Economic Commission for Africa

ACPC
African Climate Policy Centre

United Nations Economic Commission for Africa
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Working Paper 10

Integrating Renewable Energy and Climate Change Policies: Exploring Policy Options for Africa

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INTEGRATING RENEWABLE ENERGY AND CLIMATE CHANGE POLICIES: EXPLORING POLICY OPTIONS FOR AFRICA

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LIST OF ACRONYMS

ACPC	African Climate Policy Centre
APF	Africa Partnership Forum
BP	BP, Inc. Oil Company
CDM	Clean Development Mechanism
CERs	Certified Emission Reductions
CH_4	Methane
CO_2	Carbon Dioxide
CSP	Concentrating Solar Panel
DFID	Department of for International Development, U.K
DRFN	Desert Research Foundation of Namibia
ECA	Economic Commission for Africa
EEPCo	Ethiopian Electricity Power Corporation
EIA	U.S. Energy Information Administration
EVs	Electric Vehicles
GDP	Gross Domestic Product
GHG	Greenhouse gas
GTP	Growth Transformation Plan
GW/GW_{th}	Giga Watts / Giga Watts (thermal)
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
FAO	Food and Agriculture Organisation of the United Nations
IPPs	Independent power providers
kWh	Kilo Watt Hours
MDGs	Millennium Development Goals
MW	Mega Watts
NAMAs	National Appropriate Mitigation Actions (NAMAs)
NEPAD	The New Partnership for Africa's Development
NREL	National Renewable Energy Laboratory
OECD	Organisation for Economic Co-operation and Development
OFID	The OPEC Fund for International Development
PRSPs	Poverty Reduction Strategy Papers–PRSPs
PV	Photo Voltaic
REF	Rural Electrification Fund
REN21	Renewable Energy Policy Network for the 21st Century
TWh	Tera Watt Hours
UETCL	Uganda Electricity Transmission Company Limited
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organisation
WEC	World Energy Council
WHO	The World Health Organisation
WWEA	World Wind Energy Association

ABSTRACT

Lack of access to energy services is one of the main constraints to economic development in Africa. Only about 31% of the population of Sub-Saharan Africa has access to electricity, with 14% access rate in rural areas. Compounding the challenge, traditional biomass supplies up to 85% of primary energy supply, and accounts for 80% of energy consumption. With limited energy efficiency, installed generation capacity and weak institutions and energy sector governance, energy security in Africa has become a critical concern.

Adaptation to climate change is another challenge to sustainable development in Africa. Even though Africa contributes less than 4% of global GHG emissions, it is disproportionately affected by climate change effects such as food security, water supply, biodiversity, climate-related diseases and other such effects. Energy and climate change are however related, as much of the GHG emissions are related to the way society produces, distributes and consumes energy. This connection offers a policy opportunity that can allow the achievement of energy security goals in a sustainable manner, and in less carbon-intensive ways. The joint exploration of policies that can spur clean energy development that have inherent climate change mitigation benefits is the main focus of this paper.

Renewable energy technology adoption can lead to larger mitigation outcomes while enhancing access to clean energy. While coal- and fossil fuel-based energy production emit significant carbon per unit of energy generated, hydro, bioenergy, wind and solar thermal and PV technologies offer carbon-neutral energy generation opportunities. Therefore, reducing barriers to renewable energy development through innovative public policy should interest energy and climate policymakers. Such policies as net metering, feed-in tariff, renewable energy portfolios, voluntary targets, production tax credits and fiscal incentives are shown to encourage clean energy development.

To advance integrated renewable energy and climate change adaptation/ mitigation policies in Africa, this paper recommends policies and strategies, including: (1) establishment of clear energy and climate change adaptation/mitigation policies in Africa; (2) implementation of renewable energy development-inducing policies; (3) creating conducive environments for private-public partnerships in clean energy development; (4) enhancement of broader regional and continental collaboration in energy and climate change policies; (5) accessing existing international funding sources for promoting less carbon-intensive energy technologies; and (6) implementation of energy portfolio diversification.

As African countries seek to develop their energy sector, renewable energy offers a great opportunity. Recognising the links between energy security and climate change, integrative policies that advance energy development through less carbon-intensive technologies will remain to be valuable. Energy and climate change policymakers and stakeholders are encouraged to promote such innovative policies to meet energy and climate change challenges in the 21st century.

1. CHARACTERISING THE ENERGY AND CLIMATE CHANGE PROBLEM IN AFRICA

1.1. The Energy Problem in Africa

Energy is one of the main constraints to economic development in Africa, with unreliable supply and lack of access often being persistent problems (Winkler and Marquand, 2009). The region remains one of the least electrified (OFID, 2008), with energy utilisation levels accounting for 4% of global supply. Major structural challenges remain within the energy sector in Africa. First, lack of access to modern and efficient energy sources at affordable tariffs (OFID, 2008), particularly in rural areas (see Table 1), continues to be a problem. For example, an estimated 31% of the population of Sub-Sahara Africa has access to electricity, with about 14% electrification rates in rural areas (IEA, 2011). Second, traditional fuels account for the bulk of energy supply, featuring limited integration of modern energy supplies. For example, in many Sub-Sahara African countries, traditional biomass accounts for a large share of primary energy supply (see Figure 1), reaching 70-85% of primary energy supply and over 80% of energy consumption in recent years (IEA, 2011).

Table 1: Source of rural energy supply in select regions of Africa (%)

Country	Firewood	Gas, Kerosene	Charcoal	Electricity	Other
C.A. Republic	100	0	0	0	0
Gambia	97	1	1	0	1
Tanzania	96	0	3	0	0
Botswana	86	14	0	0	0
South Africa	49	23	5	21	2
Djibouti	44	48	5	1	2

Source: adapted from Karekezi and Kithyoma (2002)

Third, energy efficiency is low compared to other regions, often requiring large stock of primary energy per unit of useful energy (UNIDO, 2009). For example, the household sector in Africa, which relies mostly on traditional biomass, features efficiency levels of cooking stoves at just 10-20% (Bailis, 2005). Fourth, expansion of energy generating capacity through investments remains comparatively low. With almost half of the African population living on less than $1.25 dollar per day as at 2008 (UNDP, 2010), the low affordability of modern energy services has hampered investments in the energy sector. The lack of financial capital needed to expand modern energy services has also hindered energy development (OFID, 2008). Even though installed generation capacity increased by 23.7% from 1998 to 2008, the capacity development is smaller than the world average increase of 41.6%, with less than 20% of energy supply coming from renewable sources (mostly hydro) (EIA, 2011). Fifth, weak institutions, lack of political engagement and poor energy sector governance have also affected energy capacity development (NEPAD-OECD, 2009). Finally, challenged by the above factors and price volatility of energy commodities in international markets, there is a significant threat to energy security in Africa.

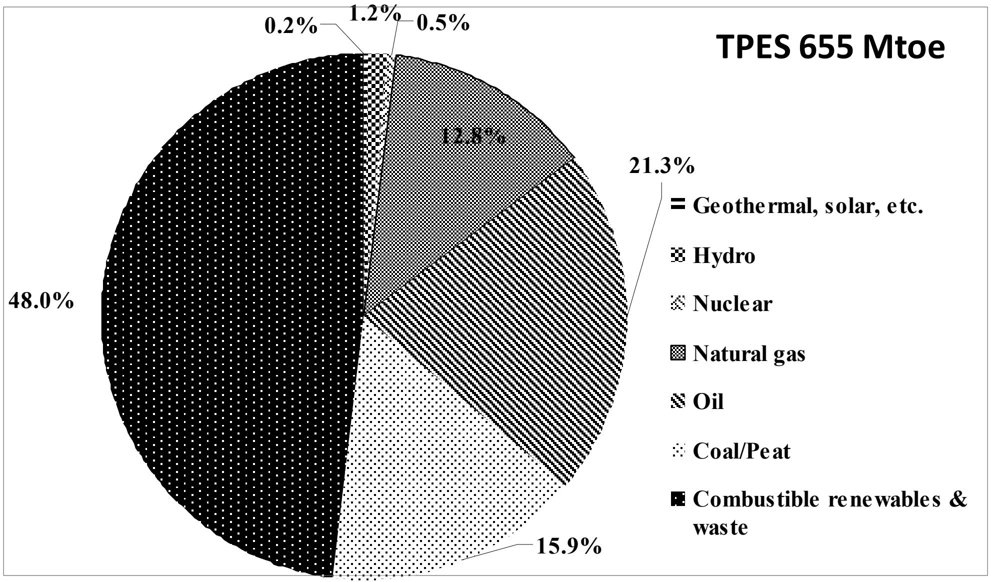

Figure 1: Total primary energy supply in Africa in 2008

Source: IEA (2011)

Energy sector development is crucial to achieving development milestones. The International Energy Agency (IEA) stipulates that to meet Millennium Development Goals (MDGs) by 2015, it will be necessary to expand access to clean energy to 395 million more people, and clean cooking facilities to over 1 billion people worldwide, perhaps requiring additional investment of $41 billion per year between 2010 and 2015 (WEC, 2010).

The relationship between economic growth and energy consumption is well established, and much of the growth in global energy consumption will come from developing countries where demand is driven by long-term economic growth. Under current policies and consumption trends, energy use in developing countries will increase by 85% by 2030 (IEA, 2011). As countries seek to leverage energy resource development to improve health, clean water supply, delivery of education, food production and income generating activities (Nair, 2009), the availability of clean, affordable and reliable energy becomes that much more important.

Addressing constraints to energy sector development in Africa is indeed at the centre of energy policy goals. Under certain conditions, renewable energy systems (especially small-scale renewables) are capable of providing modern energy services at lower costs than large scale centralised systems. The availability of renewable energy sources at the local level also makes them suitable for providing decentralised systems. Thus utilising the vast renewable energy potential in the region will provide a great opportunity to develop the energy sector at the local level, reduce the dependence on increasingly expensive fossil fuels and move towards cleaner alternatives. This will provide opportunity to include more people in the energy supply chain and contribute to a low carbon economy.

Table 2: Energy resources of Africa

Energy Type	Reserves	Regional distribution	Comments	Reference
Non-renewable				
Crude oil	132.1 billion barrels	Northern Africa: 53.2% Western Africa: 28.2% Central Africa: 16.9% Other Africa: 1.7%	Libya accounts for over 70% of the reserves in Northern Africa. Nigeria accounts for almost all of the crude oil reserves in western Africa.	BP, 2011
Natural gas	14.7 trillion M3	Northern Africa: 55.8% Western Africa: 36.1% Other Africa: 8.2%	Algeria (55%), Egypt (27%) and Libya (18%) account for most of the natural gas reserves in Northern Africa while Nigeria dominates almost all of the reserves in Western Africa.	BP, 2011
Coal	31,696 billion tonnes	Southern Africa: 95.2% Eastern Africa:1.6% Other Africa: 3.2%	About 95% of the coal reserves are located in South Africa.	BP, 2011
Nuclear	Reasonably assured resources: 663,400 tonnes Inferred resources: 286,300 tonnes	Northern Africa: 2.9% Western Africa: 36.7% Central Africa: 2.7% Eastern Africa: 4.2% Southern Africa: 53.5%	Niger accounts for all the Uranium resources in Western Africa. South Africa and Namibia account for all the Uranium resources in Southern Africa.	WEC, 2010
Renewable				
Hydro	1,834 TWh/yr	Central Africa: 57% Eastern Africa: 32% Other Africa:11%	DR Congo holds about 42% of the hydropower potential in Africa	WEC, 2010
Biomass	Woody biomass: 70 billion tonnes	All regions	Currently, most of the biomass is used for cooking as traditional biomass.	Parikka, 2004
Solar	[1]Solar insolation: 1800 – 2850 $kWh/m^2.a$	Most of Africa	[2]PV technical potential: 33 TWh/a in Gambia - 8,700 TWh/a in Sudan. Concentrating solar power potential: 7 TWh/a in Eritrea – 40,500 TWh/a in Libya.	[1]WEC, 2010 [2]NREL, 2008
Wind	Wind speeds: [1]Southern Africa (6 – 7 m/s) [2]Northern Africa (5 – 8.5 m/s)	Most attractive sites in the Northern and Southern coasts.	[3]Egypt, Morocco and Tunisia account for about 96% of the 1,014 MW installed capacity in the region.	[1]DRFN, 2010 [2]Business Insights, 2010 [3]WWEA, 2011
Geothermal	[1]9,000 MW	Eastern Africa	[2]172 MW installed in Africa as at 2008. About 95% of this installation is in Kenya.	[1]Karekezi and Kithyoma, 2003. [2]WEC, 2010

Despite the structural challenges, significant energy resources exist in Africa (see Table 2). For example, the region accounts for about 9.5%, 8% and 4% of the total proven reserves of oil, natural gas and coal in the world, respectively (BP, 2011). Africa also accounts for about 12% of the World's technically feasible hydropower potential (WEC, 2010). In addition, solar, wind and other renewable energy potentials in the region are quite significant. As pressure to increase energy generation capacity mounts and as the climate change effects of energy production and consumption require greater care in developing renewable energy sources, policymakers will confront challenges. Understanding policy opportunities to advance energy security while mitigating climate change impacts will be crucial for designing and implementing smart climate-sensitive energy policies.

1.2. The Climate Change Problem in Africa

Africa contributes less than 4% of the global greenhouse gas (GHG) emissions, but is highly vulnerable to the impacts of climate change (APF, 2007; World Bank, 2009). Projected future warming across the continent is estimated to be in the range of 0.2^{o}C (low scenario) to 0.5^{o}C (high scenario) per decade up to the year 2100 (Boko et al., 2007). This suggests increased climate-related 'shocks' in the region. The impacts of climate change are likely to be felt profoundly in Africa due to:

(1) Geographical location characterised by warmer climates and vulnerable areas exposed to low rainfall, poor soils and flood plains;

(2) Excessive economic dependence on climate-sensitive sectors such as agriculture and fisheries; and

(3) Low adaptive capacity to respond to the direct and indirect impacts of climate change due to factors such as weak economies and institutions, widespread poverty, inadequate technologies and social infrastructure, conflicts and limited human and financial capacities.

Even though the risks associated with climate change are uncertain (Adger et al., 2003), serious consequences of climate change are sufficiently established. Some of the consequences of climate change include rainfall variability and increased incidence of drought (Hulme et al., 2001), reduced crop yields and food insecurity, spread of climate-sensitive diseases, extinction of 20-30% plant and animal species (under 1-2^{o}C scenario of temperature increases) (Morey et al., 2011; Boko et al., 2007; Conway, 2009; DFID, 2004a; World Bank, 2009), and disproportionate regional impacts (Edenhofer et al., 2011). Sectoral assessment of the risks of climate change in Africa further reveals major vulnerabilities.

(1) *Agriculture and food security*: about 96% of the population in Sub-Saharan Africa depends on rain-fed agriculture (Madzwamuse, 2010). Extreme weather conditions such as persistent droughts and floods are projected to compromise agricultural productivity in terms of yield potential, length of growing season and arable land resources. In some African countries, crop yields are projected to decrease by about 50% while arable land will decline by 6% in 2050 due to climate change (Boko et al., 2007). With some 240 million people in Africa already food insecure (FAO, 2010), this would further exacerbate food insecurity and malnutrition in the continent.

(2) *Water supply*: about 75% of African countries are in zones where small deceases in rainfall could result in significant reduction in volume of river water (van Aalst et al., 2007). Climate conditions such as persistent droughts and drying of lakes and rivers will exacerbate water scarcity in the region. Boko et al. (2007) estimate that between 75–250 million and 350-600 million people will experience increased water stress by 2020 and 2050, respectively, due to climate change. This will have implications on reduced water quality, increased water-borne diseases and in some cases conflicts.

(3) *Healthcare*: the climate conditions and poor sanitation in Africa already make it vulnerable to some vector-borne diseases such as malaria, rift valley fever and cholera. The African region already accounts for about 78% of the 225 million cases of malaria worldwide in 2009 (WHO, 2010). Increased floods, droughts and altered temperature from climate change will likely increase the incidence of these vector-borne diseases. For example, it is estimated that by 2050, previously malaria-free highlands in areas such as Ethiopia and Kenya would be highly suitable for transmission of the disease (Boko et al., 2007).

(4) *Energy security*: climate change related factors such as drying of lakes and rivers and persistent droughts will decrease water flow to hydropower dams. For example, the river flow in the Nile regions is projected to decrease by 75% by 2100 (UNEP, 2006). Coupled with the increasing depletion of biomass stock due to unsustainable consumption and climate change, the region will experience reduced energy availability that will have negative implications on development.

(5) *Regional security and migration*: over 25% of the continent's population lives within 100 km of the coast (APF, 2007). Extreme conditions such as rising sea levels will increase the risks of coastal flooding. DFID (2004b) estimates that the people at risk from coastal flooding will increase from 1 million people in 1990 to 70 million by 2080. Coupled with increased desertification in the Sudano-Sahelian belts, the livelihoods and food security of the population will be affected. This will result in migrations to safer, more arable and affluent areas, which will compromise regional security and increase conflicts within and across borders as competition for resources increase in the region.

(6) *Biodiversity*: about 75% of the Sub-Saharan Africa population relies on products from forests (ECA, 2007). Extreme weather conditions due to climate change will result in the loss of biodiversity, forests and other natural habitats. Current estimates indicate that, by 2085, climate change could result in 25% to 40% loss of species' habitats in Africa (Boko et al., 2007; ACPC, 2010). This will have negative implications on the livelihoods of the population.

These effects pose serious setback risks to social development, particularly in countries where climate mitigation and adaptation capabilities are minimal. The imperative for African countries is therefore to move along a climate-resilient development pathway that promotes poverty reduction, economic growth and the enhancement of human wellbeing. There is also a need to mitigate potential increases in GHG emissions. It is essential to assess the desirability of high carbon technologies, including carbon-intensive energy development, in future development strategies in Africa. Thus, low-carbon energy options such as renewable energy supplies offer a huge opportunity to pursue a low-carbon growth in Africa.

2. THE ENERGY AND ENVIRONMENT NEXUS

2.1. Energy and Carbon Intensity

Energy and the environment are linked directly, through the contribution to emissions resulting from the production, distribution and consumption of energy and indirectly, through economic activities that energy supports. These links can be traced by charting the energy and carbon intensities related to economic activities. Africa has the lowest level of projected emissions per capita which is expected to increase from about 1.0 metric tonne in 2007 to 1.1 metric tonnes in 2035 (EIA, 2011). Changes in GDP per capita, population, energy use per unit of activity (energy intensity) and carbon intensity of energy used (carbon intensity) are major determinants of carbon emissions.

From 2000 to 2008, Africa's real GDP per capita, population, and CO_2 emissions per capita grew by about 22%, 21 %, and 8%, respectively (see Table 3), while energy and carbon intensities decreased by about 12.5% each. Energy efficiency and structural shift in the economy are two likely factors that often determine changes in energy intensity. Even though Africa's high energy intensity, coupled with the low levels of industrialisation, points to an inefficient energy use, lowering energy intensity by 12.5% while GDP per capita and population are growing by more than 20% may suggest that either Africa is becoming more energy efficient or is shifting to modern energy supplies. Africa's energy intensity is also moving down towards world average, from 57% above world average in 2000 to 40% in 2008. Africa was able to lower its carbon intensity by about 12.5% between 2000 and 2008 but it still remains about 63% higher than the world average. The average carbon intensity for Africa without South Africa was 0.24 in 2008 (World Bank, 2011), which is about 61% lower than the world average. South Africa, therefore, remains to be the most carbon intensive economy in Africa. The World Bank (2011) estimates the total CO_2 emissions in Africa at 1.13 billion tonnes in 2007, with South Africa alone accounting for about 38% of this total. North Africa accounted for about 39%, suggesting the rest of Sub-Saharan Africa accounted for the remaining 22% (World Bank, 2011).

Table 3: Energy and carbon intensities in Africa: 2000 and 2008

Indicator	World			Africa		
	2000	2008	% change	2000	2008	% change
GDP per capita ($US\$_{2000}$)[1]	5,293.00	6,049.00	14.28	719.00	877.00	21.97
Population (millions)[2]	6,088.68	6,700.77	10.05	803.61	969.97	20.70
Energy intensity (MJ/$US\$_{2005}$)[2]	10.54	10.34	-1.90	16.54	14.47	-12.50
Carbon intensity (tonnes CO_2/$US\$_{2005}$)[2]	0.59	0.60	1.69	1.12	0.98	-12.50
CO_2 emissions per capita (tonnes)[1]	3.91	4.54	16.11	1.10	1.19	8.18

Source: 1 World Bank (2011); 2 EIA (2011)

2.2. Energy and the Environment: Sectoral Overview

Exploring the energy and environment nexus can perhaps be better conceptualised at the sector-level. Observation of energy consumption patterns in Africa indicates the high consumption shares of the residential sector. This sector, along with the transportation sector, account for pollution shares slightly above world average and the rest of the economic sectors below world average (see Table 4). Energy source, technology and use patterns in these sectors will therefore determine the carbon path as energy consumption is projected to increase in the coming decades.

(1) The Household Sector

The household sector consumes about 59% of total energy in Africa (see Figure 2). The sector uses about 86% renewable energy (see Figure 3), especially combustible renewable (biomass) and waste. Fuel wood is the major component of combustible renewable resource. It is not carbon-intensive, and the carbon which was captured overtime and released into the atmosphere is the same as the carbon that was absorbed. However, two factors seem relevant as to how carbon-neutral household biomass uses would be. First, whether or not forest resources are managed sustainably can determine the extent of impact on the environment. Worldwide deforestation causes about 20% of CO_2 emissions. For about 30 developing countries, deforestation and degradation are the largest sources of CO_2 emissions (van der Werf et al., 2009). Table 4 shows that about 21% of emissions in Africa are contributed by the residential sector. Second, the efficiency at which primary energy is converted into useful energy, i.e., efficiency, is important. Transition to cleaner fuel, improving stove efficiency and enhancing forest management can help mitigate these impacts.

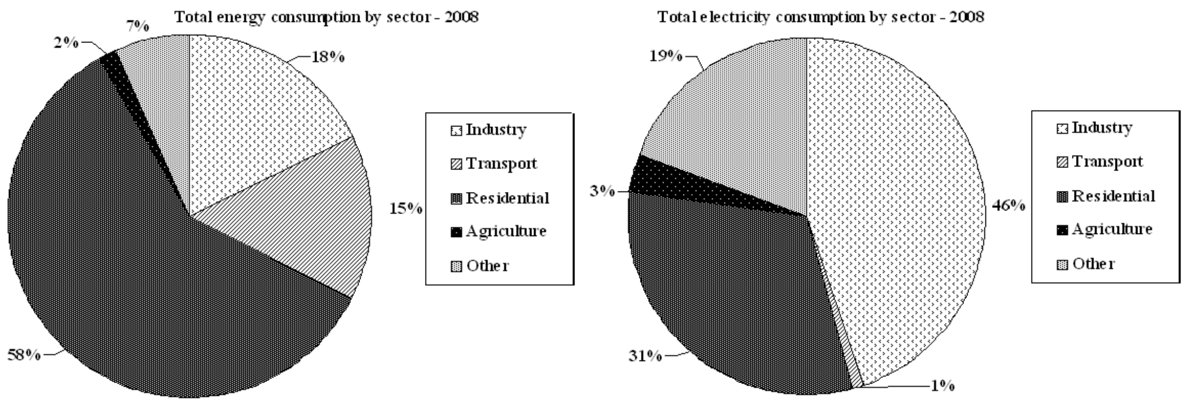

Figure 2: Energy and electricity consumption by sector in 2008

Source: IEA (2011)

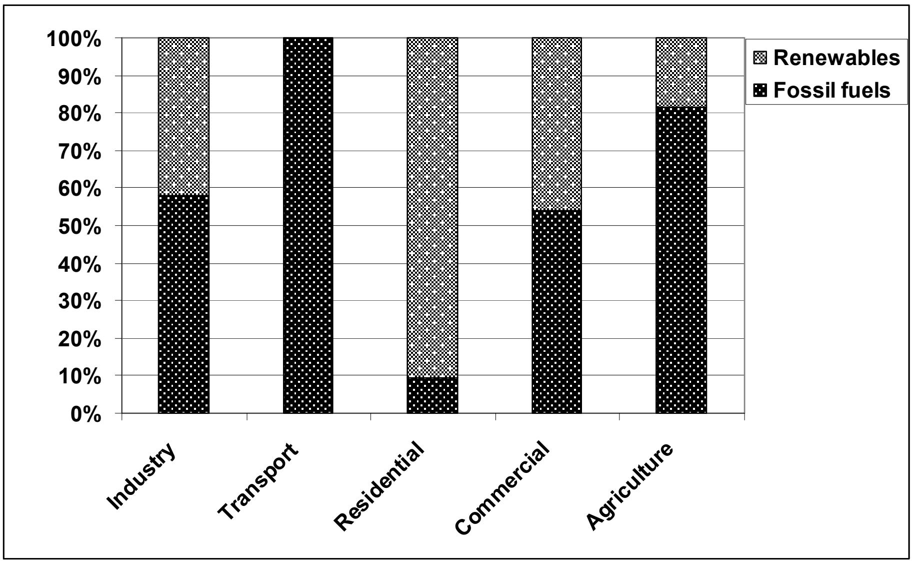

Figure 3: Energy consumption by type and sector in 2008
Source: IEA (2011)

(2) The Agricultural Sector

Africa's economy is highly reliant on Agriculture, with about 60 - 80% of the working population actively engaged in the sector (UNCTAD-UNEP, 2008). Agriculture accounts for over 25% of GDP in most African countries (ECA, 2009), but consumes only 2% of energy and 3% of electricity. The main fuel sources in agriculture are fossil fuels, accounting for about 67% (see Figure 3) and contributing more than 13% of CO_2 emissions (see Table 4), albeit at smaller overall levels. Fuel is needed to operate farm equipment, agricultural pumps and water irrigation systems in mechanised farms.

(3) The Industrial Sector

At 18%, this sector has a moderate share of total energy consumption in Africa (see Figure 2), with fossil fuels accounting for about 44.5% of the total energy used in this sector (see Figure 3). This sector is also responsible for about 35% of the total CO_2 emissions in Africa (see Table 4). Renewable energy also has a significant share. The coal dependent industries of South Africa account for 53% of the CO_2 emissions from the industrial sector in Africa. Despite the current challenge it creates, the low level of industrialisation of Sub-Saharan Africa could be an opportunity to avoid the carbon-intensive stage of industrialisation.

(4) The Transportation Sector

The transportation sector in Africa, as in the rest of the world, is heavily dependent on fossil fuels. Modern transportation largely relies on fossil fuels, and accounts for about 15% of total energy consumption (see Figure 2), and 24% of CO_2 emissions (see Table 4). Rising affluence and population globally has increased the demand for transportation fuels, thus increasing transportation-related emissions. Transportation is one area where energy and climate change concerns align significantly. While few feasible alternatives to mitigating the use of carbon-intensive fossil fuels in transportation exists in large parts of Africa, the suitability of the continent for biofuels offers a valuable transition fuel as Africa and the rest of the world sort out the environmental footprints of current transportation systems and technologies.

Table 4: CO_2 emissions by region and sector in 2008(million tonnes)

Sectors	World	North Africa	South Africa	Sub-Saharan Africa	Africa
Total CO_2 emissions from fuel combustion	29,381.43	369.81	337.42	182.70	889.93
Other energy industries*	2,051.55	29.47	16.24	9.74	55.46
Manuf. industries and construction	10,743.15	109.02	163.11	36.12	308.25
Transport	6,760.33	84.74	49.47	81.35	215.55
Residential	5,215.47	97.73	56.42	35.84	189.98
Agriculture and Other sectors	4,610.92	48.85	52.18	19.66	120.69
	Percentage				
Other energy industries	6.98	7.97	4.81	5.33	6.23
Manuf. industries and construction	36.56	29.48	48.34	19.77	34.64
Transport	23.01	22.91	14.66	44.53	24.22
Residential	17.75	26.43	16.72	19.61	21.35
Agriculture and Other sectors	15.69	13.21	15.46	10.76	13.56

Source: IEA (2010)

3. RENEWABLE ENERGY AND CLIMATE CHANGE – TOWARDS POLICY INTEGRATION

3.1. Energy and Climate Change in Africa: the Policy Context

As a result of the structural energy sector constraints discussed at the outset, energy policy has come to the fore in many African countries. These policies often target structural problems in the energy sector. First, the bulk of energy consumption, particularly in rural areas (over 80%), are for cooking purposes (Fall, 2010), often relying on traditional energy sources, with limited supply geared towards income generating economic activities. Second, the current energy structure leaves about 70% without access to clean energy sources, and forces about 80% to rely on biomass for cooking purposes. Third, the pace of economic development and poverty alleviation pursued in African countries is constrained by structural problems in the energy sector. Fourth, limited development of energy infrastructure has made the delivery of affordable, reliable and clean energy a challenge. As a result, energy policy goals often aim at four broader objectives: increasing the supply of affordable energy; securing energy supply through diverse energy sources (Karekezi et al., 2009); improving energy sector governance and reducing energy constraints to economic development (Winkler, 2005).

While energy sector reform and development are important in and of themselves, the confluence of energy problems with other societal challenges, especially climate change, has received significant policy attention. Energy policymakers in Africa are debating the relevance of the energy-climate change policy connections for Africa. For example, Karekezi (2002) notes that African energy analysts are preoccupied with the ability of the energy sector to meet short- and long-term energy needs, and less so with the role of the energy sector in climate change policy. The support for action on the part of African countries, however, remains far from universal.

While significant proportions of current energy generation in many parts of Africa come from less carbon-intensive sources (for instance, over 75% of East Africa's electricity production comes from hydro), the high levels of unmet energy demand, and anticipated expansion in energy generation capacity in the future, call the energy production process and primary fuel source to policy attention. The challenge is particularly visible in African countries where power still generates significant levels of GHG, such as in South Africa where 92% of electricity production relies on burning coal (Winkler and Marquand, 2009).

However, there is increasing evidence that expansion of power generation capacity can be met through renewable energy technologies that support the development of clean and sustainable energy supply, while positively contributing to the mitigation of climate change (Never, 2011; Fischer and Newell, 2004). Achieving climate-neutral energy development will require discovery of innovative cross-sectoral policies that have the potential to deliver on multiple social goals.

3.2. The Role of Renewable Energy in Climate Change Mitigation

Climate change policies emphasise two broader policy targets: mitigation and adaptation strategies. While adaptation strategies help countries deal with the socio-economic, environmental, species, health, food security, water supply and other climate change-related vulnerabilities, mitigation strategies aim at reducing GHG emissions. There are multiple mitigation pathways. Renewable energy development and energy efficiency enhancements offer opportunities for mitigating energy-related GHG contributions, which accounts for a dominant share of total global emissions.

Renewable energy technology adoptions can potentially lead to larger mitigation outcomes while providing access to energy services to 4 billion people worldwide who have no such access today (Edenhofer et al., 2011). Renewable energy sources, therefore, provide fossil fuel displacement benefits as they increasingly replace carbon-intensive electricity generation fuel sources (Fischer and Newell, 2004). Beyond the GHG mitigation potential of renewable energy adoption, countries have also been interested in the energy diversification and energy dependency mitigation benefits of renewable energy development (Winkler, 2005), as well as the stimulation of micro enterprise development in energy poor regions in developing countries (World Bank, 2008), contributing to poverty alleviation. For example, access even to some electricity for business development in off-grid communities can help seed the growth of businesses. The joint environment and economic benefits of these technologies, coupled with scale flexibilities allowing grid and off-grid applications, have intensified policy interest in properly integrating renewables in the national energy portfolio.

Bioenergy (generated mainly from biomass, energy crops, waste and residues), solar, geothermal, ocean, wind and other energies accounted for nearly 13% of the global primary energy supply in 2008 (Edenhofer et al., 2011). These alternative energy sources for electricity (biomass, solar, geothermal, hydro, ocean, wind, etc.), heat (biomass, solar, geothermal) and transportation (biofuels) offer GHG mitigation benefits from household and industrial energy uses, which account for over 75% of total energy consumption. The application of renewable energy technologies in household uses, such as improved biomass stoves, has shown significant environmental benefits by mitigating deforestation and reducing the demand for fossil fuels. Similarly, utilisation of biofuels in the transportation sector in Kenya, Malawi and Zimbabwe showed some encouraging results (UNIDO, 2009), though currently Ethiopia is the only country with active blending mandate. Mozambique has approved an unspecified blending target and South Africa has proposed a mandate pending approval. The application and promotion of renewable energy such as small hydro, biogas and solar technologies for productive uses, especially in the rural areas is also promising. In these diverse energy uses, the displacement of fossil fuels with cleaner energy sources will help mitigate net contributions to global GHGs. The environmental benefits of renewable energy will become more apparent in Africa, and developing countries at large, as environmental policies on carbon-intensive energy sources crystallises in the future.

The mitigation potential for some of the renewable energy sources is provided in Table 5. The carbon emission implicit social cost associated with per kWh energy supply shows the tremendous potential of non-combustive renewable energy generation options (with zero contribution) compared to coal, or other fossil-based energy sources, even though such fuels sources are cheaper per kWh energy generated in markets that do not price environmental pollution.

Table 5: Cost ranges and potential by 2010 and 2020 for CO_2 reduction using alternative electricity generating technologies

Power station type	Carbon emissions (g C/kWh)	Emission savings (g C/kWh)	Generating costs (USc/kWh	US$/t carbon avoided	Reduction potential to 2010/2020 (Mt C/year)
Pulverised coal – as base case	229	0	4.9	0	
Integrated gasification combined cycle (IGCC) – coal	190-198	31-40	3.6-6.0	-10-40	49/140
Pulverised coal + CO2 capture	40-50	179-189	7.4-10.6	136-165	10/100
Combined cycle gas turbine (CCGT) – natural gas	103-122	107-126	4.9-6.9	0-156	38/240
CCGT gas + CO2 capture	14-18	211-215	6.4-8.4	71-165	Uncertain
Hydro	0	229	4.2-7.8	-31-127	26/92
Bioenergy IGCC – wood wastes	0	229	2.8-7.6	-92-117	14/90
Wind – good to medium sites	0	229	3.0-8.0	-82-135	63/173
Solar thermal and solar PV	0	229	8.7-40.0	175-1400	2.5/28

Source: Sims (2004)

Effective climate recovery will require cheaper and accessible energy technologies that serve the needs of the poor, enabled largely through innovation across the technology scale (Morey et al. 2011). However, the central policy question is how can climate change-neutral (or mitigating) energy technologies, that provide significant amount of energy to expand energy access, be widely available at feasible costs. This is at the core of the energy-climate change policies nexus, and the broader policy debate.

3.3. Climate Change Policy and Emission Reduction Targets

Observation of data on climate change suggests that the concentration of GHGs globally has increased significantly, with increased concentration of CO_2 by 36% and CH_4 levels doubling compared to pre-industrial levels, along with a global mean surface temperature rise of between

0.56-0.92^{o}C in the last century (IPCC, 2007a). Climate scientists caution about the global catastrophic effects discussed earlier. The IPCC (2007b) projects that global GHG emissions will increase to 9.7 - 36.7 $GtCO_2eq$ (25-90%) between 2000 and 2030 in the business-as-usual scenario. While the overall technical GHG reduction potential is 30-32% by 2020 from business-as-usual levels, under some assumptions, it is believed that 10% of these savings is expected to come from cleaner energy generation choices and energy efficiency.

In order to achieve these global mitigation targets, regional institutions and countries have ratified agreements and protocols and pursued mitigation policies. European countries have been at the fore-front of climate mitigation policy and action. For example, in cohesion to the European climate targets, Sweden is setting a 40% reduction in GHG emissions by 2020, partly coming from a 50% expansion in renewable energy capacity and 20% improvement in energy efficiency, with an additional 10% adaption of renewable energy in the transportation sector (Never, 2011). Climate policy and target-setting is also taking hold in Africa, though consensus and commitment to climate targets is not certain. South Africa has advanced its climate policy by putting forth proposals, such as the National Climate Change Response Green Paper, the National Cleaner Production Strategy and Carbon Tax. There are also stated intents, including at the climate change conference in Copenhagen, that South Africa will aim to reduce GHG emissions by 34% by 2020 and 42% by 2025 (Never, 2011). While similar climate policy intents are not widely observed in African countries, the apparent drive to deal with climate change, and the broader goal of making clean energy accessible to the majority is likely to drive energy policy to the centre of climate change policy, and climate change considerations to the centre of sustainable energy supply.

The recent activities relating to the issue of National Appropriate Mitigation Actions (NAMAs) in Africa deserve some attention as a policy or strategy option in linking mitigation efforts with energy activities. NAMAs are voluntary emission reduction measures undertaken by developing countries, which are reported by national governments to the UNFCCC. On their part, developed country parties would provide enhanced financial, technological and capacity-building support for preparation, implementation and reporting of NAMAs. There are about 50 NAMA submissions globally, with 20 coming from Africa. Countries such as Ghana, Ethiopia and Morocco offer some valuable lessons for other countries in the continent on how to use climate policy instruments to unlock potential finance for renewables. For example, Ethiopia's NAMA plan includes hydro, wind, geothermal, and biomass projects. The 2011 UNFCCC data shows that Ethiopia's ambitious hydropower projects include over 5,600 MW of capacity and more than 760 MW of planned wind power capacity from seven different projects. In addition, the country plans to develop more than 450 MW of geothermal capacity by 2018, and plans to produce about 64 million litres of ethanol from 2010 to 2015 and 622 million litres of biodiesel between 2010 and 2015 (UNFCCC, 2011). Morocco's NAMA submission is quite ambitious as well. It calls for the installation of 440,000 square meters of rooftop solar water heater collectors by 2012 and 1.7 million square meters by 2020. Other plans in Morocco include the development of a 1,000 MW wind park and plans to increase the capacity to 5,000 MW by 2030.

Although many questions remain on the design of NAMAs and the requisite regulatory framework to make them work effectively, the lack of rulings provides an opportunity for developing countries to play a pivotal role in the development of an international guidance on

NAMAs with favourable features for their circumstances. This would be crucial for Africa, which has benefited little from previous opportunities related to greenhouse gas mitigation instruments, mainly because it remained peripheral to the many of the technical discussions. For example, the distribution of Clean Development Mechanism (CDM) projects did not favour Africa, mainly because the CDM rulings only focused in making CDM attractive to developed country investors. Due to the continent's limited industrialisation, Africa, has only seen 8 million of the 670 million CERs (CDM credits) issued by September 2011 go to African projects (IGES, 2011). There are eight wind power, three solar and two geothermal projects representing 12% of all Africa CDM projects (ibid).

NAMA crediting could better facilitate the flow of money and technology as developing countries can choose the projects. This would offer better prospects for Africa to raise the resources needed to invest in key infrastructures. Perhaps, this demonstrates that energy policies and strategies are becoming inextricably linked with climate policy. NAMAs are likely to play a central role in drawing together these policy options into mutually reinforcing outcomes.

In addition, there are also instruments outside of the UNFCCC that could be used to mobilise finance for renewable energy initiatives. To this end, Multilateral Development Banks (MDBs) have introduced a range of dedicated funds for financing climate change activities. The Climate Investment Funds (CIFs) is one such fund, which was set up jointly by the World Bank and Regional Development Banks in 2008. The CIFs were intended as an interim measure to scale up assistance to developing countries for climate-related interventions. Two separate multi-donor trust funds comprise the CIF: the Clean Technology Fund (CTF) and the Strategic Climate Fund (SCF). The CTF provides 'scaled-up financing' for demonstration of low-carbon development and mitigation of greenhouse gas emissions through the deployment of clean technologies. The trust fund committee has so far endorsed 13 investment plans for a total \$4.3 billion for 12 countries, all of which are from middle-income and fast-growing developing countries. The group of countries contained three from Africa: Morocco, Algeria, Egypt and South Africa. Among the endorsed projects is a '\$500 million loan to the government of South Africa for renewable energy and energy efficiency measures'.

The SCF serves as an umbrella vehicle for the receipt of donor funding and disburses to the various funds aimed at 'piloting new development approaches'. Under the SCF, there are three funds. These consist of: i) the Pilot Program for Climate Resilience (PPCR), which was established to 'integrate risk and resilience into core development planning' and focusing on adaptation, designed to build upon NAMAs; ii) the Forest Investment Program, mainly focusing on mitigation efforts in the forestry sector; and iii) the Scaling Up Renewable Energy in Low Income Countries Program (SREP), which is set-up to support low carbon pathways for development. To date, \$1 billion for PPCR, \$587 million for FIP and \$318 for SREP have been approved for financing. Niger, Zambia, Mali, Ethiopia and Kenya are among the potential recipients of these funds.

The Regional Development Banks (RDBs) are also increasingly active in financing climate change action. The African Development Bank (AfDB) has begun to engage in climate finance for the region through a variety of investment initiatives. As the regional implementing body for investments identified by the Climate Investments Funds (CIFs), the AfDB will play a significant role in investment of clean technology projects. About $625 million will be channelled to the AfDB for such activities, which it intends to blend with its own resources to support several large-scale projects, such as a 500 MW solar power complex in Morocco and a 200 MW wind farm in Egypt[1] It is expected that the CIFs will channel

As renewable energy development is believed to provide half of the electricity generation by 2050 (Edkins et al., 2010; Grant, 2009), the nexus of energy and climate change policy is therefore increasingly becoming apparent and timely. Setting clear environmental standards and emission targets will define the degree to which renewable energy becomes an instrument of mitigation. Similarly, the degree to which renewable energy technologies can be accessible at affordable cost to mass consumers could define how bold climate policies could be in developing countries.

3.4. Barriers to Integrating Renewable Energy and Climate Change Policies

The confluence of environmental and energy concerns at the fore of public policy has required dealing with the energy and environmental crisis innovatively. The conjoined nature of these problems would require effective strategies that leverage functional interdependences. However, there are barriers that stifle the development of renewable energy and its significant role in national energy strategies, and the pursuit of climate change policies, particularly vis-à-vis energy.

Climate policy adoption and setting meaningful targets, particularly through international and regional initiatives, can face challenges emanating from coordination and coherence (Newell et al., 2009). Moreover, setting environmental standards and targets can involve costs related to private sector compliance expenditures, administration and monitoring, etc. Though strategies for pursuing the role of renewable energy in achieving climate change targets can be pursued differently, joint policy efforts will require proper understanding of the institutional settings within which diverse policy targets are pursued.

With respect to renewable energy development, coherent, consistent and favourable policies are usually lacking in Africa's context. This makes it difficult for investors to capitalise on this sector. According to UNIDO (2009), energy and renewable energy are missing in most development plans (Poverty Reduction Strategy Papers–PRSPs) of countries. Moreover, institutional capacity that could facilitate the various technical, economic, and marketing are either lacking or weak. Technical skills shortage and financial barriers are also constraints. Of the estimated annual US$27 billion total investment required to achieve universal access to reliable and cleaner electric power by 2030, only about US$2 billion has been leveraged. Government support is weak and discourages private sectors, banks and lending facilities from investing in renewable systems. Similarly, support is lacking in the area of promoting the market environment of technologies. For instance, import duty for Solar Home Systems in Ethiopia is high reaching up to 20-30% (Power and Shanko, 2009).

Painuly (2001) identifies a comprehensive set of other factors that can be barriers to policy development in the energy sector. These include: energy market failure (e.g. monopoly, high investment requirements, poor infrastructure); market distortions (e.g. subsidies and tax incentives to fossil fuels, import tariffs on renewable energy technologies, lack of pricing emissions); financial environment (e.g. economic viability of renewables, lack of access to credit, lack of financial institutions support); technical constraints (e.g. lack of codes and certification, shortage of skilled personnel, system constraints); social and behavioural resistance (e.g. consumer acceptance, belief that products may not be reliable); and others (e.g. uncertainty of government policies, high risk of investment in new technologies, technological change).

However, it is important to note that attempts to develop renewable energy policies in Africa have been centred more on removing barriers that would hamper the expansion of the renewable energy technologies instead of promoting its development. This is reflected in the low budgetary allocations or other dedicated funds for the promotion of renewable energy. Most renewable projects are pilot projects that are externally financed and dedicated funds are less than 3% of total public expenditure (UNIDO, 2009).

Beyond the barriers, little is also know about climate policy integration in the energy sector (Dupont and Oberthur, 2011). But if these synergies become effective, energy can lead the way to decarbonisation by seeing increasing role of renewables (Heaps et al., 2009). Ample opportunities exist to advance policies that meet the dual goals of energy accessibility and sustainability. Some of these are explored next.

3.5. Policy Options for Low Carbon Energy Development in Africa

3.5.1. Electricity Generation and Consumption

The leading causes of emissions are related to energy generation and consumption, particularly in household and transportation sectors. Reducing emissions at the generation level often requires setting emission standards, but also encouragement of cleaner energy supply from renewable sources. The latter could be a more attractive policy option in the context of Africa. Mitigating emissions from transport-related energy uses also relies on technological standards, such as improving mileage standards on vehicles, and on fuel types, such as biofuels but other than biofuels, those are outside the control of African policy makers. Environmental policy implementation thus relies on smart energy policies that encourage renewables.

Energy policies that encourage the integration of low carbon renewable energy supplies often enable three aspects of reform: democratising access to the grid for independent power providers (IPPs); induce increased share of renewables in the energy portfolio (mandatory and incentive-based); and enhance the price-competitiveness of renewable energy technologies. Most renewable energy policies enable the achievement of these reforms.

(1) Energy Infrastructure Related Policy Options

- *Net metering* – enables grid transactions whereby net supply (power purchased from grid minus power supplied to grid) will be compensated. This is applied in cases where self-generated power supplies are used either from solar PV or other renewable sources. This permits utility networks to provide “energy-storage” for small users. The policy is operational in at least 14 developed countries, but currently is not implemented in Africa. By permitting independent access to the grid, power suppliers can be expanded beyond public generating sources.

- *Feed-in tariffs* – establishing a price for renewable energy supply to the central grid. It is a market-independent mechanism that promotes renewables through payments of a certain guaranteed price 'for power generated from a renewable energy source, and usually sets a long-term contract period (typically 20 years)' (REN21, 2011). It is also known as advanced renewable tariffs, premium payments or minimum price standards. The utility company, or the grid operator, is usually the one that administers the payment. Worldwide, feed-in tariffs are implemented in at least 61 countries, 5 from Africa (see Table 6).

These set of policies open the energy infrastructure to independent power suppliers, and in so doing incentivise increasing supply of renewable energy that decarbonises generation.

(2) Energy Portfolio-related Policies

- *Renewable portfolio standards* – seek to mandate certain percentage of energy supply, by a certain date, comes from renewable sources. One type of target is for a share of total electricity consumption to come from renewables, with several cities adopting policies with targets in the range of 10–30%. Another type of target is the share of energy targeted to be from renewables (including transport and heating, not just electricity). Yet another is the share of renewable energy for a specific segment such as buildings. Some targets are for amounts of installed renewable energy capacity, such as megawatts of solar PV or wind power, or the surface area of solar hot water collectors (REN21, 2011). These renewable target policies are now available in 98 countries. However, targets are rare in developing countries, and are not currently implemented in Africa.

- *Mandatory purchase agreements*: require utilities to purchase clean energy from IPPs. Mandating purchases creates markets for renewables and encourages diversification of electric generation in the long-run.

- *Voluntary targets* – aims to meet electricity generation diversification through voluntary actions of power suppliers. By communicating targets, voluntary participation of energy sector stakeholders is expected to lead to outcomes.

- *Regulated approval for new power plants* – regulates licensing of new power plants. By limiting permitting of carbon-intensive power plants from entering the generation system, long-term energy supplies are decarbonised. This is often conducted through environmental policies that set emission targets high enough to limit the role of intensively polluting power plants.

- *Production tax credits* – provides tax incentives to electricity generated from renewable sources. By altering the competitive advantage of traditional fuels through fiscal intervention, tax credits help induce supplies of renewables. Currently this policy is not implemented in Africa.

(3) Renewable Energy Competitiveness-related Policies

- *Tax reductions* – including energy sales and value added taxes. By lowering tax burdens, fiscal policies aim at inducing the supply of renewable energy. Tax policies also focus on subsidies, grants and rebates. Zambia, for instance, has started reducing taxes in mining areas in the effort to encourage 'investment in power capacity' preferably renewable energy technologies including hydropower and solar (REN21, 2011). Kenya and Zimbabwe have removed tax on PV systems (UNIDO, 2009). Fiscal policies are the most common form of intervention in Africa where 5 countries offer subsidies, grants or rebates and 12 countries offer tax reductions (see Table 6).

- *Public investment, loans or financing* – access to credit and finance is one major constraint to renewable energy adoption. By providing preferential loan and financing opportunities and creating public investment resources, these policies seek to expand renewable energy development. Currently, 6 African countries offer public investment, loans or financing (see Table 6).

Even though the experimentation with these policies as tools to diversify energy portfolios and achieve environmental targets is not widespread in Africa, enough examples of adoption of these policies exist. As shown in Table 6, few African countries attempt to utilise policies to induce renewable energy development. Those that actively implemented a policy often rely on tax credits, subsidy or public investment. Even though feed-in tariff provisions in Algeria, Kenya, South Africa, Tanzania and Uganda are encouraging, the fact

Table 6: Renewable energy policy adoption in Africa

Country	REGULATOR POLICIES			FISCAL INCENTIVES				PUBLIC FINANCING	
	Feed-in tariff	Biofuels obligation/ mandate	Heat obligation/ mandate	Tradable renewable energy credits	Capital subsidy, grant or rebate	Investment, production tax credits	Reductions in sales, energy, VAT or other taxes	Public investment, loans or financing	Public competitive bidding
Algeria	X								
Botswana							X		
Egypt					X		X	X	X
Ethiopia		X					X	X	
Gambia							X		
Ghana				X			X		
Kenya	X						X		
Mali							X		
Mozambique		X						X	
Morocco								X	
Rwanda							X	X	
South Africa	X			X	X				X
Tanzania	X				X		X		
Tunisia					X		X	X	
Uganda	X				X		X		
Zambia							X		

Source: Adopted from REN21 (2011)

that Renewable Portfolio Standards, net metering, energy production payments or production tax credits are not implemented in any country demonstrates that a wide range of potent policies are available to Africa's energy and climate policymakers.

However, the fact that a significant number of African countries have primary and final energy diversification targets (see Tables 7 and 8) is indeed encouraging. Implementation of these targets can open avenues for joint exploration of energy and climate change policies in Africa.

Table 7: Share of primary and final energy from renewables – targets in African countries

Country	Primary Energy Target	Final Energy Target
Botswana		1% by 2016
Burundi		2.1% by 2020
Egypt	14% by 2020	
Gabon		80% by 2020
Madagascar		54% by 2020
Malawi	7% by 2020	
Mali	15% by 2020	
Mauritius	35% by 2025	
Morocco	8% by 2012	
Niger	10% by 2020	
Senegal	15% by 2025	
Uganda	61% by 2017	

Source: Adopted from REN21 (2011)

Table 8: Energy diversification targets of African countries

Country	Resources	Target
Algeria	Wind	100 MW by 2015
	CSP	170 MW by 2015
	Solar PV	5.1 MW by 2015
	Cogeneration	450 MW by 2015
Egypt	Wind	12% by 2020, or more than 7,200 MW
	Hydro	6% by 202
	Other renewables	2% by 2020
Ethiopia	Wind	760 MW new installed capacity by 2013
	Hydro	5.6 GW new installed capacity by 2015
	Geothermal	450 MW new installed capacity by 2018
Kenya	Renewable capacity	Double installed capacity by 2012
	Geothermal power	4 GW by 2030
Morocco	Small-scale hydro	400 MW by 2015
	Solar PV and CSP	2,000 MW to provide 20% of elec. by 2020
	Wind	1,440 MW by 2015; 2,000 MW by 2020
	Solar hot water	400,000 m2 (0.28 GWth) by 2020; 1.7 million m2 (1.2 GWth) by 2020
Mozambique	Renewable capacity	2,000 MW each from wind, solar and hydro
	Rural	Installation of PV systems for lighting (50,000), refrigerators (5,000), TVs (2,000), water pumping (5,000) and community services (20,000); installation of 1,000 biodigesters; installation of 3,000 wind pumping systems; installation of 5,000 renewable-energy-based productive systems; installation of 100,000 solar heaters.
Namibia	Non-hydro renewable capacity	40 MW by 2011
Nigeria	Renewable capacity	16 GW by 2015
Rwanda	Small hydro	42 MW by 2015
South Africa	Renewable generation	10,000 GWh, 3,100 MW by 2013, including 500 MW wind and 50 MW CSP

	CSP	43 TWh annually by 2030
	Solar PV	14% of generated electricity by 2050
Tunisia	Renewable capacity	1,000 MW by 2016; 4,700 MW by 2030
	Wind	330 MW by 2011
	Solar PV	15 MW by 2011
	Solar hot water	750,000 m2 (0.5 GWth) by 2011
Uganda	Small hydro, biomass, geothermal	188 MW by 2017
	Solar hot water	30,000 heaters by 2017
	Biogas	100,000 digesters by 2017

Source: Adopted from REN21 (2011)

3.5.2. Transportation

Transportation poses a particular problem for energy and climate change policymakers. Nearly all of transportation fuels in Africa are from fossil fuels, with high emission levels. Emission-sensitive energy policies in the transportation sector have largely focused on two broad set of policy goals: improving fleet fuel efficiency and conservation, and increasing the share of less-polluting bio-energy in fuel supplies. Technological innovation and fuel mileage standard mandates have improved efficiencies in the transportation sector, while competitive biofuels have helped mitigate use of fossil fuels. While adoption of mileage standards seems exogenous to Africa's policymakers, biofuel development offers an alternative.

Biofuel production or blending with fossil fuel is gaining momentum. Policies such as biofuel subsidies, tax exemptions, or blending mandates are commonly practiced at the national level. Fuel tax exemption and production subsidies exist in at least 19 countries where four of these are developing countries and blending mandates exist in at least 31 countries. Currently, Ethiopia is the only country in Africa with this mandate; biodiesel and E8 (8% ethanol) mandate by 2013. Conducive policy instruments are necessary for biofuel production in Africa. Besides blending mandates, tax benefits, smart subsidies and loan guarantees could be adopted as feasible policy instruments to promote the expansion of biofuel. One limitation to biofuels is the fact that they are very context-specific and the complexity of replicating success stories. Many African countries have the potential to produce biofuels for their local markets, and even for export. However, examining the national status is very crucial to avoid biofuel production from affecting food supply, land use and ecosystems (UNIDO, 2009).

Electric vehicles (EVs) development is an alternate policy expanding in the transport sector. However, these policies do not necessitate that the electricity supply is from renewable sources. Governments try to promote the increased use of EVs through reducing tax and expanding public recharging infrastructure.

These technologies have significant potential in mitigating emissions, but require significant resources and infrastructure to be effectively integrated into African transportation systems.

4. CLEAN ENERGY DEVELOPMENT AND POLICY INTEGRATION IN AFRICA – LESSONS FROM SELECT ENERGY PROJECTS

Lessons from countries that pursued renewable energy development suggest the following. First, renewable energy deployment will be accelerated if regulatory and incentive-based policies are put in place. Second, renewable energy development has a great deal of GHG mitigation benefits, suggesting energy and environmental policy integration is feasible. Third, numerous barriers exist that can stifle the development of renewable energy, and policy will need to ease the integration of renewables. Fourth, institutional, regulatory and financing mechanisms have to be in place to ensure the integration and expansion of renewable technologies into socio-economic development. Small-scale trials of renewable energy in Africa reveal some of these facts.

Role of policy in decarbonising electricity and transportation energy.

Electricity expansion plans in Ethiopia

The Government of Ethiopia focuses on a twin-track approach for rural electrification, accelerating grid expansion to rural towns, and using gensets and mini-grids to bring electricity to off-grid consumers. The electricity industry is monopolised by the state-owned Ethiopian Electricity Power Corporation (EEPCo), which is responsible for the production, distribution and maintenance of the national grid. The energy policy places high emphasis on hydropower resource development and encourages energy mix with renewable such as solar, wind and geothermal to be developed given their cost competitiveness. Currently, hydropower, diesel and geothermal systems account for 88%, 11% and 1%, respectively of total electricity generation in the country. The total installed generation capacity in the country at the end of 2010 is about 3,981.07 MW, with hydropower systems accounting for about 3,523.90 MW. Ethiopia's national development plan (Growth Transformation Plan (GTP) 2011-2015), promotes Green Development Strategy with the aim of meeting the demand for energy in the country by providing sufficient and reliable power supply. The plan promotes an extensive hydropower expansion plan that includes the Blue Nile dam with electric generation capacity of 5,250MW, sufficient for domestic use as well as for export. It also plans to expand the biofuel, wind and solar energy sector.

GTP Targets for the Energy Sub-Sector

Description of Targets	2009/10	2014/15
1. Hydroelectric power generating capacity (MW)	2,000	**10,000**
2. Total length of distribution lines (Km)	126,038	258,000
3. Total length of rehabilitated distribution lines (Km)	450	8,130
4. Reduce power wastage (%)	11.5	5.6
5. Number of consumers with access to electricity	2,000,000	4,000,000
6. Coverage of electricity services (%)	41	75
7. Total underground power distribution system (Km)	97	150

These ambitious plans alone still fall short to meet the energy demand of the country any time soon. Besides the fact that the rate of electrification is one of the lowest in Sub-Sahara Africa (6% direct connection), the vastness of the country and the rugged topography coupled with the scattered settlement of residential areas makes grid-based electrification too costly. With this realisation, the government has set up institutional and financing (Rural Electrification Fund) frameworks to facilitate and accelerate off-grid rural electrification particularly through solar PV and mini/micro hydropower development in the country. The Rural Electrification Fund (REF) provides concessional loans to diesel (85% loan with an interest rate of 7.5%) and renewable energy projects (95% loan with zero interest rate). In order to favourably promote the renewable energy projects, REF provides 20-30% capital subsidy of the investment costs to project developers on a reimbursement basis. REF has distributed solar PV systems to 100 rural schools, 200 health facilities, and 600 households.

Source: Power and Shanko, 2009 and EEPCo, 2010

Role of grid access, power purchase agreements, feed-in tariffs and collaborative financing in carbon mitigating energy development.

Subsidies and Tariffs in Uganda
Kakira Cogeneration Grid connected IPP

The project, which is part of the Kakira Sugar Works overall expansion plan, is expected to generate 19MW of electricity through cogeneration using bagasse. Out of the power generated, 7 MW will be used by the factory and the surplus 12 MW will be exported to the national grid.

The project received a refinancing facility of US$8.6 million administered by the Bank of Uganda and a subsidy of US$3.3 million from the Rural Electrification Agency, both under the Energy for Rural Transformation Programme. The project is now substantially complete feeding 12 MW to the national grid. The Power Purchase Agreement states that Uganda Electricity Transmission Company Limited (UETCL) will buy the first 6 MW at 4.9 US cents per kWh (because of the subsidy) and the rest at 6.15 US cents per kWh. This project shows the importance of public Private Partnerships with feed-in tariffs for promoting renewables.

Source: UNIDO, 2009

Roles of grid access, energy pricing and revenue sharing arrangements for cogeneration opportunities.

Tariffs and Stakeholder Participation in Mauritius

About 30% of Mauritius' electricity generation capacity is reliant on sugar cane factories. In 1998, the sugar industry exported 195 GWh of excess electricity, nearly 14% of the national power production. The annual sugar production is 600,000 tons with 1.8 million tons of bagasse available principally for electricity generation. To ensure that all stakeholders benefited from the sale of electricity to the grid, the Government established a bagasse transfer price fund and the Sugar Investment Trust, which ensured that the revenues from the cogeneration is equitably shared by all stakeholders. The key lessons are i) the need for clear policies to promote cogeneration, ii) the need to involve local entrepreneurs in IPP initiatives (whereas elsewhere IPPs are foreign owned greenfield projects), iii) the consultation of all the relevant stakeholders to ensure consensus on an equitable revenue sharing mechanism.

Source: UNIDO, 2009

Role of sustained and consistent policies and public sector support in cleaner fuel adoption.

Efforts that did not work

Zimbabwe - Blending programmes existed in Zimbabwe from 1982-1992. Annual ethanol production in Zimbabwe is 25 million liters on average. Zimbabwe initially set blending target at 13-18%. Factors such as public-private partnership, clear pricing policy, and well-planned implementation strategy contributed to the earlier success of Zimbabwe's ethanol program. The policy was terminated when drought reduced feedstock drastically in 1992. Economic reforms favored export of ethanol instead of domestic consumption.

Kenya- Similarly annual ethanol production reached 15 million liters and blending target was set at 10%. The Kenya ethanol program, which was known as the Madhvani project, had a costly design and poor management that caused losses due to uncompetitive pricing. External factors such as resistance from oil companies and loan servicing burden also contributed to the discontinuity of blending target in 1993. Ethanol is only exported at the moment.

Lessons

In both cases, the failed blending attempts indicate that clear, consistent and sustained policies are crucial and government support is indispensable. Close public-private partnership and capital and pricing incentives are necessary to promote the biofuel sector. Securing feed availability is fundamental in avoiding competition between the two. Overall, biofuel projects, as are other renewable energy promoting projects, have to be comprehensive and policy coherent.

Sources: Batidzirai (2007); UNIDO, 2009

5. INTEGRATING RENEWABLE ENERGY AND CLIMATE CHANGE POLICIES IN AFRICA - POLICY RECOMMENDATIONS

As African governments seek to develop their energy sector, renewable energy technologies offer significant long-term advantages by providing grid and off-grid options. The following recommendations and policy opportunities offer climate change policymakers a valuable platform to integrate polices aimed at expanding energy access in Africa sustainably.

Recommendation #1: Establish clear, consistent and achievable targets for energy development and environmental stewardship.

> Presence of clear and consistent energy policy that sets a target for share of renewables into the future is an essential first step. Without such policy mandates, renewable energy development is likely to be patchy. Even though setting and implementing renewable energy targets itself will have environmental benefits, setting clear targets on environmental goals will also open opportunities for policy synergies. Stakeholder participation in the process of determining overarching policy goals as well as specific targets can be important for acceptance and legitimacy, which in turn is conducive to fulfilment of goals and targets.

Recommendation #2: Design and implement a broad range of renewable energy development-inducing policies and demonstrate GHG mitigation outcomes.

> The implementation of fiscal policies to promote renewable energy development in some African countries is encouraging. It is also encouraging that many countries have formulated targets. This shows that there is wide spread recognition of the benefits and opportunities associated with renewable energy development, and that the time is ripe for development and implementation of such policies. Utilising a broad range of policies that will enhance the development of clean energy should be considered. Demonstrating the GHG mitigation outcomes is important and useful particularly in the global context if carbon becomes properly priced.

Recommendation #3: Engage in regional and continental initiatives to establish a climate change policy vision for Africa and enable the energy sector to meet some policy targets.

> In the current global climate change negotiations, there seems to be no clear GHG mitigation targets agreed-to by African countries. While Africa contributes a fraction of global emissions, it remains to be vulnerable to climate change. Establishing regional and continental goals can help shape the development path of countries towards sustainability. Enabling the energy sector to shift to cleaner generation sources can help position African countries in capitalising on future climate policy-induced opportunities, especially if they lead to monetisation. Visions and roadmaps can be important strategising and learning tools. Such longer-term visions should be linked to short-term priorities and implementation strategies for greater impact.

Recommendation #4: Encourage small-scale renewable energy adoption and leverage scaling-up opportunities offered by energy technologies.

The low level of energy access in Africa will require significant attention to be paid to solving the energy access problem. For the majority of population with limited grid access, small-scale technologies can offer feasible solutions to provide modern energy services. Energy technologies that rely on wind, solar and biomass resources are increasingly attractive alternatives. Large-scale application potential of these will need to be considered, and if feasible, should be encouraged through supportive policies.

Recommendation #5: Create conducive environments for public-private partnerships in clean energy development.

Private sector engagement will accelerate energy development by mitigating public finance shortfalls and encouraging deployment of energy technologies. Energy governance and institutional efficacy will matter. So will public education about uncertainty and risk related to lack of familiarity with renewable energy technologies. By inviting private sector participation, adoption of renewable technologies can be enhanced, in an overall effort to foster new technologies and markets.

Recommendation #6: Encourage the establishment of global carbon trading to attract resources for mitigation efforts in Africa.

One of the significant opportunities for Africa is receiving a price for its current low carbon contribution and its potential future clean energy contribution. Instituting a global emissions management system will award carbon credits to African countries. Though the details of how carbon markets work are complex, the ability of markets to price and communicate price signals for GHG emissions will serve best in effectively integrating climate policy goals with that of the ability of the energy sector to deliver on mitigating incremental emissions. Carbon markets can monetise carbon mitigation and help raise funds for further clean energy development initiatives.

Recommendation #7: Utilise existing international policy frameworks and funding sources to promote renewable energy development.

Already existing policies such as the Clean Development Mechanism (CDM) aim at stimulating sustainable development in developing countries. Africa can request climate adaptation funds to be deployed to renewable energy development. A strategic approach that links renewable energy development goals with measurable enhancements to GHG reductions could help access CDM funds.

Recommendation #8: Recognise the potential impacts of climate change on energy security, and implement energy portfolio diversification strategies.

Even in countries with large share of current energy supply coming from renewable sources such as hydropower, climate change introduces energy supply risks in the future. Variability of water volumes can be a significant problem. A diversified energy development strategy will offer solid foundation for enhancing energy security, and simultaneously serve as an adaptation strategy to the potential impacts of climate change on energy generation. Reduced dependence on imported fossil fuels, oil in particular, is an important aspect of energy security.

Recommendation #9: Recognise the interdependencies among broader access to clean energy services, climate change mitigation (and adaptation) and social development. Action needs to be taken to enhance policy coherence and integration in these related fields.

Policies that treat energy, climate change and sustainable development separately are unlikely to fully leverage synergies offered by their interplay. If there will be a global consensus around a climate change target, these relationships are even more pronounced. Policymakers in Africa should evaluate their current policies and innovatively integrate and harmonise cross-sectoral policies. Similarly, sustainable development efforts can integrate clean energy access as part of the development strategy for urban and rural Africa. These efforts can also be meaningful at the regional level where efforts to expand energy access can be advanced by harmonising with regional climate change adaptation goals, while social development programs can benefit from co-development of clean energy.

There will remain to be numerous challenges to effectively tackle Africa's energy problem. Climate change-related impacts will also continue to pose serious risks to social development that is taking root. However, Africa's policymakers have a wide array of policy options and effective instruments to pursue a coherent and integrative energy and climate change policies that can start to point in the right direction. Renewable energy technologies such as bioenergy, waste/biogas, wind energy, solar energy, wave and tidal energy, geothermal and hydro power are increasingly competitive alternatives, but will need to be leveraged innovatively with other broader societal goals.

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