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FOSSIL FUELS IN AFRICA IN THE CONTEXT OF A CARBON CONSTRAINED FUTURE

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LIST OF ACRONYMS

AfDB	African Development Bank
APF	Africa Partnership Forum
AR4	Fourth Assessment Report of the IPCC
BP	British Petroleum
CCGT	Combined Cycle Gas Turbines
CCS	Carbon Capture and Storage
CCTs	Clean Coal Technologies
CDM	Clean Development Mechanism
CHP	Combined Heat and Power
CIA	Central Intelligence Agency
CO_2	Carbon Dioxide
DFID	U.K. Department for International Development,
DRC	Democratic Republic of Congo
DRFN	Desert Research Foundation of Namibia
EAC	East African Community
EIA	U.S. Energy Information Administration
FBC	Fluidised Bed Combustion
FITs	Feed-in-tariffs
GDP	Gross Domestic Product
GHG	Greenhouse gas
IEA	International Energy Agency
IGCC	Integrated Gasification Combined Cycle
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt Hours
MDGs	Millennium Development Goals
MW	Megawatt
NEET	Networks of Expertise in Energy Technology
NREL	National Renewable Energy Laboratory, US
OECD	Organisation for Economic Co-operation and Development
OFID	OPEC Fund for International Development
PCC	Pulverised Coal Combustion
PFBC	Pressurised Fluidised Bed Combustion
PV	Photovoltaic
R&D	Research and Development
REN21	Renewable Energy Policy Network for the 21st Century
RPS	Renewable Portfolio Standards
SHP	Small-scale Hydropower
TWh	Terawatt hours
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organisation
WCA	World Coal Association
WEC	World Energy Council

WGA	Western Governor’s Association
WHO	World Health Organisation
WWEA	World Wind Energy Association

ABSTRACT

Africa has considerable reserves of fossil fuels of all kinds: oil, coal, and natural gas. Much of this resource is either utilised outside Africa or has not yet been developed for use within the continent. However, given increasing concerns to limit carbon emissions in developing Africa's energy resource potential, it is important to explore the resource and technical challenges and opportunities associated with expanding the use of fossil fuels in Africa. This paper reviews the existing reserves and geographical distribution of fossil fuels across Africa, examines technical options for decarbonisation, and provides recommendations for policies that would enable fossil fuel resources to be used for Africa's development while ensuring the minimisation of greenhouse gas emissions.

1. INTRODUCTION

Fossil fuels (crude oil, natural gas, and coal) are important energy sources that play vital roles in the economies of virtually all countries. Africa has substantial reserves of fossil fuel resources. These include about 9.5 percent of the total global proven reserves of crude oil, 8 percent of natural gas reserves, and 4 percent of coal reserves (BP, 2011). Fossil fuels account for about 50 percent of the total primary energy supply and one-third of energy consumption (excluding their contribution to electricity generation) of Africa (IEA, 2011a). According to the same source, over 80 percent of the electricity generated in Africa is also derived from fossil fuels. These energy resources are a major source of revenue for the oil and gas producing countries in Africa, accounting for 50-80 percent of government revenues in these countries (Zalik and Watts, 2006). Thus, oil exports account for about 80 percent of government revenues in Libya, Nigeria, and Angola while natural gas exports account for about 60 percent of revenues in Algeria (CIA, 2011). These figures suggest that a huge amount of the fossil fuels produced in Africa is consumed elsewhere.

More strikingly, despite its huge energy resources, Africa is still faced with enormous energy challenges, including low access by many to modern energy, insufficient energy infrastructure, low efficiency, and lack of institutional and technical capacity to use these huge resources. For example, only about 31 percent of the people of Sub-Saharan Africa have access to electricity. About 60 percent have access in urban areas, but only some 14 percent have access in rural areas (IEA, 2011a). In addition, traditional biomass dominates energy consumption in the region, accounting for about 50 percent of the total energy supply in 2008 (IEA, 2011a). These energy challenges have hampered economic growth and contributed to poverty in Africa. Despite the challenges, Africa's large fossil fuel reserves provide it with important opportunities to improve access to energy, accelerate economic growth, and reduce poverty.

The heavy reliance on fossil fuels to generate energy, however, has contributed to a number of environmental and social problems at the local, regional, and global levels. These include depletion of non-renewable resources, depletion of ozone, ocean acidification, and global warming. The contribution of energy generation to global warming is particularly worrisome due to the emissions of carbon dioxide (CO_2) and other greenhouse gases (GHGs) during the combustion of fossil fuels. According to the IEA (2010a), the burning of fossil fuels for energy accounted for about 65 percent of global GHG emissions in 2008. Given that GHG emissions have been shown to contribute to global warming, the continuation of emission trends is alarming.

The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) (2007a) suggests global GHG emissions must be reduced by 50-80 percent (compared to 1990 levels) in order to limit the average global temperature increase to 2°C above pre-industrial levels by 2050. This implies that the use of fossil fuels is likely to be restrained in the future and that more attention will be given to less polluting energy sources. Although Africa accounts for less than 4 percent of global GHG emissions (APF, 2007; World Bank, 2009), it is the most vulnerable region to the impacts of global climate change. The continent is highly vulnerable to increased climate-related 'shocks,' such as droughts, flooding, and extreme temperatures. Africa's vulnerability has enormous implications for key sectors, including agriculture and food security, water supply, health care, energy, and regional security, and biodiversity (Boko, et al., 2007; Conway, 2009; DFID, 2004; World Bank, 2009). Its vulnerability to climate change will threaten achievement of the Millennium Development Goals (MDGs) and the socio-economic development of the continent. Africa thus has twin challenges. The first is to use its huge amount of fossil fuel resources to improve energy access and increase economic growth, both vital to sustainable development. The second is to mitigate emissions from the consumption of these resources. The future use of fossil fuels in Africa will necessarily need to occur in a way that minimizes GHG emissions.

This paper explores the impacts related to fossil fuel development in Africa and the challenges and opportunities that exist for developing low-carbon-emitting fossil fuel technologies. Section 2 reviews reserves, production and consumption of fossil fuels, and GHG emissions. Section 3 examines the technical and policy options that could help mainstream fossil fuel use into Africa's future energy mix via a low carbon pathway. Section 4 focuses on the policy, institutional, and financial challenges to implementing these options. And, Section 5 discusses the implications for energy policy and provides some conclusions.

2. FOSSIL FUEL PRODUCTION AND USE AND ASSOCIATED GHG EMISSIONS IN AFRICA

With the increasing turmoil in the Middle East, the importance of Africa as a source of energy for the US and Western Europe has grown considerably. Fossil fuels are a major source of revenue for the leading oil and gas producing countries in Africa. For example, crude oil accounts for over 90 percent of foreign exchange earnings in Nigeria, and the hydrocarbon sector accounts for about 35 percent of Algeria's GDP (CIA, 2011).

2.1. Fossil fuel reserves in Africa

Table 1 shows the reserves of fossil fuels and their distribution in Africa. Over 80 percent and 90 percent of the oil and natural gas reserves, respectively, are found in northern and western Africa. Libya accounts for over 70 percent of the oil reserves in North Africa, and Algeria accounts for about 55 percent of natural gas reserves in the same region. Nigeria accounts for almost all the oil and natural gas reserves in West Africa. This uneven distribution of energy resources in Africa is amplified by the fact that South Africa accounts for about 95 percent of its coal reserves (EIA, 2011).

Table 1. Fossil fuel reserves in Africa

Energy Type	Reserves	Regional distribution
Crude oil	132.1 billion barrels	Northern Africa: 53.2% Western Africa: 28.2% Central Africa: 16.9% Other Africa: 1.7%
Natural gas	14.7 trillion m^3	Northern Africa: 55.8% Western Africa: 36.1% Other Africa: 8.2%
Coal	31,696 billion tonnes	Southern Africa: 95.2% Eastern Africa:1.6% Other Africa: 3.2%

Source: BP (2011)

There is, however, a more optimistic side to this state of affairs. The proven crude oil reserves in Africa are increasing. They have increased from 58.7 billion barrels in 1990 to 132.1 billion barrels in 2010 (BP, 2011). The recent increases in crude oil prices have made it more economical to explore and develop 'marginal' deposits. Today, exploration is taking place in many regions in Africa, and countries such as Ghana, Uganda, and Chad have already started drilling activities.

2.2. African fossil fuel production, consumption, and export patterns

The trends in African oil production and consumption are shown in Figure 1. The generally upward trend in Africa's share of global oil production is clear since the 1980s, while Africa's share in global oil consumption has been increasing steadily since the early 1960s. A comparison of oil consumption in barrels per day across continents in 1965 shows that Africa consumed about 530,000 thousand barrels compared with 3.25 million in Asia, almost 12 million in Europe, and some 13 million in North America (BP, 2011). Between 1965 and 1985, Africa's oil consumption tripled to 1.7 million barrels per day and reached 3.2 million barrels per day in 2010. Oil consumption in North America was nine times that of Africa in 2005 but declined to seven times in 2010, although this largely due to the financial crisis that shrunk the economies of North America and Europe.

One feature that is characteristic of the fossil fuel situation in Africa is the gap between consumption and production. Africa's share of global consumption in 2010 was only 3.7 percent compared to its share of production of about 12.4 percent (see Figure 1). Production has remained between 10.4 and 12.3 percent as a proportion of total production, while consumption across Africa was still less than 4 percent of global consumption in 2010. Another paradox in this picture is that most African countries are net energy importers, as currently exploited oil reserves are concentrated in only a few countries. As a consequence, the continent has 38 net oil-importing countries, demonstrating the high dependence of most African economies on imported fossil fuels. This exposes them to volatile world oil prices and jeopardises their balance of payments positions. For most oil-importing countries in Africa, sharp increases in the cost of imported energy, coupled with increasingly scarce traditional energy resources (e.g., fuel wood), have created what has been termed a double energy squeeze. The squeeze has eroded some of the economic gains that have been made in recent years and has exerted strong pressure on macroeconomic stability and economic growth.

Of the total production of crude oil in Africa, Nigeria, Libya, and Angola account for over 75 percent. Well over 70 percent of the crude oil produced in Africa is exported (EIA, 2011). Thus, about 8 million of the 10.6 million barrels of daily production in 2009 were exported (see Figure 2). During the same year, about 915 thousand barrels per day was imported to Africa (South Africa accounted for almost 50 percent of these imports). One explanation for this is the limited refining capacity across the continent, which stands at just over 3 million barrels day (EAC, 2008). Thus, a majority of African countries (including the oil producers) are net importers of petroleum products. Over 1 million barrels per day of petroleum products were imported to Africa in 2007 (EIA, 2011).

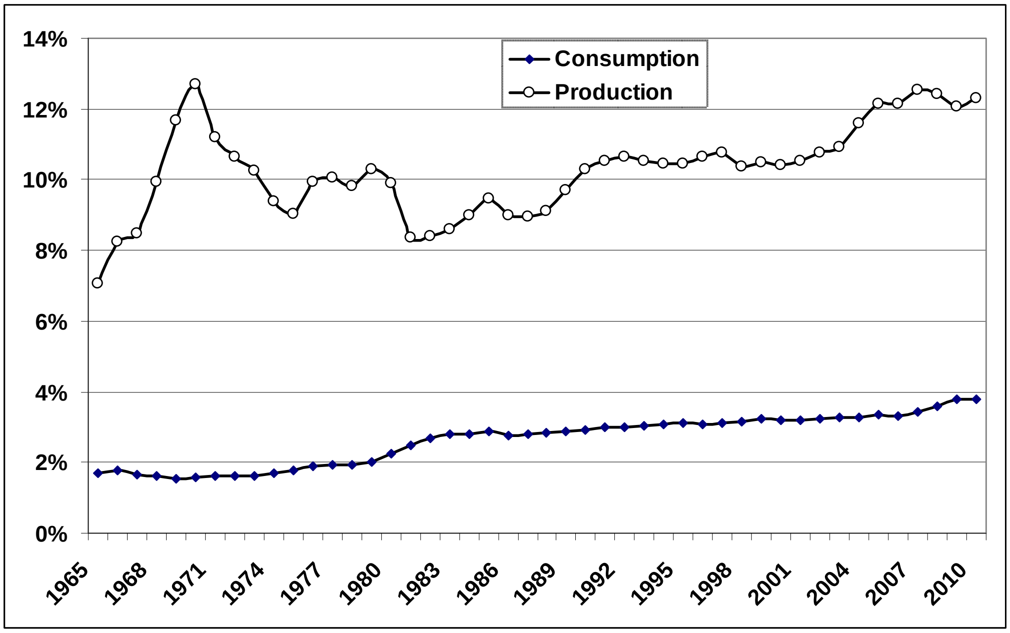

Figure 1. Africa's share in world oil production and consumption 1965-2010

Source: BP (2011)

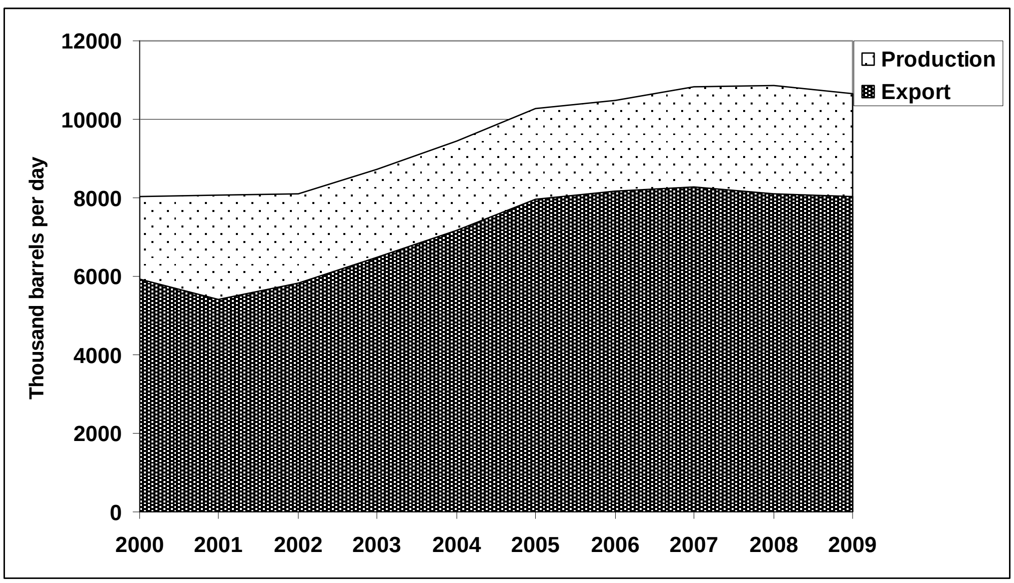

Figure 2. Production and exports of crude oil in Africa 2000 - 2009

Source: EIA (2011)

The production of dry natural gas in Africa increased by over 60 percent between 2000 and 2009 (see Figure 3). Algeria and Egypt have accounted for 40 percent and 30 percent, respectively, of the total production of natural gas in Africa, and, as with crude oil, over 55 percent of the dry natural gas produced in Africa is exported (EIA, 2011). According to the IEA (2011a), coal production in Africa reached 262 million tonnes in 2008 (representing about 4 percent of global production). About 23 percent of this amount was exported, suggesting that this resource is mostly used within the continent. An increasing share of these resources will likely be earmarked for generating electricity in Africa, as demand for electricity is increasing.

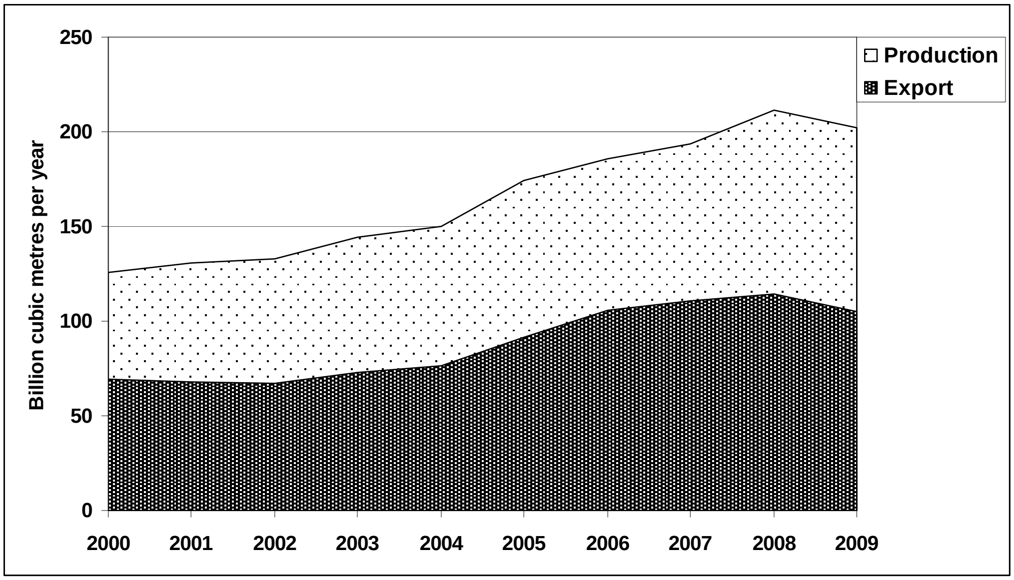

Figure 3. Production and exports of dry natural gas in Africa 2000-2009

Source: EIA (2011)

Africa will continue to play a significant role in the world energy market. Development of oil and gas resources is central to the economic growth of many African countries. Europe and China are currently the main partners for Africa. It is now evident that China has turned to Africa to meet its increasing demand for energy for economic growth. As a result, about one-third of its total oil imports come from Africa (Jiang and Sinton, 2011). Algeria, Egypt, Equatorial Guinea, Libya, Mozambique, and Nigeria are net exporters of gas (AfDB, 2010). The export of refined petroleum products peaked at almost 1.5 million barrels per day in 2001 but then declined to about 900 thousand barrels per day in 2008 (see Figure 4). These exports are mostly dominated by North African countries, with Algeria alone accounting for about 50 percent of the exports in 2008 (EIA, 2011). However, the volatility of oil and gas prices, social and political conflicts, and poor management have significantly reduced gains from export revenue in most of these countries. These countries would benefit by diversifying their revenue bases in order to reduce dependence on single commodities (AfDB, 2010).

The industrial and transport sectors are the largest consumers of fossil fuels in Africa[1] (see Figure 5). The industrial sector accounts for about 55 percent of the coal and natural gas consumed, while the transport sector accounts for over 60 percent of crude oil consumption. Fossil fuels account for about 82 percent of total electricity generation, of which 41 percent is supplied by coal and 28 percent by natural gas (see Figure 5).

[1] This analysis does not include consumption in the electricity sector

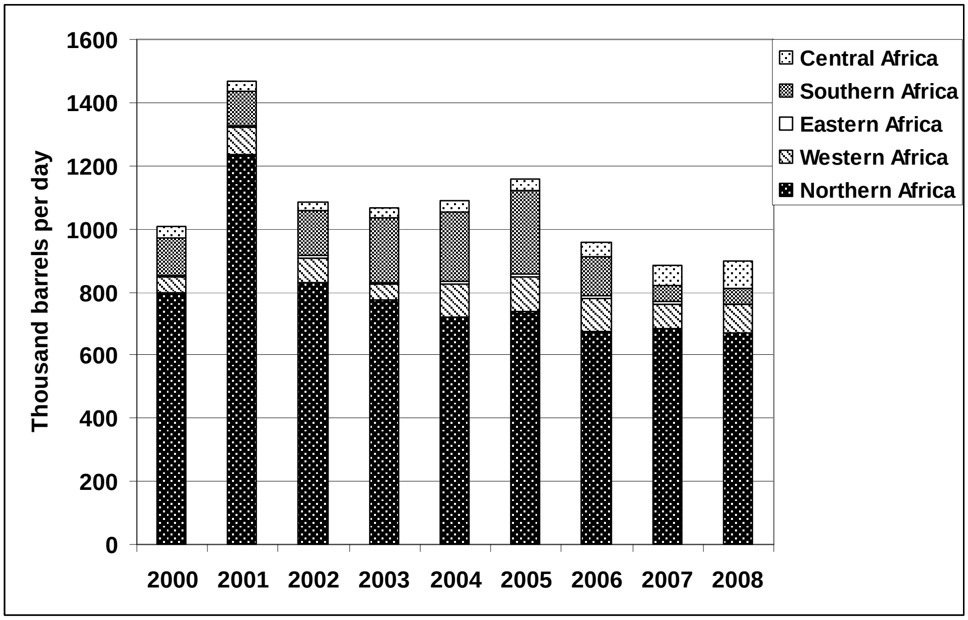

Figure 4. Share of exports of refined petroleum products per region 2000-2007

Source: EIA (2011)

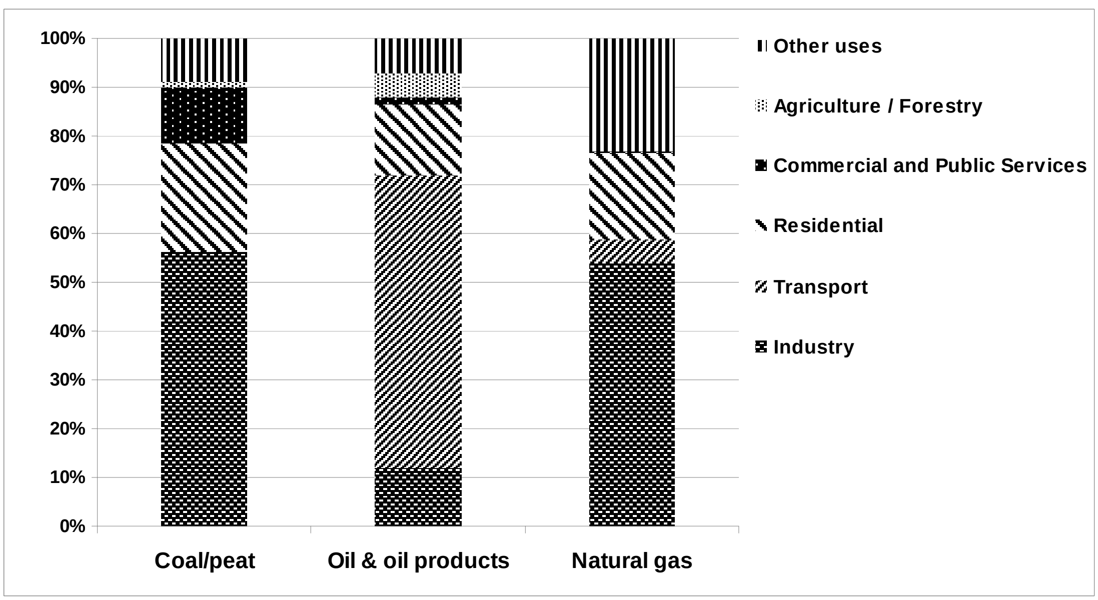

Figure 5. Sectoral consumption of fossil fuels in 2008

Source: IEA (2011a)

2.3. The role of fossil fuels in GHG emissions

Africa emits relatively low amounts of GHG emissions in comparison to other regions, and it has very low CO_2 emissions per capita. It accounted for only about 3.7 percent of the global CO_2 emissions from the consumption of energy in 2009 (EIA, 2011). Total CO_2 emissions in Africa increased by 26 percent between 2000 and 2009, reaching about 1.12 billion tonnes of CO_2 in 2009 (see Figure 6). Much of this increase can be attributed to a combination of higher growth across the continent, which has been driven largely by the construction and industrial sectors. This trend is not unique to Africa. Increases in GDP and increases in energy consumption have often followed parallel paths in in Europe and North America and, more recently, in Asia. Consumption of petroleum accounted for 40 percent of CO_2 emissions, followed by coal, natural gas, and gas flaring at 35, 18.4, and 6.3 percent, respectively. A small number of countries in Africa are largely responsible for these emissions. Six countries, including Algeria, Egypt, Libya, Morocco, Nigeria, and South Africa accounted for over 70 percent of CO_2 emissions from the consumption of petroleum, while Algeria and Egypt accounted for about 71 percent of the CO_2 emissions from the consumption of natural gas in 2009. South Africa accounted for over 92 percent of CO_2 emissions from coal consumption in the same year. Africa also accounted for about 31 percent of global CO_2 emissions from gas flaring. Nigeria accounted for the most, as it contributed about 36 percent of CO_2 emissions from flaring in Africa and 11.4 percent globally (EIA, 2011).

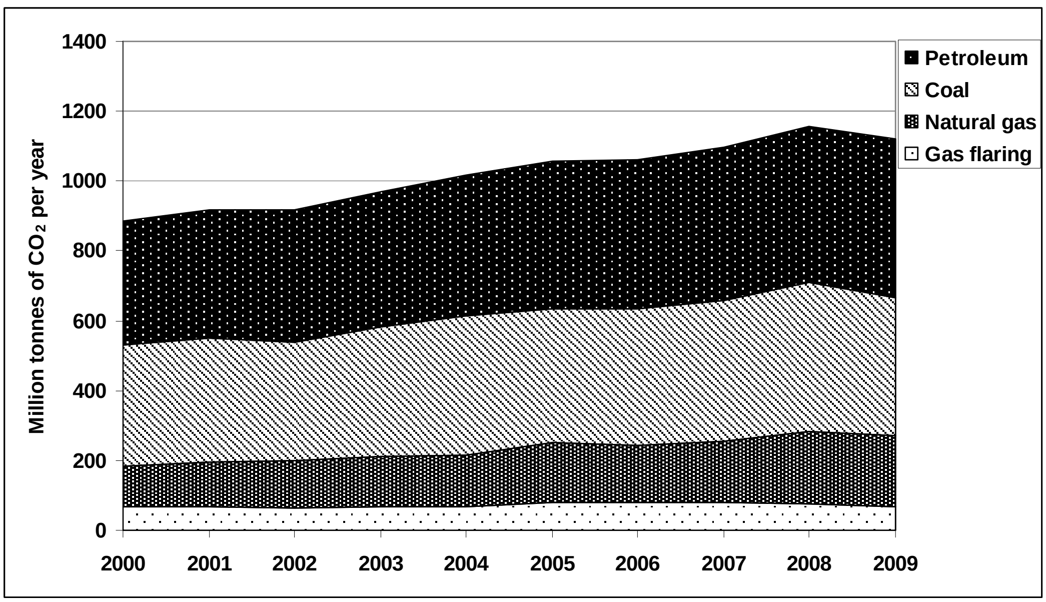

Figure 6 CO_2 emissions from the consumption of fossil fuels in Africa 2000 - 2009

Source: EIA (2011)

3. AFRICA'S OPTIONS IN A CARBON CONSTRAINED WORLD

3.1. Role of renewable energy sources

Renewable energy accounted for about 16 percent globally of final energy consumption in 2010 and about 50 percent of *new* electricity generation capacity (REN21, 2011). Recently, renewable energy has gained attention in Africa for several reasons. First, the high volatility, but generally increasing, prices of fossil fuels, especially oil, has meant that shifting to other energy sources is desirable for energy security. Moreover, the increasing prices of fossil fuels and the costs of grid extension are also making the prices of some renewable energy technologies more competitive under certain conditions. Second, there is a growing demand for energy in the region, and renewable energy systems (especially small-scale ones, given their availability and modularity) offer cost-effective options to provide off-grid energy supplies to isolated and remote areas. Third, fossil fuels are a major source of anthropogenic GHG emissions, but renewables are seen as an important option for mitigating or avoiding them. Finally, Africa has a large potential for developing its substantial renewable energy resources, which include hydropower, biomass, solar, wind, and geothermal energy.

The potential for hydropower in Africa is estimated at 1,834 TWh/yr. This potential is mostly concentrated in central Africa (57 percent) and eastern Africa (32 percent). The Democratic Republic of the Congo (DRC) alone accounts for about 42 percent of the hydropower potential in Africa (WEC, 2010). Hydropower already accounts for about 16 percent of the electricity generation in Africa (IEA, 2011a) and supplies over 50 percent of the electricity consumed in 23 African countries (UNIDO, 2009). However, only about 7 percent of the hydropower potential in Africa is currently being utilised (WEC, 2010). The incentive to develop the huge potential is high. While large-scale hydropower could be harnessed to provide modern energy for development and urban areas, small-scale hydropower systems (SHPs) could also be used to provide electricity to rural areas.

The potential for biomass resources (woody biomass) is estimated at over 70 billion tonnes (Parikka, 2004), and this resource is available in all regions. Biomass is the most used energy resource in the continent, accounting for about 50 percent of Africa's total primary energy supply. However, current consumption of biomass is unsustainable, as some 654 million people, most of them in rural areas, rely on traditional biomass for cooking. (IEA, 2010b). Unsustainable consumption has exacerbated environmental and health problems. For example, more than 400,000 people in Africa die each year due to indoor pollution caused by the burning of biomass for cooking. Most of the casualties are women and children (WHO, 2009). However, the potential is sizeable for deploying modern, more efficient biomass fuels and technologies, such as biogas and improved cooking stoves, in the household sector. Biogas could also be used for power generation and transport. Bioenergy in the form of bio-ethanol and biodiesel could also serve as substitutes for petroleum products in the transport sector.

Africa also has enormous potential to benefit from solar energy, which is available in all regions. Solar insolation in Africa is estimated at from 1800-2850 kWh/m^2 per annum (WEC, 2010). The US National Renewable Energy Laboratory (NREL) estimates the photovoltaic (PV) technical potential in Africa at up to 8,700 TWh per annum and concentrating solar power potential of as much as 40,500 TWh per annum (NREL, 2008). With electricity consumption in Africa of only about 500 TWh in 2008 (EIA, 2011), realization of the solar energy potential could meet the electricity demand multiple times. However, despite the high potential for solar energy in Africa, especially in desert areas like the Sahara and Namibia, only South Africa operates a solar thermal power plant so far. This plant has a generating capacity of 0.5 MW (UNIDO, 2009). Cost is considered as the major factor limiting large-scale development of solar energy projects in Africa.

Wind energy could also play a significant role in diversifying the energy sector in Africa, given wind speeds of 6-7 meters/second (m/s) in southern Africa (DRFN, 2010) and 5-8.5 m/s in northern Africa (Business Insights, 2010). There are currently about 1,000 MW of installed wind power capacity in Africa, 96 percent of which is concentrated in northern Africa (mainly Egypt, Morocco, and Tunisia) (WWEA, 2011). The potential of geothermal energy is estimated at about 14,000 MW (WEC, 2010), with opportunities for developing this resource mostly concentrated in western Africa. Currently, about 172 MW have been installed, about 95 percent of which is in Kenya (WEC, 2010).

Renewable energy systems could be deployed in the form of large- or small-scale systems for electricity, heating, mechanical power, and other applications. Large-scale renewable energy systems could help to diversify energy supplies, reduce energy imports, and help in mitigating climate change at the local and global levels. Large-scale renewable energy systems are usually connected to a grid and thus are normally funded through public funds (i.e., national budgets). Small-scale renewable energy is usually used in off-grid applications and stand-alone systems. These aim to increase access to modern energy in areas that are too far from the grid or that are too costly to connect to it.

Many African countries have a huge potential for developing SHP, which is typically a low cost option and which gives the private sector opportunities to participate. Stand-alone modular systems, such as solar PV and wind pumps, could also provide the mechanical power needed in isolated communities.

3.2. The role of cleaner fossil fuel technologies

A major share of the increased concentration of CO_2 and other GHGs in the atmosphere is attributed to the production and consumption of fossil fuels. According to the IPCC (2007b), the burning of fossil fuels and small contributions from cement manufacture have been responsible for over 75 percent of the increased atmospheric concentrations of anthropogenic CO_2 since pre-industrial times. The burning of fossil fuels in the electricity, transport, and industrial sectors accounted for 41 percent, 23 percent, and 20 percent, respectively of total global CO_2 emissions in 2009 (IEA, 2011b). About 43 percent of CO_2 emissions from fuel combustion were produced from coal, while oil contributed 37 percent and gas accounted for 20 percent in 2009 (IEA,2011b). About 42 percent of the world's electricity was generated with coal, the most carbon-intensive fossil fuel source (WCA, 2011). Dependency on coal for electricity generation is even higher in developing countries and in economies in transition. (China is 79 percent dependent, India 69 percent, Poland 90 percent, South Africa 93 percent, and Kazakhstan 70 percent) (WCA, 2011).

Trends in fossil fuel consumption, especially in developing countries, are likely to continue in the short- to medium-term for reasons including resource availability, low technical capacity, the high costs of many clean energy technologies, and the imperative of increasing modern energy access to satisfy increasing demand. Thus, the use of cleaner fossil fuel technologies will be critical if GHG emissions are to be reduced. For example, the IEA (2011b) suggests that the use of carbon capture and storage (CCS) technologies will curb CO_2 emissions from the intensified use of coal.

The imperatives of improving energy access and of alleviating poverty in Africa suggest that expansion of fossil fuel supplies will be necessary in the short- to medium-term. But such expansion should be balanced with measures to develop cleaner energy solutions for the future. Therefore, focusing on technologies that improve energy efficiency and energy conservation is the best strategy to reduce GHG emissions from the combustion of fossil fuels. Shifting to new renewable energy technologies is appropriate in the longer-term, but such a shift will take time, and some challenging barriers, such as high initial costs, lack of technical expertise, and institutional constraints, will need to be overcome. It makes good financial sense to seek maximum efficiency gains as the first step. However, given that fossil fuels will continue to dominate energy supplies in the short- to medium-term, attention needs to be given to cleaner fossil fuel technologies if GHG emissions are to be reduced.

Clean coal technologies (CCTs) offer opportunities to reduce GHGs and other pollutants from the combustion of coal. The IEA (2008a) identifies four groups of CCTs, including coal upgrading technologies, improvements in existing power plants, use of advanced technologies, and near-zero emission technologies. Coal upgrading technologies involve treating coal before combustion to improve characteristics such as its moisture content. This increases combustion efficiency and reduces emissions during combustion. The technology can reduce CO_2 emissions by up to 5 percent (IEA, 2008a). Improving the efficiency of existing coal-fired power plants helps reduce the amount of coal burned and thus the amount of CO_2 emitted. It is one of the least expensive ways to modestly reduce CO_2 emissions, although new equipment is needed (WGA, 2008). CO_2 emission reduction of up to 22 percent may be achieved (IEA, 2008a). Advanced coal technologies can be used to reduce sulphur dioxide and nitrous oxides in addition to reducing CO_2. Advanced technologies include integrated gasification combined cycle (IGCC) technology, pulverized coal combustion (PCC) using sub-critical and super-critical steam, pressurised fluidised bed combustion (PFBC), and fluidised bed combustion (FBC) using bubbling and circulating FBC beds. Near-zero emission technologies, such as CCS, may achieve CO_2 emission reductions of up to 99 percent (IEA, 2008a). However, CCS is in the early stages of development and is not ready for commercial use. Sizable investments in CCS R&D are being made, so there is some promise of a technical breakthrough. Since the CO_2 captured is typically stored deep underground or under the ocean floor, concerns exist about leakage and other environmental problems.

Other advanced fossil fuel technologies that could be used to reduce CO_2 emissions from electricity generation include combined cycle gas turbines (CCGT), co-firing systems (e.g., combining coal with other fuels such as biomass), and combined heat and power (CHP) systems (using coal, oil or gas). The deployment of advanced fossil fuel technologies, however, is limited in developing countries, and in Africa in particular, due to high capital and operating costs. Other barriers include lack of experience with the new technologies, lack of incentives and regulations from the government, and higher operational costs (Anastassia, et al., 2009).

GHG reduction measures need not be solely concentrated on technologies. Inter-fuel substitution and fuel switching strategies could also useful. Inter-fuel substitution and fuel switching in Africa will be particularly important in the electricity, household, industrial, and transport sectors. For example, natural gas is a cleaner alternative to coal or oil given its much lower CO_2 emissions per unit of energy. Thus, coal power plants emit about 1 kg of CO_2 per kWh of electricity while natural gas plants emit only about 40 percent of this amount (0.4 kg) (Levine, et al., 2010). The potential is large for using natural gas in Africa. A strategy for the transportation sector to reduce GHG emissions, in addition to fuel switching, is to improve traffic management and vehicle maintenance, increase vehicle efficiency, and shift to different modes of transportation.

4. POLICY, INSTITUTIONAL, AND FINANCIAL CHALLENGES

4.1. Policy instruments

A number of policy instruments could be used to mitigate the emissions of greenhouse gases produced by the production and use of fossil fuels. These include emission taxes, targeted subsidies or their removal as appropriate, product charges, regulation, emissions trading, and provision of information.

a. Taxes

Economic incentives, such as taxes and subsidies, can, in principle, be used to change the behaviour of polluters. Thus, taxes could be used to discourage emissions of GHGs from fossil fuel use. However, the inadequate regulatory environment in many African countries could make the imposition of taxes on GHG emissions difficult. Moreover, African countries are not required by international agreements to reduce GHG emissions due to their low emissions. Therefore, the scope for imposing taxes is limited. Nevertheless, a number of African countries already impose taxes on fossil fuel consumption. Other instruments, such as tariffs, import duties, and taxes on vehicles or equipment that use fossil fuels could also reduce consumption.

b. Subsidies

Subsidies could also be used to reduce GHG emissions. For example, governments could subsidize companies using low-emission technologies so that any additional costs incurred by using these technologies would be refunded. Because of limited financial resources, however, most African countries would find this option difficult and would no doubt have different priorities for the use of scarce resources.

Some subsidies have perverse effects. That is, they actually lead to increased GHG emissions. Significantly, fossil fuels are the most heavily subsidised energy sources in the world (UNFCCC, 2007). According to the IEA (2010b), fossil fuel subsidies globally totalled US$312 billion in 2009. Removing these subsidies could greatly facilitate energy security and environmental goals, including GHG mitigation. In Africa, Nigeria, South Africa, and Egypt are among the twenty largest non-OECD countries with significant energy subsidies. In South Africa, for example, “poverty tariffs” are imposed on utilities, with the aim of providing 20-50 kWh of electricity per month free to poor households (Winkler, et al., 2011). Using such tariffs to provide free energy, however laudable, represents a substantial cost to South Africa’s economy and does nothing to reduce GHG emissions. Removal of the average subsidy of 6.4 percent of the market price would improve annual economic efficiency by 0.1 percent of GDP while reducing energy consumption and CO_2 emissions by 6.3 percent and 8.1 percent, respectively (UNFCCC, 2007). The difficult challenge is to reduce, and even eliminate, such subsidies while at the same time providing increased access to energy and improving equity. The goal in subsidizing kerosene for cooking, after all, is to help the poor.

c. Product charges

Adding charges to the purchase of various technologies, vehicles, or equipment can be used to restrict the use of polluting technologies. For example, adding a “pollution charge” to the purchase of older, more polluting cars can discourage their purchase. Product charges may not be perfect substitutes for taxes on GHG emissions related to fossil fuels, but they can be designed to reasonably accurately reflect the association between the fuel used by various technologies and the amount of the emissions they produce. Product charges as a policy instrument could take two forms. One is putting a limit on the amount of GHG emissions from different sources, which is difficult to monitor especially in the context of African countries. The second is putting restrictions on the type of technology to be used such as the type of vehicle or equipment. Although the intention may not be the reduction of GHG emissions, there are examples of the second form of regulation where older and more polluting technologies such as import of older cars are discouraged.

d. Tradable permits

Tradable permits, or emissions trading, work by setting an overall limit for emissions and then granting permits to emit to different agents up to the total allowable emissions. The agents are allowed to trade permits so that those who find it more costly to limit emissions can buy permits from those whose cost of reducing emissions is lower. Over time, total allowable emissions (and the number of permits) are reduced. An important advantage of tradable permits over regulation is that the costs of controlling emissions can be lowered by agents seeking to lower their costs. While use of tradable permits is becoming more common in developed countries, they are not common in Africa. Some countries have had experience using the Clean Development Mechanism (CDM), although only a few CDM projects have been implemented in Africa. At present, negotiations are underway within the UNFCCC process on how to reform CDM rules and methodologies so that the mechanism can be more accessible to African countries.

e. Provision of Information

Making information more available can help reduce GHG emissions in a variety of ways, including through labelling and requirements for public disclosure. Such requirements are mandated in Indonesia and Mexico, for example, although their primary purpose may not be to reduce GHG emissions but to address other pollution problems (Sterner, 2003; Tietenberg and Lewis, 2009).

f. Indirect effects of some instruments

Another important dimension is the effect that policy for other energy sources has on fossil fuels consumption. In particular, policies to encourage the use of renewable energy, such as feed-in-tariffs (FITs), renewable portfolio standards (RPSs), and mandated quotas could contribute to reduced GHG emissions if they result in lowering the consumption of fossil fuels. Other instruments, such as financial and fiscal incentives, e.g., exemption from import duties of renewable energy technologies, may encourage reduced use of fossil fuels, thereby leading to reduced GHG emissions.

Policies intended to reduce GHG emissions should also consider the trade-off between efficiency and equity. For example, removal of subsidies or the imposition of taxes on fossil fuel use would stimulate more efficient use of fossil fuels. The equity of such policies would depend on the nature of the subsidies or taxes and/or whether they are progressive or regressive. Recent studies have found that taxes on transport fuels in some African countries are progressive, indicating that the burden of these taxes falls more on richer households (Sterner, 2007; Sterner, forthcoming (2012)). However, this is less so for fossil fuels like kerosene that are used for cooking (Mekonnen, et al., forthcoming (2012)).

The various policy instruments discussed here have different cost implications for society at large. Reducing GHG emissions is not the only goal, but if Africa is to assist in reducing global GHG emissions, it will need support, including financial assistance, human capacity building, and technology transfer.

4.2. Barriers to technology development and use

Miller and Eil (2011) review the economic and institutional barriers to the development and deployment of clean energy technologies. Economic barriers include high development and capital costs, limits on access to financing, lack of trained staff, technology risks that are difficult to mitigate in regular financial markets, failure to internalize the externalities associated with competing, high-emission energy sources, and barriers (such as fossil fuel subsidies) that artificially reduce the competitiveness of new technologies. Energy prices are still below marginal opportunity costs in many developing countries, reflecting the desire of governments to use energy supplies to achieve political objectives (UNDP, 2000). Also, African countries generally prefer to invest in additional capacity rather than in cleaner fossil fuel technologies or energy efficiency unless there are clear short-term benefits for the country concerned. This suggests that developed country financing should be used to encourage these countries to use cleaner technologies and to improve energy efficiency.

High capital and operating costs are the main barriers for deployment of advanced fossil fuel technologies, particularly in Sub-Saharan Africa. For example, CCS technology has the potential to substantially reduce global energy-related CO_2 emissions. However, its current high costs are a major impediment to its deployment (WEC, 2007).

Institutional barriers to the diffusion and commercialisation of new technologies include problems related to monitoring and enforcement, environmental regulations, information shortages, and cultural and social issues. In general, the development and deployment of new technologies is difficult in most developing countries and especially difficult in Sub-Saharan Africa with the exception South Africa. Moreover, in a part of the world where the main focus is the transition away from traditional energy to modern fuel sources, the adoption of cleaner fossil fuel technologies is usually not be a priority.

4.3. Investment requirements and availability of finance

In Sub-Saharan Africa, excluding South Africa, lack of finance is the principal barrier to sustainable energy use. While official aid flows to Africa are increasing, there still exists a need for additional external financing (UNEP, 2009). Since Africa has huge fossil energy resources, it can, in theory, meet its electricity needs solely from fossil fuels. However, available capital for electricity generation is limited.

The World Bank (2006) estimates that developing and transition economies, including Africa, would need an average of US$300 billion per year between 2003 and 2030 to meet their energy needs (in particular, their electricity needs, which constitute about 73 percent of the total). Also according to the World Bank, yearly investments of US$80 billion for electricity in these countries would only cover about 50 percent of what is needed. In Africa, the financing gap amounts to about US$23 billion per year in the power sector out of some US$41 billion[2] (6.4

[2] This estimate excludes the cost of clean and sustainable energy

percent of GDP) per year required to meet all energy needs (Duarte, et al., 2010). It is obvious that this huge investment amount cannot be raised through public funds alone (which include funds from government, bilateral, and multilateral donors). Private investment capital, both foreign and domestic, will be needed for developing electricity infrastructure. Thus, electricity markets and an appropriate policy framework (OFID, 2008) will be required.

4.4. Research and development

Concerted efforts are underway internationally to develop and implement cleaner fossil fuel technologies. However, most of these efforts are taking place in developed countries. The IEA Networks of Expertise in Energy Technology (NEET) initiative seeks to expand the participation of major energy consuming nations in the IEA energy technology collaborative network. To facilitate this, NEET energy technology workshops in non-IEA countries with fast growing economies enable energy experts and policy makers to share know-how and experience on technical, institutional, and market issues (IEA, 2008b). African countries should be encouraged to join these networks.

Currently, Africa lacks the R&D capacity to support energy decision-making. The problem of research and development in the energy sector can be illustrated by looking at the proportion of GDP that African countries have allocated to R&D. According to the World Bank (2008), they have devoted just 0.3 percent of their GDP to research and development. This low amount makes it difficult to provide the relevant knowledge and core skills needed for Africa. Again, lack of adequate funds, skilled professionals, and commitments from policy makers limit R&D in Africa on clean fossil fuel technologies.

5. CONCLUSIONS AND POLICY IMPLICATIONS

Fossil fuels are important energy sources playing vital roles in African economies. Today, the bulk of energy needed for many applications in Africa is largely met by fossil fuels. These resources account for about 50 percent of the total primary energy supply and one-third of energy consumption (excluding the contribution to electricity generation) on the continent. Over 80 percent of the electricity generated across Africa is from fossil fuels. These energy resources are also a major source of export earnings for the major oil and gas producing and exporting countries in Africa, including Libya, Nigeria, and Angola. Despite having huge energy resources, the continent is faced with enormous challenges. These include low access to modern energy, insufficient energy infrastructure, low efficiency, and lack of technical capacity to use the resources. These challenges have hampered economic growth have thus contributed to poverty in Africa. Despite these challenges, however, its vast reserves of fossil fuels provide Africa with great opportunities to improve energy access, accelerate economic growth, and reduce poverty.

Africa must use its considerable fossil fuel resources to improve energy access and increase economic growth. However, this must be done wisely, as greater use of fossil fuels will necessarily lead to more local, regional, and global environmental impacts. Although per capita emissions in Africa are still low compared to those in the rest of the world, emissions from all fuel sources have grown in Africa over time. South Africa, Egypt, Algeria, Nigeria, Libya, and Morocco are the African countries responsible for most emissions from fossil fuel and cement production in Africa. As it seeks to develop its fossil fuel resources, Africa will benefit if it does so using low carbon-emitting technologies whenever possible.

The use of cleaner energy systems mitigate and even neutralise the adverse consequences related to the use of fossil fuels and permit their positive qualities to be enjoyed for economic and social development. Africa has many options in a carbon constrained world. Use of renewable energy systems, such as biofuels, hydropower, solar, wind, and geothermal energy, provide attractive environmentally-sound options for the medium- and long-term. Inter-fuel substitution or shifts to other fuels, which can reduce local and global environmental problems, are also important for Africa. Although few studies examine inter-fuel substitution in developing countries, it is believed that fuel substitution is possible at the household and industrial levels. Policies that encourage energy consumers to shift to less polluting fuel sources should be designed and implemented in Africa, but this needs to be done with a full understanding of the behaviour of consumers regarding consumption of different types of fuels.

It is becoming increasingly clear that abandoning traditional fossil fuel energy sources is not a viable option. Therefore, cleaner fossil fuel technologies must be emphasized. Although a number of these technologies exist in developed countries most African countries are faced with many challenges in the use and deployment of state-of-the-art fossil fuel technologies. South Africa is the only country in Africa highly dependent on coal and that is currently trying to deploy clean coal technologies. The use of such advanced technologies in Africa is limited by economic and institutional barriers, including high capital and operating costs. Lack of finance, lack of expertise, and policy constraints, such as subsidies for traditional technologies, also contribute to the problem. Institutional barriers, such as problems related to monitoring and enforcement, environmental regulations, information shortages, and cultural and social issues impede the diffusion and commercialisation of such technologies. Moreover, in a part of the world where the focus is of necessity the transition to the use of modern fuel sources, the adoption of cleaner fossil fuel technologies may not be the priority of governments. There is also a need to cooperate with developed nations as the associated environmental problems are global, as well as local, in nature. Finally, clean energy technology deployment requires concerted public and private commitments and partnership.

Various policy instruments could be used to reduce the GHG emissions from fossil fuels consumption in Africa. These include emission taxes, subsidies, product charges, regulation, emission trading, and the provision of adequate information. Taxes could be used to discourage emissions of GHGs from fossil fuel use, although implementing these taxes could be difficult. Policy instruments, such as tariffs, import duties, subsidies, and taxes on equipment that uses fossil fuels could also help to reduce fossil fuel use. The challenge for the application of subsidies is to promote increases economic efficiency without incurring costs for the poor.

Regulating the amount of GHG emissions or putting restrictions on the type of technology that can be used would be useful. The former is difficult to monitor, however, especially in African countries. The latter can be applied easily by restricting, for example, the purchase and/or import of older and more polluting cars.

Policy instruments such as tradable permits are becoming increasingly common in developed countries and could be used in Africa to mitigate GHG emissions. Policies designed facilitate the development of renewable energy can help also reduce consumption of fossil fuels and hence reduce GHG emissions.

We argue that Africa lacks sufficient R&D capacity to support decision-making on energy. The funds are simply not available in Africa for detailed studies of GHG mitigation measures. Moreover, the absence of skilled professionals and of commitments from government limits R&D on fossil fuel technologies in Africa. Increasing public investment in innovative technologies and large-scale demonstration projects is necessary. Moreover, we recommend that African countries participate in the IEA NEET initiative, which would enable Africa to gain expertise and experience in clean and advanced technologies.

Finally, further research on fossil fuels may help Africa reduce GHG emissions and enable the design of appropriate policies and strategies for deploying fossil fuel technologies in Africa. For example, a need exists to investigate the role of different tax systems in the consumption of fossil fuels in Africa. There is also a need to examine the barriers to the adoption of different fossil fuel technologies at the country level, as the problems are country-specific. Strategies to implement clean technologies should be based on research on consumption, production, and barriers to adoption of different types of clean technologies.

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