements and produce surplus electricity for sale to the national grid or directly to other electricity users.

Investment in cogeneration has the potential to bring in additional revenues. It is estimated that revenue turnover could increase between 20 and 40 per cent, through plant efficiency improvement and increased production, to remain competitive in a liberalised sugar sector.

There is much opportunity in bagasse-based cogeneration as all of the seven sugar factories in western Kenya will venture into electricity generation. Currently, these companies produce an average of 1.8 million tonnes of bagasse per year, 60 per cent of which is used as boiler fuel for steam generation, with electricity being generated from surplus steam. The remaining is mostly disposed of by burning, at times at a cost.

Davsam Wind-pump Project

This case study is based on energy access for agricultural purposes and domestic water access in rural areas through use of wind energy. The broad goal of this project is to support households and communities to get access to domestic water and water for irrigation purposes.

The project aims to improve access to energy through supply of domestic water, irrigation and all-year-round farming through use of wind energy as an alternative to treadle and diesel pumps, which were and are still common in eastern and northeastern parts of the country.

Typically, a wind pump reduces about 51,136kg of CO_2 and considering it has a 20-year useful lifespan, a total of 1,022,717kg of CO_2 reduction can be achieved. The Davsam Wind-pump Project has so far installed more than 80 wind pumps in the arid and semi-arid areas in Kenya.

The use of wind pumps for water access and irrigation purposes is now on the increase owing to the frequent droughts experienced in the country brought about by climate change.

The wind pump has many applications, which include: supply of domestic water, watering livestock, irrigation and drainage.

With the advent of climate change in the east and Horn of Africa, this wind-pump project stands to benefit rural poor in the arid and semi-arid regions.

Upesi Stove Project

The Upesi Stove Project is based on improving energy access and efficiency at household and institutional level. The project has improved the quality of life of poor households in rural west Kenya by reducing their dependence on biomass fuels, increasing their access to appropriate energy-saving technology options and investigating income-generating opportunities.

The stove is made of pottery cylinder built into a mud surround in the kitchen. It can be used to burn wood or other agricultural wastes such as maize and sorghum stalks, and animal waste (cow dung).

The project produced and marketed about 4,500-5,000 Upesi stoves, 11,000-12,000 Kenya ceramic jikos (charcoal stoves) and 1,500-2,000 innovative designs of wood-burning stoves. The annual production of Upesi stoves is estimated at 10,000-11,000 and the profit generated by the project provided artisans with a higher-than-average rural wage.

Additional benefits include time savings of about 110 hours per year, health-cost savings of Kenya shillings (Kshs) 260 per year and indoor smoke reduction of 60 per cent. Family health status has also been improved through reduction of acute respiratory infections for children and mothers by 60 per cent and 65 per cent respectively, and reduction of conjunctivitis in children under five and mothers by 70 per cent and 67 per cent respectively. As a whole, commercialisation of the stove has improved the living standards of west Kenya communities.

communities and small- and medium-scale enterprises can source credit. Renewable energy technologies are still not well understood; the private sector and financial institutions still consider renewable energy projects as high-risk investments. The setting up of a dedicated fund, such as a leapfrog fund, will provide an impetus for their uptake.

Financing plays a major role in the promotion of renewable options, especially in rural areas where the majority of people still rely on biomass for most of their energy. A leapfrog fund has the potential to increase rural access to cleaner energy options, such as electricity from small-hydro plants, which can be used for lighting, use of efficient stoves for cooking, which will lead to sustainable exploitation of forest resources, and to achieve greater scaling up of wind-pump and biogas technology.

The fund can also be used for knowledge and capacity development and increase multi-stakeholder involvement.

RWANDA

Prepared by: Chukwumerije Okereke and Sally Tyldesley, Smith School of Enterprise and the Environment, Oxford University

Rwanda is one of the smallest countries in Africa. It is mountainous and landlocked, with a temperate climate and annual rainfall of about 1,028mm.

Rwanda has a fast-growing population of around 10 million people and is the most densely populated country in Africa. The population is largely rural, with only 20 per cent living in urban areas. Nearly half (44 per cent) of the urban population live in the capital city, Kigali.

In 1994, Rwanda experienced a genocide, during which nearly 1 million Rwandans were killed. This was the result of the 1990-1993 civil war. Rwanda has strong leadership and good governance with low corruption levels – in 2010, Transparency International ranked Rwanda as the 66th 'cleanest' out of 178 countries. Public officials, including the President, are required to declare their wealth to an Ombudsman and the public.

Rwanda is a Least Developed Country (LDC), with 56 per cent of its population living below the poverty line. The economy is dominated by agriculture, which makes up 34 per cent of GDP, and employs 80 per cent of the workforce. Services contribute 46 per cent to GDP and industry makes up around 14 per cent of GDP. Most businesses are classified as small or medium enterprises.

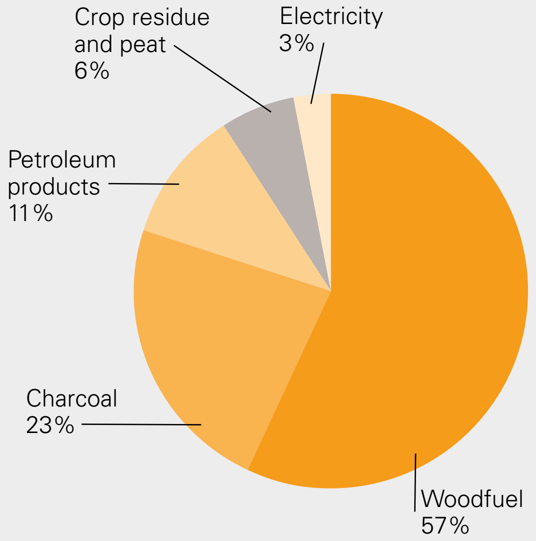
Rwanda's per capita income is US$560, up from US$200 in 2000. The government developed Rwanda's Vision 2020, which aims to transform the country from a subsistence agriculture economy to a knowledge-based middle-income economy, with a per capita annual income of US$900, and to develop a strong private sector, and has made reforms in justice and business regulations accordingly.

Current energy situation

Biomass from wood and charcoal makes up 86 per cent of energy used in Rwanda, primarily in rural areas. Electricity makes up 3 per cent of energy, and petroleum products make up the rest of Rwanda's energy use (11 per cent), most of which are used in transportation and electricity production.[163]

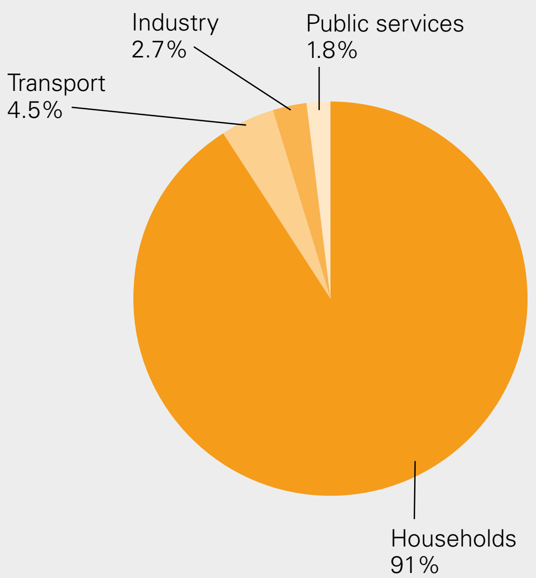
Rwanda consumes about 44kWh of electricity per capita per year, which is one of the lowest consumption rates in the world. Up to 90 per cent of Rwandans have no access to electricity. Of the 20 per cent living in urban areas, only

Figure 1: The energy balance in Rwanda



Source: Adapted from MININFRA 2009

Figure 2: Rwandan energy consumption by sector



Source: Adapted from MININFRA 2009

about 25 per cent are connected to the national grid. The rest rely on biomass and liquid fuel for cooking and light.

Rwanda currently has around 85MW installed generation capacity and about 77MW available capacity, or roughly 100 per cent growth compared to available capacity in 2007. Electricity is generated mostly by hydropower and thermal power plants in equal shares. Since 2008 about five per cent of electricity per year has been generated by methane extracted from Lake Kivu. Rwanda also imports electricity through cross-border interconnections. The Rwandan government plans to increase generation capacity to up to 1,000MW by 2017 – a massive increase of more than 300 per cent of current generating capacity.

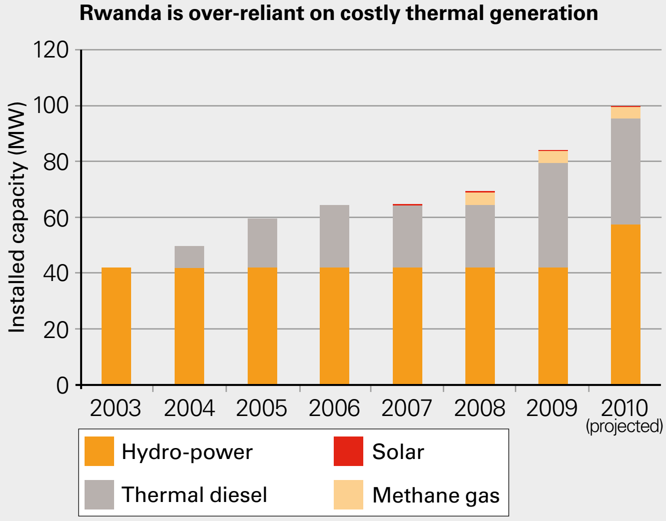
In 2010 the electricity grid covered around 57 per cent of the country's population within a boundary of 4km along the medium voltage (MV) line. However, only around 35 per cent of the population within this distance are able to pay the fees for their consumption. Domestic consumers pay 112 Rwandan Francs per kWh (0.21US$ per kWh), compared with the commercial and industrial price of 105RWF per kWh (0.19 US$ per kWh). The high price of electricity is due to the high cost of renting thermal plants from a private company and of importing fuel for government-owned diesel-generated power plants. The price would be even higher without subsidies. Subsidies include a waiver on import duties for imported fuel and direct financial support to the EWSA to offset the high price paid for the electricity produced by the rented generators.

Industry and public and private service sectors are the main users, accounting for more than 60 per cent of electricity sales. At the end of 2008, most electricity customers were in Kigali. Around 60 per cent of peak demand is predicted to come from domestic sources, while 20 per cent will come from cross-border mining and industry projects, and 20 per cent will come from the sub-regional electricity market.

In 2004, Rwanda suffered the worst energy crisis since its independence in 1962. Due to droughts, reduced output from other electricity sources and increased demand for hydroelectricity, the two main hydroelectricity plants experienced a severe drop in yield.

This resulted in severe electricity rationing and long daily power cuts across the country, with a huge negative impact on businesses, many of which were forced to buy highly expensive diesel generators. To provide emergency relief,

Figure 3: Rwanda's growing reliance upon thermal power plants[164]



the government signed a contract for 15MW of rental diesel plant with AGGREKO, an independent power provider. Since then thermal power has increased from zero to its current level of 37.7MW – nearly half of Rwanda's generation capacity (Figure 3, above). The reliance on thermal generation with imported diesel fuel means that Rwanda is paying a great price to sustain its rapidly growing economy. It also means that economic growth is very fragile and threatened by the rising cost of oil.

The government recognises the need to deal with the problem of shortages of energy, high prices, low access and over reliance on thermal generation, and recognises that energy provison is a fundamental prerequisite to economic growth and poverty alleviation. Achieving a sustainable energy mix is well within the reach of the country, given the abundance of renewable energy potential and the visionary leadership so far demonstrated by the government.

Renewable potential

A hydropower atlas published in 2007 by the Ministry of Infrastructure assessed the country's potential for micro- and pico-hydropower, demonstrating that only 21.4 MW remains unexploited domestically.[165] The study highlighted that there is a potential for much greater use of pico-hydropower.

Estimates say geothermal energy could lie in the region of 700 MW.[166] However, geothermal exploration and development in Rwanda is still at a very early stage.

Lake Kivu in Rwanda is one of only three lakes in the world in which gases can accumulate. It is believed that 700MW can be continuously produced from methane extracted from the lake for at least 55 years. The electricity produced costs only around US$0.06-0.07 per kWh, but the technology used at the moment is not extracting the gas as efficiently as expected.

A solar power plant located at Jali hill in the Gasabo district is currently the largest solar PV plant in Africa, feeding the grid with 250KW of energy. The country has a daily average of around eight hours sunshine and average solar radiation is 4-6kWh per m^2 per day, allowing for great solar potential.

Biogas digesters provide a small-scale off-grid renewable source of energy, which can be used by rural households and institutions in cooking and lighting. The potential for waste to energy on a larger scale using methane produced from landfill sites is estimated to provide 30MW.[167]

Biomass is at risk of being overexploited and causing environmental degradation in Rwanda. More emphasis must be put on reducing consumption, increasing efficiency through the use of improved cook stoves, and the substitution of biomass with alternatives such as biogas, carbonised peat and papyrus and other biomass briquettes.

Electricity generation capacity at present and planned additional capacity[170]

Source	Installed Capacity (MW)	Planned New Capacity (MW)
Domestic hydro	26.25	47.5
Regional hydro	15.5	164.97
Micro-hydro	0.7	50
Domestic thermal	27.8	20
Rented thermal	10	-
Solar PV	0.25	8
Methane	4.2	300
Geothermal	-	310
Peat	-	100
Total	**84.7**	**990.47**

The Government of Rwanda has ambitious plans for the energy sector. The Energy Sector National Policy and Strategy sets out the aim of installing a total of 1,010MW electricity generation capacity by 2017 (up from 85MW at present), from geothermal (310MW), hydropower (300MW), methane (300MW) and peat (100MW). The grid will be extended by 2,100 km, increasing the number of connections to 1.2 million up from 175,000 today.[168]

Technical capacity and finance are the main challenges associated with the energy sector development plan.

Low-carbon plan

A national strategy on low-carbon and climate-resilient development is currently being developed by the Smith School of Enterprise and the Environment at the University of Oxford, in conjunction with the Government of Rwanda. Rwanda has considerable incentives to follow a low-carbon development pathway, particularly in terms of moving away from its current dependence on oil-based fuels for electricity generation and transport. Rwanda has no domestic fossil fuel reserves and as such must import all the oil-based fuel that it uses. This situation is problematic for several reasons. First, the high level of imports increases Rwanda's trade deficit. Second, fuel importation consumes a large amount of the country's foreign exchange reserve and limits its ability to invest in its real economy. Third, the practice results in high electricity costs and leaves the Rwandan economy susceptible to oil-price spikes. Finally, dependence on imported oil implies energy insecurity, with all the problems and uncertainties that go with it.[169] Given this situation, there is incentive to develop domestic, low-carbon resources and a strategy to ensure this happens.

Through steering committee leadership and stakeholder consultation, the goal is to provide high-level strategic policy input and promote coordination across the various sectors and ministers in the development of a National Strategy on Climate Change and Low Carbon Development for the Government of Rwanda. The strategy will look forward to 2050, but will also include some quick wins that will help Rwanda onto the path of low-carbon development.

Low-carbon case examples

Compact Fluorescent Lamp Distribution Project

The World Bank and CDM-funded Compact Fluorescent Lamp (CFL) distribution project was established in 2007 in order to take advantage of the fact that CFLs are 75 per cent more efficient than incandescent lamps. It was designed to help reduce grid electricity demand, lower electricity bills for consumers, educate households on the need to be more efficient, and help reduce carbon emissions. A secondary aim was to bring new customers onto the electricity grid, and the implementing agency, EWSA, did so by offering CFLs as part of a start-up package.

There were numerous public awareness campaigns during the time of the distribution to spark interest in CFLs and in energy efficiency.

It was estimated that the initial phase of the project, when 400,000 CFLs were distributed, saved the equivalent of 46,000MWh per year. This is equivalent to around 18,000 new electricity customers. The public seemed to have more awareness of the product and of the importance of efficiency. However, CFLs cost much more than incandescent lamps in Rwanda and in fact are too expensive for the average consumer. Without CDM funding and subsidising the cost, EWSM and the government would have incurred a significant loss during the distribution.

National Domestic Biogas Programme

The National Domestic Biogas Programme (NDBP), started in 2007, is part of an effort to encourage people and businesses to move away from using biomass for energy and move towards biogas, briquettes from crops and papyrus, peat carbonisation and methane gas resources. Alternative sources are better for health, sanitation and the environment, and biogas, for example, can be used as a fertiliser too.

While it is estimated that 110,000 families have the potential for using biogas, this is not without its challenges. Participating in the project meant investing in a biogas system, which many households were unwilling or unable to do, as it was necessary to have cattle to make the system work. The system was subsidised, but even then households were required to get micro loans and other sources of finance to take it up. The finance was a problem and will continue to be in taking the project further. Additionally, the lack of data on households and businesses able to take it up has prevented the project from taking off.

Methane to power

In order to diversify the electricity supply and eventually to replace oil-based generators, the Rwandan government began to use methane extracted from Lake Kivu to generate electricity in 2008. The rationale for this is as follows: generating electricity from this source will reduce the vulnerability of the energy sector to climatic changes by diversifying electricity generation; generating electricity from this domestic resource will cost less than using oil-based generators; burning methane to generate electricity is relatively low carbon.

Two pilot plants have been built on the lake and began producing electricity in 2008. The first, a government-sponsored 4.5MW methane gas power plant, named Kibuye Power, was built in order to attract and stimulate investment in the resource. The Rwandan Investment Group has also developed another pilot project of 3.6MW. The Rwandan authorities developed a set of management prescriptions for Lake Kivu Development in 2009,[171] to which it is essential that all companies operating there adhere in order to ensure the safety of the operations. These form the basis for the legislation for licensing and development of the lake.

Two main barriers to success so far have been the fact that the technologies used have not been as efficient as expected, and the fact that both Rwanda and DRC can lay claim to the resource and therefore much cooperation must happen in order to proceed with any extraction.

Leapfrog potential

There are a large number of low-carbon options in Rwanda, the exploitation of which would bring significant economic, social and environmental benefits to the country, as well as awareness and commitment from the government. However, progress has been limited, largely due to financial and technical constraints. A sufficient leapfrog fund for a dynamic country such as Rwanda could be the most important contribution the international community could make in helping the country overcome the problems of energy poverty and under-development.

Funding could go towards speeding up Rwanda's geothermal energy exploration and extraction at a cost of about US$935m, which at the moment is well beyond the government's financial means. Or funds could go towards revolving loans to provide microfinance for consumers to invest in small-scale technologies, such as solar systems for domestic and local use, biogas and pico-hydro systems. In order to support both low-carbon development and the development of a sustainable private sector, finance should be made available to companies and entrepreneurs wishing to invest in constructing renewable energy projects in Rwanda. To make the best use of whatever funding is available, the international community must reduce fragmentation of current funding flows by increasing coherency in international development and climate change financing architecture.

Given the criticality of capacity challenges in Rwanda, a significant portion of the leapfrog fund would have to be devoted to well-considered training programmes, to provide hands-on experience, both for government and the private sector.

GHANA

Prepared by: Ishmael Edjekumhene and Jacqueline C. Cobson-Cobbold, KITE

Ghana is inhabited by 24.2 million people and is ranked 130th on the 2010 United Nations Human Development Index ladder. With a GDP per capita of US$1,343, Ghana has since 2010 joined the ranks of middle-income countries, as well as becoming a major oil producing country. About 28.5 per cent of the total population live on less than a US$1 a day. The services sector is the largest contributor to GDP, accounting for 51.4 per cent of national income; followed by agriculture (29.9 per cent) and industry (18.6 per cent).

Current energy situation

Ghana's energy sector is characterised by huge dominance of traditional biomass resources – mainly fuels such as firewood and charcoal – which accounts for an average of 81 per cent of primary energy consumed in Ghana between 2000 and 2008. Petroleum accounts for 12 per cent of primary energy supply, while the share of electricity in the national energy mix is assessed at between 6 per cent and 7 per cent over the same period. However, the energy balance of Ghana is likely to be altered significantly following the discovery and commercial production of hydrocarbons in Ghana since late 2010.

Woodfuel (charcoal, firewood and crop/sawmill residue) is the main source of cooking fuel for up to 85 per cent of households in Ghana. With no dedicated woodlots or concerted afforestation/reforestation programmes in place, the country's woodfuel resources have dwindled at a very alarming rate of 3 per cent per annum, creating difficulties for households who now have to travel over long distances to collect firewood for cooking and for sale.

Approximately 67 per cent of all Ghanaians have access to grid electricity compared to a sub-Saharan average of 22 per cent and a West African average of around 18 per cent. Per capita electricity consumption is estimated at 460kWh based on 2010 consumption. However, electrification is very much an urban phenomenon, with as many as 78 per cent of urban inhabitants having access to electricity compared to less than 30 per cent of their rural counterparts. Electricity is produced from two main sources – hydro and thermal – with a total installed capacity of 2,011MW.

It has been estimated that power system reliability failures are costing the Ghanaian economy a whopping amount of between US$320m and US$924m (excluding a number of indirect costs) or between 2 per cent and 6 per cent of GDP every year.

Renewable potential

Ghana is endowed with a range of renewable energy resources. The table on p54 provides a summary of the renewable energy potentials of Ghana.

This table shows that the renewable energy potential of Ghana is huge, yet remains largely unused. However, Ghana has set a target of 10 per cent for new renewable energy systems (excluding large hydro and woodfuels) in its electricity-generation mix, to be reached by 2020, and the formulation of a Renewable Energy Bill, which is currently before the Ghanaian Parliament.

Low-carbon plan

Although Ghana's contribution to global GHG emissions is infinitesimal – and thus it could be justified if it adopts a nonchalant attitude towards climate change – its reliance on climate sensitive sectors such as agriculture, forestry and energy production makes the country particularly vulnerable to climate change and variability.

Ghana recognises that looking at development through a low-carbon lens could be beneficial in itself since that can bring about significant short and long-term development benefits to the nation.

Since 2010, Ghana has initiated a process towards formulating a comprehensive national climate change policy, dubbed the National Climate Change Policy Framework (NCCPF). The aim of the NCCPF is to ensure a climate resilient and climate compatible economy, while achieving sustainable development and equitable low-carbon economic growth for Ghana. The NCCPF seeks to achieve three main objectives: low-carbon growth, effective adaptation to climate change and social development.

In November 2010, the National Climate Change Committee (NCCC) under the auspices of the Ministry of Environment Science and Technology (MEST) produced a discussion document entitled Ghana Goes for Green Growth (GGFGG). This explores what climate change means for Ghana, and what is needed to address low-carbon growth, adaptation and the social dimensions of climate change. The GGFGG does not prescribe priorities for sectors, regions,

Summary of renewable energy potential of Ghana

Resource	Resource Potential	Current Status
Solar	Daily solar irradiation levels between 4 and 6kWh per m^2 and annual sunshine duration ranging between 1,800 and 3,000 hours.	More than 6,000 solar stand-alone home systems mainly for electrification in off-grid regions with capacity of 3.2MW have been installed. This is relatively small compared to the huge potential of the country.
Wind	The wind energy potential has been estimated to be 5,600MW, with wind speeds of more than 6m/s found along the coastal belt of Ghana.	Power generation from wind has largely been untapped.
Hydro	Potential exploitable hydro resource for Ghana is estimated to be 2,500MW.	1,180MW already is used for large hydropower generation at Akosombo and Kpong dams. The construction of the 400MW Bui hydroelectric power project is currently underway. The remaining 840MW of resource can be obtained from 21 sites, mainly for medium and small hydropower plants.
Bioenergy	An estimated 18 million metric tonnes of woodfuel is produced every year from the natural forest while the climatic and soil conditions are suitable for large-scale cultivation of early-maturing tree species. In addition to the woody biomass potential of Ghana, the country generates huge volumes of crop and animal residue that could be converted into electrical and/heat energy.	Apart from traditional uses of biomass, the modern bioenergy potential of Ghana remains largely unutilised. However, some biomass-fired co-generated projects have been implemented in oil-palm industry with installed capacity of 1,954kW with an average annual production of 7.0GWh.

Source: Ministry of Energy, Renewable Energy Directorate, 2010

technologies or instruments, but is intended to kick-start a national dialogue among key stakeholders that will lead to general consensus on what needs to be done to achieve green growth for Ghana.

The pursuit of climate compatible development in Ghana, especially interventions in the energy sector, has been hampered by a number of barriers in the areas of policy, regulation and financing. Lack of access to appropriate and affordable financing mechanisms to, among other things, help bridge the gap between low-carbon solutions and their commercial viability as well as remove high upfront cost, is arguably the most inhibiting hurdle that has stifled the uptake of cleaner energy and energy efficient technologies in Ghana.

Leapfrog potential

A leapfrog fund made accessible on affordable terms will undoubtedly give the development and commercialisation of low-carbon energy projects targeted at poverty reduction a big shot in the arm. Such a fund should be designed to provide support throughout the entire business development cycle, in the form of investment loans and micro-finance schemes. The cost of capital and of doing business still remains high and does not look to be coming down any time soon. It is therefore imperative that a leapfrog fund should be so structured to buy down the cost of borrowing before private sector capital could be leveraged to support the low-carbon development agenda of the country.

A leapfrog fund can typically be expected to address the financial constraints to pursuing a low-carbon development

Case examples

Improved Charcoal Cook Stoves Project

Charcoal is the main cooking fuel for approximately 1.3 million households (31 per cent) in Ghana. Fifty-three per cent of urban and 14 per cent of rural households depend on charcoal to meet their cooking energy needs. However, charcoal production has been singled out as a major cause of forest degradation and deforestation in Ghana because charcoal is typically produced from inefficient kilns.

Toyola Energy Limited in Ghana is one of the most successful and sustainable charcoal cook stove businesses in the world. The company has trained about 300 artisans and a total of 154,000 stoves have so far been sold. The Toyola stove is projected to reduce charcoal use by 26,000 tonnes per year, thereby saving trees and cutting CO_2 emissions by 150,000 tonnes.

TEL is implementing an innovative business model that involves the poor along the whole value chain as suppliers, manufacturers, retailers and customers. The company has trained about 300 artisans who are each encouraged to specialise in the production of one of the stove's 26 constituent parts. TEL often sells its products, priced at US$7, on credit to local market vendors who earn a 10 per cent commission on each product sold. In some cases, TEL also sells directly on credit to end-users to be paid back over a two-month period using the money saved on charcoal, with many stashing their savings in a Toyola Money Box. There is a huge opportunity for the improved cook stoves projects to be replicated and scaled up.

The Ghana Energy Development and Access Project

The development objective of the GEDAP is 'to improve the operational efficiency of the electricity distribution system and increase the population's access to electricity, and to help transition Ghana to a low-carbon economy through the reduction of greenhouse gas emissions'. The project has three main components: a) sector and institutional development; b) electricity distribution; and c) electricity access and renewable energy.

The Electricity Access and Renewable Energy (EARE) component seeks to assist the Ghanaian government to establish an enabling environment and facilitate market development to attract private investments in large-scale commercialisation of renewable energy and energy efficiency improvement.

The following are some of the achievements of EARE as of December 2010:

- 106 remote health facilities provided with solar PV systems
- procurement process for solar systems in additional health facilities and remote teachers' quarters underway
- contract awarded for socio-economic study on island communities on the Volta River.
- off-grid electricity with PV systems successfully launched in 11 villages
- 104 solar PV large systems, 263 solar PV small systems and 1,060 solar lanterns installed/supplied
- operational manual for matching grants for business development services, modified to include renewable energy business
- fund manager procured
- capacity-building ongoing for rural banks and solar companies.

Source: GEDAP Project Coordination Unit, Ministry of Energy, 2011

National implementation of CFL exchange programme

It is estimated that the use of CFLs in households increased from 20 per cent in 2007 to 79 per cent today, compared to the use of incandescent bulbs, which dropped from 58 per cent to 3 per cent during the same period. However, the increased penetration of CFLs is attributable largely to a massive CFL distribution programme embarked upon by the Ghana authorities in 2007, which is the subject of the next case study. Currently, there is ban on the importation of incandescent lamps, effective as of January 2011.

In 2007, Ghana experienced its worst power crisis since 1998. The power crisis, which was caused by poor hydrology in the Volta Lake and lasted for up to 12 months, led to a far-reaching power-rationing regime, whereby all categories of electricity consumer went without electricity for at least 12 hours every other day. As part of the measures to address power shortages, Ghana's government imported six million CFLs of various wattages, at a cost of US$13m. It then distributed them free of charge to households throughout the country under a public exchange programme, which included the disposal of incandescent filament lamps.

pathway. It is therefore important for other complementary policy and regulatory measures to be put in place to address other barriers, such as:

- constraints to technology transfer – for example, as a result of barriers to foreign direct investment, limited capacity to adopt and learn from new technologies, intellectual property rights or behavioural inertia
- informational constraints relating to technology availability and associated benefits and costs, including uncertainty about future energy prices
- capacity constraints across sectors to identify and develop low-carbon alternatives
- institutional constraints relating to slow development of markets.

The private sector has a key role to play in plugging financing gaps that will inevitably exist even with the establishment of a leapfrog fund. However, to be able to attract much-needed private capital, investors would first look to see whether the investment environment is ideal and safe enough before venturing into any business. The GEDAP project is seeking to create the enabling policy and regulatory environment to help attract private capital. It remains to be seen the extent to which the GEDAP can succeed in doing this.

ETHIOPIA

Prepared by: Ethio Resource Group (ERG)

Ethiopia is a country of 86 million people, who are largely employed in agriculture (41 per cent GDP). The economy has grown rapidly over the past five years (11 per cent per year) and per-capita GDP now stands at US$300.

Current energy situation

One of the defining characteristics of the energy sector in Ethiopia is its overwhelming dependency on biomass energy. Recently, liquid bioenergy in the form of ethanol has started to be used as a gasoline in Addis Ababa. Per capita consumption of bioenergy in Ethiopia is about 1 tonne; annual consumption of biomass energy exceeds 80 million tonnes.

The energy balance in Ethiopia is dominated by biomass energy. Eighty eight per cent of the energy supplied in the country comes from biomass fuels (wood, charcoal and agricultural residues). The main use of biomass energy is for cooking in residential and commercial establishments. Demand for biomass fuels is growing as rapidly as food production (at a rate of 6 per cent annually).

Fossil fuels provide 9.5 per cent of the total final energy supply and are consumed in the transport, industry and residential sectors. Ethiopia does not produce fossil fuels and imports all its requirements through a government agency. The annual import of fossil fuels now stands at 2 million tonnes. The largest demand for fossil fuels is for transport, where about three-quarters of the total import is used; the remaining amount is consumed in industry and in urban residential cooking. Per capita consumption of petroleum production is just 23kg.

Electricity provides 2.5 per cent of the final energy supply and it is generated through hydro and thermal plants. Total electricity consumption is slightly more than 3,000GWh divided by sector as follows: residential (36 per cent), industrial (37 per cent) and commercial (26 per cent). The electricity supply infrastructure in Ethiopia now consists of 2,000MW of installed capacity in 11 hydro- and several small-thermal plants, 12,150km of transmission and 126,000km of distribution lines, and about 2 million customers. Per capita consumption of electricity is only 35kWh per annum.

Renewable potential

Ethiopia has diverse renewables including hydro, bioenergy, wind, geothermal, and solar but it relies heavily on biomass for thermal energy and large hydropower for electricity.

However, bioenergy uses in Ethiopia are generally not sustainable and hydropower is affected by climate change. According to a recent study, in more than two-thirds of districts, bioenergy uses surpass sustainable yields. Bioenergy contributes to GHG emissions, due to deforestation and non-renewable use of biomass, and creates other local environmental problems.

Hydropower is the most economically viable power generation resource for Ethiopia, but only five per cent of the available potential is now utilised. The government has now made considerable commitment to accelerate the development of hydropower resources, with the view to

Indigenous energy resources of Ethiopia

Resource	Unit	Exploitable potential	Developed
Hydropower	TWh	159	7.6
Small hydropower	TWh	16	Negligible
Wind	Area with wind speed above 7m/s (km^2)	33,771	0
Solar	$kWh/m^2.d$ (kilowatt-hour per metre squared per day)	5.5	Negligible
Geothermal	TWh	22	0
Biomass	Yield in million tonnes per year	96	58
Natural gas	Trillion cubic feet	2.7	0
Coal	Tonne	70	0

Source: Ministry of Mines and Energy, 2007; World Energy Council, 2007.

increase output to 40GW (or about a quarter or the total potential available) by 2015 to 2020.

Wind energy, solar energy and geothermal power are currently little exploited, but the government has plans to harness them more. In fact, demand for energy is growing rapidly in Ethiopia and the main challenge is to increase access to sustainable energy and ensuring energy security for the nation. Emissions are expected to rise sharply in the next 20 years but can be reduced drastically if energy efficiency and the use of sustainable alternatives are adopted.

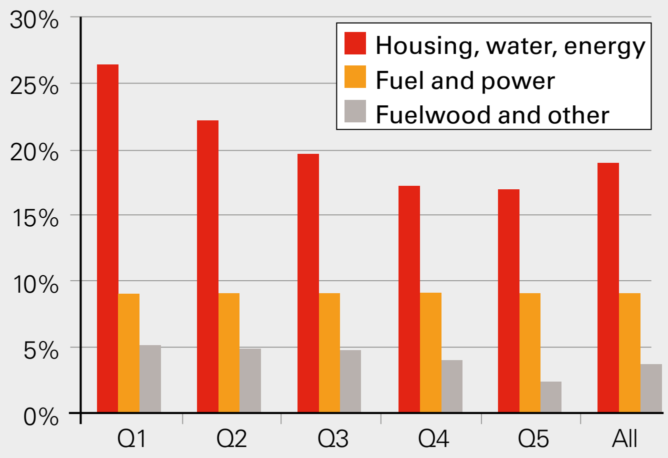
Low-carbon plan

The Ethiopian government has stated its intention to follow a green development path in its five-year development plan (2011-2015) and is currently drafting a Climate Resilient Green Economy (CRGE) strategy. The strategy foresees cutting GHG emission from Ethiopia by more than half by 2030 and diversifying energy supplies and uses to increase climate resilience in the energy sector. Some of the major actions proposed include energy efficiency for biomass fuels and substitution of fossil fuels with renewable electricity such as electric freight rail to replace petroleum fuel-based road-freight transport.

The major actions anticipated for Ethiopia, including renewable electricity for transport and energy efficiency, cost less than their conventional alternatives on life-cycle basis (that is, if you look at the whole span of a project from conception to end delivery). Some of these measures also have considerable local environmental benefits in reducing air pollution (indoor and outdoor), and in re-establishing the balance between resource supplies and uses.

The major barriers for low-carbon technologies include the relatively high investment requirement, low institutional readiness, and human and material capability for implementation. A low-carbon development leapfrog fund can address these barriers and contribute towards the rapid uptake of low-carbon technologies in Ethiopia.

Figure 1: Energy spending by expenditure quintile



Households in Ethiopia spend 9 per cent of their income on energy. Firewood and other cooking fuels account for 40 per cent of this expenditure. While the share of energy expenditure is the same for all income classes, the share of expenditure on fuelwood and other cooking fuels is greater for low income households compared to better-off households.

Source: CSA, 2007

Leapfrog potential

Ethiopia has a diverse range of renewable resources and a great potential market in its large population with growing incomes. Despite a rise in the adoption of renewable energies, only a small fraction of the potential is realised. The main barriers for large-scale adoption of renewable energy in Ethiopia are the relatively high investment requirement and the limited capacity in institutions.

The low-carbon leapfrog fund for Ethiopia would have major impacts in disseminating decentralised renewables and for forest management that meet the main challenges of access and sustainability in the energy sector:

- potential programmes at the household level: household energy efficiency, promotion of domestic biodigesters, rural electrification through solar systems
- potential programmes at the community level: forest regeneration, micro-hydropower, wind water pumping, renewable energy for community services (water supply, health centres and schools).

The low-carbon leapfrog fund could thus be used to finance investment by users, communities, and private sector renewable energy promoters and to develop implementation capacity for the public and private sectors.

Low-carbon case examples

The National Biogas Program of Ethiopia

The National Biogas Program of Ethiopia (NBPE) was launched in 2008 with the goal of disseminating 14,000 domestic biodigesters in five years (1,400 installed as per June 2011).

The adoption of biodigesters provides access to sustainable energy and natural fertiliser while reducing environmental degradation and greenhouse gas emission.

The investment for the biogas plants averages at Birr 13,000 (US$675), with the government contributing Birr 5,000. Owners can access micro finance to cover the remaining amount. Due to the comparatively high cost, the programme is currently targeting better-off households, while trying to develop a less expensive model.

The biodigesters of NBPE have significant positive impacts:

a. they reduce demand for wood thus improving sustainability of local resources

b. they reduce time spent on collecting fuel and cooking

c. they improve access to natural fertiliser from biodigester waste

d. they reduce indoor air pollution from inefficient biomass stoves

e. they reduce greenhouse gas emission.

The technical market for domestic biogas in Ethiopia is estimated to be 1 million biogas units, with a market potential of 100,000 units per year. A dedicated leapfrog fund could address some of the main issues that this programme faces, such as availability of co-financing for farmers, and the ongoing need for capacity-building at the district level for construction and maintenance of the biodigesters.

Humbo Natural Regeneration Project

The Humbo Natural Regeneration Project started in 2006 to regenerate 2,728 hectares of degraded natural forest.

The project uses a set of low-cost and participatory techniques developed in west Africa over the past 20 years for community forest management and income generation. These include the creation of areas devoted to fuel wood, to minimise the risk of pilferage. In addition to this, carbon credit through CDM for sequestration of carbon is incorporated into the project to generate income for surrounding communities.

The regeneration project has brought multifaceted benefits to the local and global environment, and local communities.

a. Regeneration of the natural resource base has helped the recovery of biodiversity.

b. There is an enhanced supply of firewood for cooking.

c. The project generates income for communities through sustainable harvesting of both timber and non-timber products.

d. The project creates long-term employment opportunities in forest management.

e. Communities expect US$726,000 from the World Bank for the sales of part of the Certified Emission Reduction (CER) within 10 years.

f. The project is expected to mitigate 850,000 tonnes of CO_2 by sequestration of carbon in the forest in 30 years.

A wider replication of this type of project can be supported by a leapfrog fund, which could be used to cover the pre-project costs, while income from CERs could cover the management costs.

Solar energy for rural electrification

The SEF developed a concept of providing Solar Home Systems to meet the lighting and audio-visual requirements of households in rural areas, providing a safe and sustainable alternative to kerosene lamps and wood fires.

The five projects implemented so far have provided electricity to 3,740 homes and businesses and improved water supply and health services to more than 10,000 people. The plan is to increase the solar villages to 50 and users to 50,000 by 2013.

The projects have provided considerable social, environmental and economic benefits to the communities involved, improving their health and opportunities for education, productive work and leisure. Solar systems have also eliminated pollution caused by batteries, reduced emissions and created employment opportunities at the local level.

By 2020, there will be 87 million people in 18 million households in Ethiopia. Traditional rural electrification programmes cannot be expected to address more than half this population in 10 years, therefore the potential for promoting solar systems at the household level is huge. The leapfrog fund could thus support the scale up of solar systems and the capacity-building efforts needed at the institutional and community levels.

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