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Review

Promoting a low cost energy future in Africa

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With a large part of the population not having access to modern energy services in their daily life, energy poverty remains one of the most pressing development challenges on the African continent. Africa's fossil fuel resources as well as its renewable energy potential can serve as the means to achieve this. For Africa's social and economic development in the 21st century, however, the benchmark for these sources is to deliver energy that is affordable, reliable and sustainable. The following study offers a comparison between the two energy sources according to economic, social and environmental indicators. As the analysis shows, renewable energy technologies increasingly become the preferred option for Africa's energy challenge. The study then concludes with a description of policies for African countries to realize the up-scaling of these technologies.

Key words: Renewable energy, green growth, energy transition.

INTRODUCTION

Energy poverty remains a pressing development challenge in the African continent. A large part of the African population does not have access to power in their daily life. Improving this situation can be achieved through the use of fossil fuel technologies. Indeed, Africa is endowed with immense resources of oil, gas and coal making this an appealing solution. According to estimates, 45 out of the 54 African countries possess proven and/or probable oil and/or gas reserves, and most of these resources are untapped. Nevertheless, Africa is also well-placed to use renewable energy technologies [1](RETs) to address energy poverty due to its abundant renewable energy potential. The hydro potential in Africa alone equals three times Africa's current electricity production (IRENA, 2011a).

Whether Africa relies on fossil fuels or renewable energy technologies for its energy future, is subject of a detailed comparison between these two sources of energy provision. Important criteria are their levelized costs of energy[2] as well as their impacts on energy independence and sustainability. After all, Africa's social

[1]Throughout the text renewable energy is defined as any energy resource that is naturally regenerated over a short time scale and derived directly from the sun (such as thermal, photochemical, and photoelectric), indirectly from the sun (such as wind, hydropower, and photosynthetic energy stored in biomass), or from other natural movements and mechanisms of the environment (such as geothermal and tidal energy) (EREC, 2004)

[2]Levelized cost of energy (LCOE) is the ratio of lifetime costs to lifetime electricity generation, both of which are discounted back to a common year using a discount rate that reflects the average cost of capital. As an economic assessment of the cost of the energy-generating system including all the costs over its lifetime, it is a useful indicator to compare the electricity costs from different sources.

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Abbreviations: CCS, Carbon Capture and Storage**; CIF,** Climate Investment Fund**; CSP,** Concentrated Solar Power**; GHG**, Greenhouse Gas**; LCOE,** Levelized Cost of Energy**; NAMA,** Nationally Approriate Mitigation Actions**; PV,** Photovoltaic**; RET**, Renewable Energy Technology**; SEFA,** Sustainable Energy Fund for Africa.

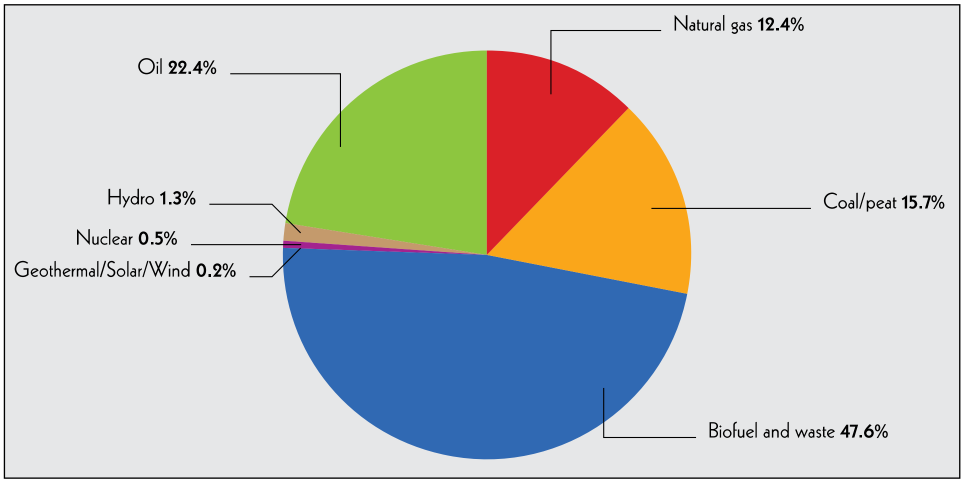

Figure 1. Share of Total Primary Energy Supply in Africa in 2009. Source: IEA (2012).

and economic development in the 21st century depends on affordable, reliable, and sustainable energy. Current trends show that RETs become the more suitable solution over time to reach these objectives.

This study offers a comparison of the two different models for Africa's energy future according to the criteria mentioned above. It summarizes policy options for African policymakers for the large-scale diffusion of the more suitable model, namely RETs, to reach a low cost energy future in Africa. First, a short overview of the energy sector in Africa is given. Then, the study discusses the potential of RETs as compared to fossil fuel technologies. In the end, the study recommends policy options that will contribute to the diffusion of RETs within African countries.

THE ENERGY SECTOR IN AFRICA- FOSSILS FUELS AND RURAL ENERGY POVERTY

Fossil fuels, biofuels and waste currently take up a pivotal role in Africa's energy mix as the most important sources of energy. Fossil fuels represent about 54% of total primary energy supply. As shown in Figure 1, oil, coal and natural gas contributed respectively 22, 16 and 12% of the continent's total primary energy supply in 2009. In 2010, about 80% of the continent's electricity was generated from fossil fuels.

Biofuels and waste, in comparison, amounts to 48% of energy supply (Figure 1). The reliance of many Africans on traditional biomass shows that Africa is still lagging behind the rest of the world in terms of access to modern energy, energy infrastructure, and institutional and technical capacity. Yet, access to modern energy is vital for improving the social and economic conditions for the African population. For instance, electrification enhances lighting, gives access to communication tools, allows the mechanization of production, and enables refrigeration, which in turn helps in improving food security and health-care conditions. Figure 2 shows that the majority of the African population (58%) lacks access to modern energy. However, out of this 58%, 47% are located in rural areas compared to only 11% in urban ones. This trend will not undergo an alteration at least until the near future (Figure 2). As a result, efforts to address energy poverty will have to focus on rural areas.

POTENTIAL OF RENEWABLE ENERGY TECHNOLOGIES COMPARED TO THEIR FOSSIL-FUEL COUNTERPARTS

The most economical solution (in rural areas)

Renewable power generation now represents close to half of new annual capacity additions globally (IRENA, 2013). This massive up-scaling is the main driver behind the trend of falling costs of RETs through economies of scale, learning-by-doing mechanisms and increased competition in the various RETs markets. At the same time, it also shows how increasingly cost competitive RETs are becoming towards fossil fuel technologies.

In fact, renewable energy solutions such as hydro-power, wind power, biomass and solar photovoltaic (PV) are already the most economical solution for off-grid and mini-grid electrification in remote areas in Africa, as well as in some cases of centralized grid supply too (IRENA, 2013). The cost advantage of RETs with regards to off-grid and min-grid electrification can be explained on the basis that only 15% of the rural population in Africa lives within 10 km of a substation (or within 5 km of the medium-voltage line) so that only a small proportion of the rural population can be added to the electricity grid at relatively low cost (Mafalda et al., 2010). But even for grid-connected projects, RETs are increasingly becoming the most economical solution compared to fossil fuel

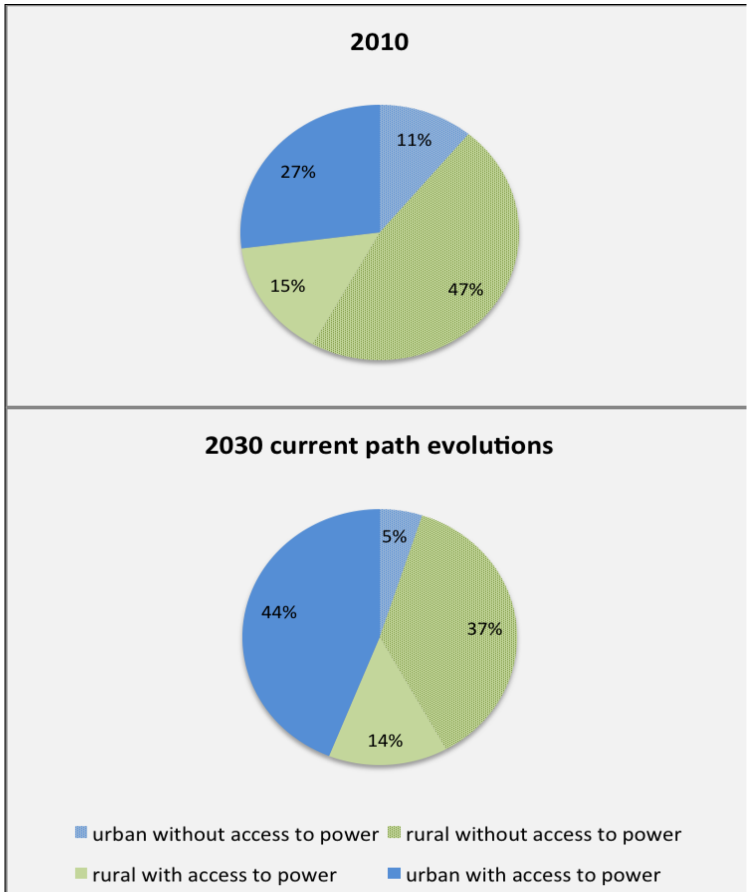

Figure 2. Comparison of Rural and Urban Electricity Access in 2010 and 2030, if current trends in Africa continue. Source: IRENA (2013).

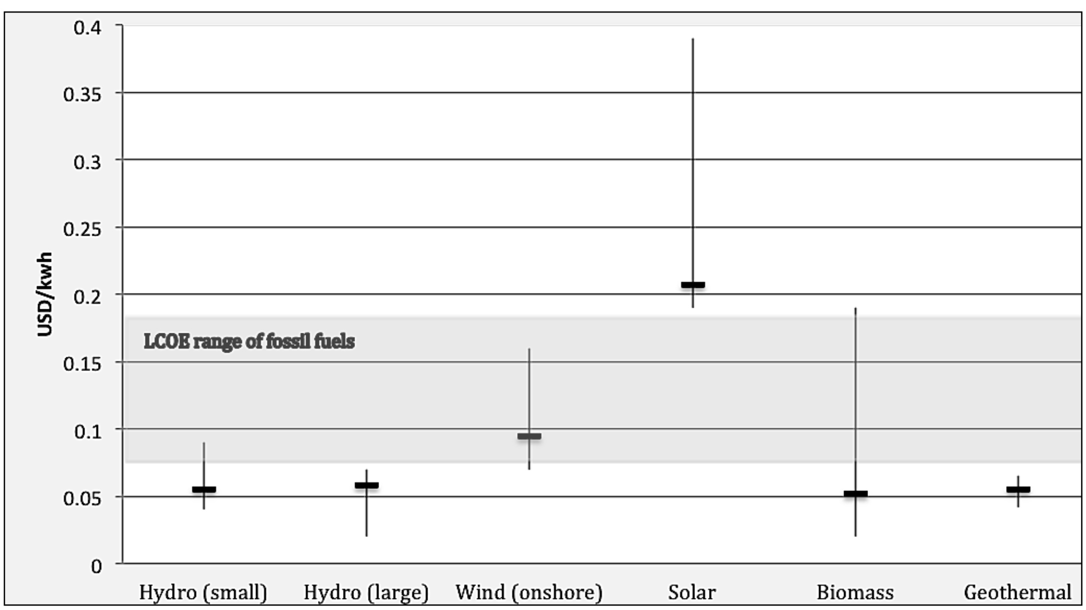

Figure 3. LCOE Ranges of Renewable Energy Technologies in Africa as compared to Fossil Fuels (for selected grid-connected projects). Source: IRENA 2013; IRENA 2012. Note: The horizontal black bars are the capacity weighted average value. Values for LCOE range of fossil fuels summarize ranges from South and East Africa as in IRENA 2013.

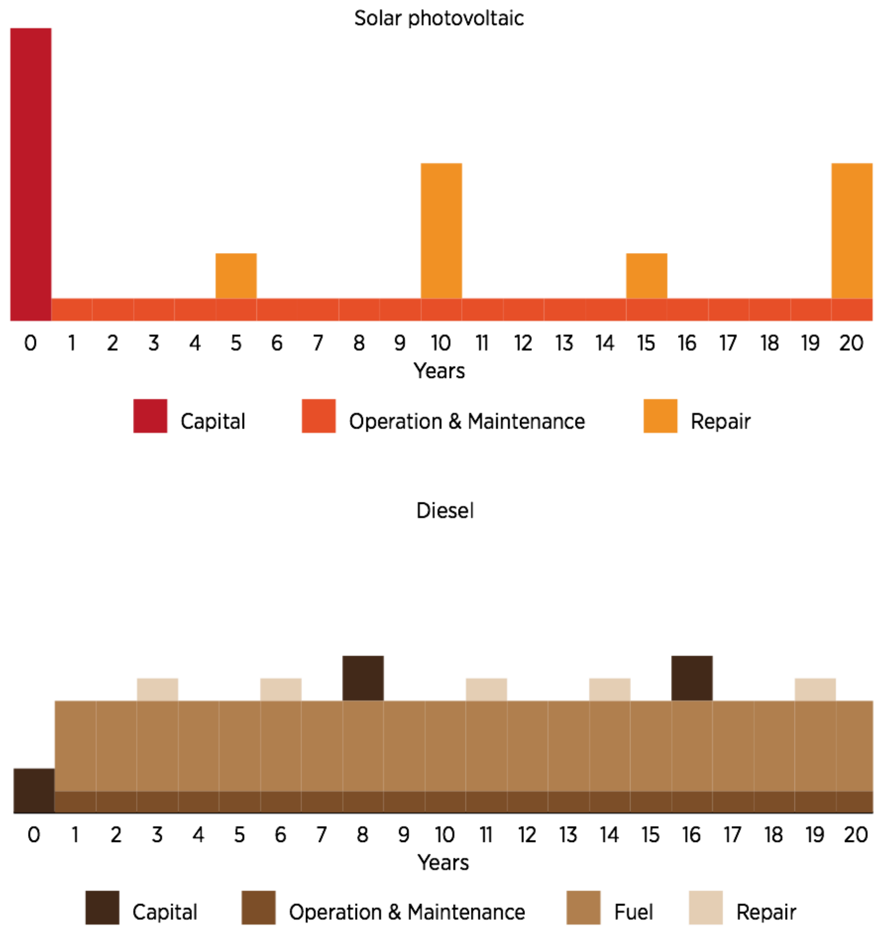

Figure 4. Comparison of Lifetime Costs of PV Project with Diesel Generator (indication). Source: IRENA 2013.

options. As shown in Figure 3 that compares the LCOE ranges of renewable energy and fossil fuels in Africa, hydropower is the cheapest option to generate electricity. Wind, biomass and geothermal remain below or on the same cost level as fossil fuel options. Only solar energy including concentrated solar power (CSP) and PV remains on a level slightly above fossil fuel technologies.

A safe energy model for Africa's future

RETs have the potential to strengthen the self-sufficiency of African countries, in particular for the countries that depend on the imports of fossil fuels. Figure 4 shows exemplary for PV that RETs see their on-going costs fall once installed. Their lifetime costs are mainly composed of upfront investment costs; costs for operation, maintenance, and repair compose only a smaller fraction. The costs of fossil-fuel technologies represented by the diesel generator in Figure 4, in contrast, are more evenly distributed throughout their lifetime. Lower upfront capital costs are offset by higher ongoing costs, mainly because fossil fuels are continuously needed as input to produce electricity. The oil price as an example of these fossil fuel inputs more than quadrupled to US$ 112 per barrel in 2012 from less than US$ 20 per barrel in 1999 becoming less and less affordable for customers (AfDB, 2013). Thus, fossil fuel technologies have higher ongoing uncertainties in their costs, due to fluctuations in fuel prices whereas all renewable costs are known. Limiting the exposure to the volatility of global fossil fuel markets in terms of price and supply contributes to the energy security[3] of African countries and reduces possible negative economic impacts.

Furthermore, the current prices of oil pose a burden on government budgets in Africa. Fossil fuel subsidies have become more and more unsustainable for many African governments. In 2010-2011, over half of all African countries had some subsidy in place for fuel products, and these subsidies consumed, on average, 1.4% of GDP in

[3]Defined as the availability of sufficient supplies at affordable prices following Yergin, 2006

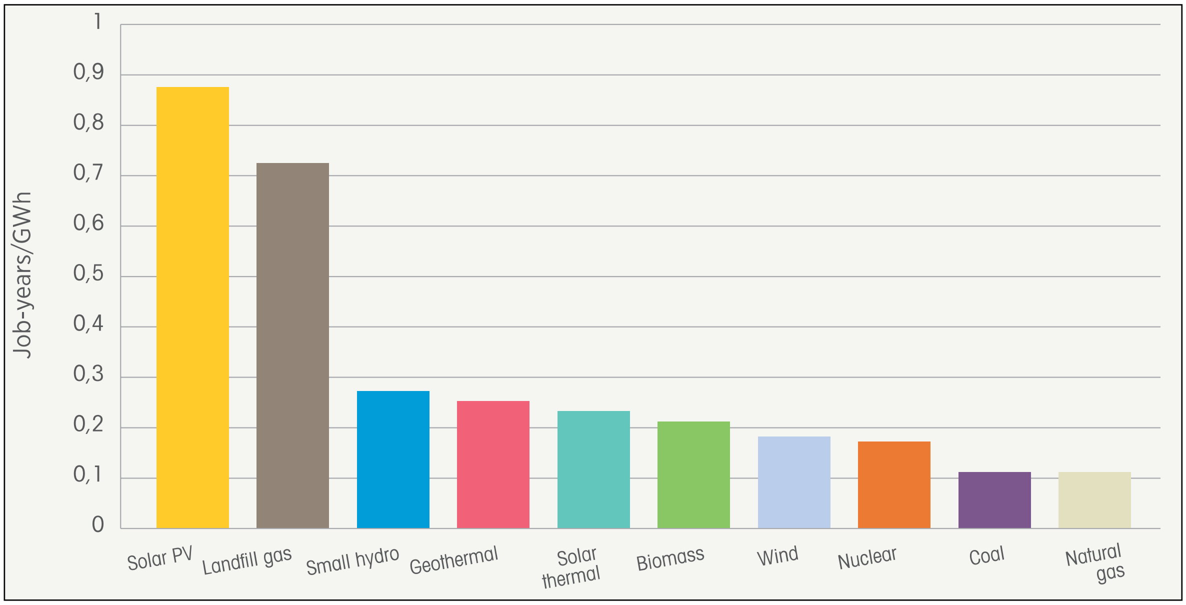

Figure 5. Comparison of Job-Years across different Energy Technologies (Job-Years/GWh). Source: Wei et al. 2010 as illustrated in IRENA (2011b).

public resources. Of the 25 countries with fuel subsidies, the fiscal cost of subsidies in six countries—primarily oil exporters—was at or above 2% of GDP in 2011. The fiscal cost for oil exporters was almost two-and-a-half times the levels observed for oil importers (World Bank, 2012).

The engines of job creation

The promotion of RETs is an efficient way of addressing poverty by creating additional income opportunities and new enterprises. There are important details about job creation with respect to RETs, particularly small scale RETs and their use in rural areas. Many of the jobs are in the service end of the supply chain and include distribution and sales, installation, maintenance, and so on. For some RETs (biogas plants and improved cook stoves) there are also opportunities for manufacturing or construction jobs at the beginning of the supply chain, which are unlikely in the case of PV modules because of the high level of skills required. These job opportunities could potentially benefit women and thus promote gender equality in access to labor markets.

Compared to fossil fuel technologies, the promotion of renewable energy will imply the creation of more job opportunities. Wei et al. (2010) averaged estimates about the labor intensity of different energy technologies over a range of studies. Their findings presented in Figure 5 show that all RETs have higher labor intensity than fossil fuel technologies. For example, the labor intensity of solar PV is more than eight-times that of natural gas. Within RETs, the above-mentioned solar PV has the highest labor intensity whereas wind has the lowest.

The environmentally sustainable energy generation

The deployment of RETs puts Africa on a more environmentally sustainable development path. Firstly, it leads to reduction in GHG emissions. Figure 6 gives a summary overview of lifecycle GHG emissions from a selection of technology groups. The figure reports this number within a range, particularly with regards to bioenergy. This has partly to do with the way lifecycle assessments are conducted. Some will be more comprehensive than others. But it is also related to the range of technologies within each group. Nevertheless, there is little overlap between the worst performing biofuels and the fossil energy sources, all of which produce much higher levels of GHG emissions than the “other renewables”, except when carbon capture and storage (CCS) is used.

Secondly, RETs also result in the reduction of local pollutants, especially particulates. According to Johansson et al. (2012), this could mean “a saving of 20 million disability adjusted life years (DALYs) from outdoor air pollution and more than 24 million DALYs from household air pollution” compared with just the introduction of air-quality legislation that is currently planned. The authors also suggest that these positive health impacts could help to persuade individuals to adopt RETs, more so than asking them to make changes to achieve global benefits such as the mitigation of climate change.

Lastly, non-bioenergy RETs can significantly reduce the rate of deforestation within Africa[4]. The clearing of forests serves as an important source of energy and food

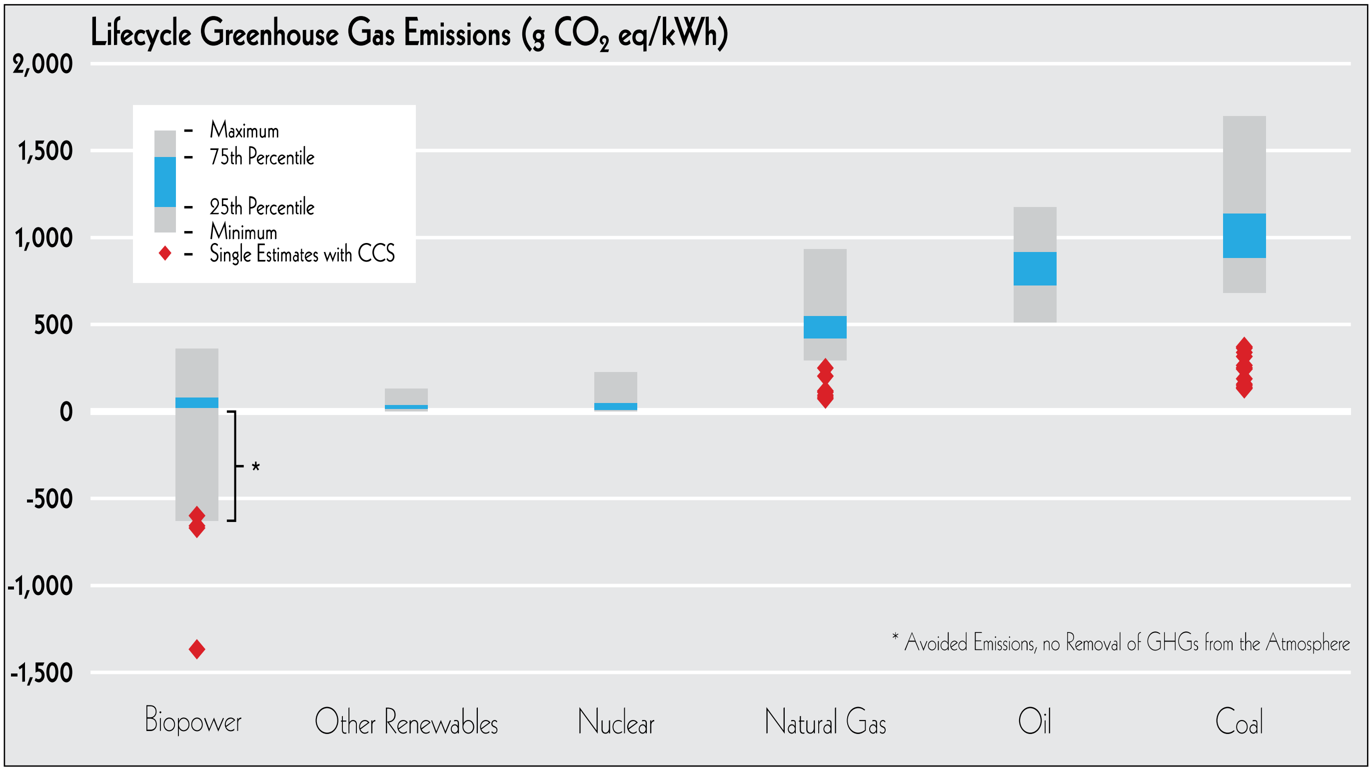

Figure 6. Lifecycle GHG Emissions of Renewable Energy, Nuclear Energy and Fossil Fuels. Source: Moomaw et al. (2012) as illustrated in AfDB (2013).

security, especially for Africa's rural poor. This trend is likely to continue as the total number of households in absolute terms relying on this traditional biomass is predicted to increase from 657 million to 922 million (OECD/IEA, 2010). This indicates, on the one hand, that increases in population outweighs shifts to "modern" energy services but, on the other hand, stresses the need to up scale the deployment of RETs to stop this trend.

POLICY OPTIONS

Policies play a crucial component in the large-scale deployment of RETs. Investments in the energy sector last for decades so that investors and the industry need the right policy environment ensuring reasonable returns over the lifetime of projects. This can be achieved through a mix of policies that send reassuring signals, provide relevant information, and offer long-term guarantees. Furthermore, governments need to ensure financing is adequate to set the right incentives for customers to uptake renewable energy.

[4]In contrast, bioenergy could potentially lead to deforestation (or negatively affect food production). Policies to promote bioenergy need to take these negative effects into consideration for their design.

Announcing a long-term target for the share of renewable energy

Announcing a long-term target for the share of renewable energy in total energy supply can signal investment security in RETs. This can leverage private investment for the diffusion of RETs because having such a target as part of national strategies ensures the investors of the long-term commitment on the side of the corresponding government. As of 2011, 16 African countries had already announced a long-term renewable energy target (UNEP, 2012). Morocco, for example, aims at an ambitious target of 20% of power supply coming from renewable energy in 2020.

Providing detailed information on the country's renewable energy potential

Providing detailed information on the country's renewable energy potential can contribute to strengthen the confidence of financial institutions and investors in RETs. The publication of a national solar and wind atlas, for example, informs potential investors about suitable areas and reduces the costs for feasibility studies (Renewable Energy Ventures, 2012). Due to a lack of knowledge and project experience with RETs, obtaining financing for RETs is currently more difficult than for fossil-fuel plants despite a comparably better economic case (IRENA, 2013). Banks are often reluctant to finance projects, or agree to finance but only at premium rates. Mapping renewable energy potentials including their techno-economic feasibility can contribute to overcoming financial burdens faced by investors and in helping financial institutions making profitable investments.

Offering long-term guarantees to renewable energy producers

Offering long-term guarantees to renewable energy producers through power purchase agreements such as feed-in-tariffs is the key policy for the diffusion of RETs. Market liberalization is an important prerequisite for renewable energy producers to be able to enter energy markets currently dominated by national utilities in a lot of African countries. Long-term guarantees along with market decentralization policies can ensure the easy access for new renewable energy producers. At the same time, these guarantees mean to obtain necessary financing for projects because producers are offered a price guarantee for a fixed period of time. In 2011, 7 African countries had already used feed-in tariff policies (UNEP, 2012). This group of African countries includes a small-island state dependent on fuel imports (Mauritius), the continent's biggest carbon polluter (South Africa), countries with less than 3% rural electrification (Tanzania), and others with almost universal access to electricity (Egypt and Algeria) (Renewable Energy Ventures, 2012). The design of feed-in tariffs can be aligned towards achieving a country's specific development objective whether this is the building of large-scale renewable energy plants or an increase of energy access in rural areas. In the first case bidding processes are the preferred options whereas for the latter ones differentiated tariffs ensuring that smaller installations are included are better (Renewable Energy Ventures, 2012). For the design of the tariff costs of generation, return on investment, impact on electricity prices and the costs of the support need to be taken into account; the choice of a tariff structure should be based on a holistic and long-term analysis based on the lifetime costs of RETs (IRENA, 2013; Renewable Energy Ventures, 2012)

A financing strategy for the diffusion of RETs

A financing strategy for the diffusion of RETs should be in place that ideally sets incentives for the poorer population to use renewable energy sources. In Africa, energy subsidies benefit industrial user and richer households. For example, an estimated 44.2% of fossil fuel subsidies go to the richest 20%, while the poorest 20% benefit from only 7.8% of these subsidies (AfDB, 2013). Social-transfer mechanisms and the cross-subsidization of low-income households through higher tariffs to rich customer could potentially change the current status-quo in favor of the poorer population. As an example for the former, South Africa already provides a monthly quota of free electricity to low-income households. For the latter, tariff structures in Kenya and Ethiopia are based on a pricing scheme with low prices for low consumption. Minimally, a financing strategy needs to ensure that feed-in tariffs will not incur an additional cost burden for households, especially in poor rural areas. This could potentially have negative consequences to achieve the objective of improving energy access. Additional funding will thus become necessary to protect poorer households from higher prices. For African countries, there are several strategies to finance feed-in tariffs by focusing on inter alia harnessing fiscal and environmental policy tools and leveraging global financing options (AfDB, 2013). Algeria and Mauritius have both taxed fossil fuels in order to fund renewable energy. Meanwhile Ghana and Uganda are looking to international climate finance such as through Nationally Appropriate Mitigation Actions (NAMAs) under the UNFCCC and the new Green Climate Fund (Renewable Energy Ventures, 2012). The African Development Bank and other organizations can help African countries here by facilitating awareness, knowledge sharing and upstream technical support or through their role as manager or host of a range of innovative financing instruments. For example, throughthe Climate Investment Funds (CIFs) and the Sustainable Energy Fund for Africa (SEFA), the Bank has several funding instruments that help promote scaling up of clean energy solutions at different levels. Robert et al. (2013) reported about the Ecological Modernization of the German Economy by a modern environmental policy. Dessau-Roßlau: German Federal Environment Agency.

CONCLUSION

The study has shown that RETs provide the better economic case for Africa's energy future compared to fossil-fuel technologies. They are the lowest cost option for different kinds of electrification projects and will even improve this status if current trends of rising fossil-fuel prices will continue. More income earning opportunities can be created through the deployment of RETs and customers can expect lower energy costs in the middle-to long-term. Also, in terms of energy independence and environmental sustainability, RETs make a more compelling case than their fossil-fuel counterparts.

For the large-scale deployment of RETs, the study recommends policy options to address two critical issues for a low cost energy future in Africa: ensure investment security and set incentives for low income households. For the former, a mix of policies is necessary that send signals of the government's long-term commitment, provides relevant information for profitable investments and offers guarantees for reasonable returns over the lifetime of projects. For the latter, a financing strategy needs to be put in place that ideally sets incentives, but minimally ensures that guarantees will not result in additional costs for low-income households. For African countries, options include the harnessing of fiscal and environmental policy tools and leveraging global financing options.

REFERENCES

African Development Bank (AfDB) (2013). The African Development Report 2012- Towards Green Growth in Africa. Tunis: The African Development Bank Group.

European Renewable Energy Council (EREC) (2004). Policy paper for the international conference on renewable energy. Available at:http://www.stakeholderforum.org/practice/renewables/Position%20Papers/RE%20Manufacturers%20&%20Suppliers.pdf (Accessed 28 November 2013).

International Energy Agency (IEA) (2012). IEA Energy Statistics. Available at: http://www. iea.org/stats (Accessed 05 July 2013).

International Renewable Energy Agency (IRENA) (2011a). “Scenarios and Strategies for Africa, Working Paper Presentation.” IRENA-Africa High-Level Consultations, Abu Dhabi, 8th and 9th July.

IRENA (2011b). Renewable Energy Jobs: Status, Prospects & Policies. Abu Dhabi, United Arab Emirates: IRENA.

IRENA (2012). Renewable Power Generation Costs: An Overview. Available at: http://irena.org/DocumentDownloads/Publications/Overview_Renewable%20Power%20Generation%20Costs%20in%202012.pdf (Accessed 29 August 2013).

IRENA (2013). Africa’s Renewable Future- The Path to Sustainable Growth. Abu Dhabi, United Arab Emirates: IRENA.

Johansson T, Nakicenovic N, Patwardhan A, Gomez-Echeverri L, Arent D, Banerjee R (2012). “Technical Summary.” In The GEA Writing Team (eds.) Global Energy Assessment – Toward a Sustainable Future. Cambridge, UK, New York, USA and Laxenburg, Austria: Cambridge University Press and the International Institute for Applied Systems Analysis.

Mafalda D, Nagarajan S, Brixiova Z (2010). “Financing of Sustainable Energy Solutions”. Committee of Ten Policy Brief, No. 3. Tunis: The African Development Bank Group.

Moomaw W, Yamba F, Kamimoto M, Maurice L, Nyboer J, Urama K, Weir T (2011). “Introduction.” In Edenhofer, O., R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer and C. von Stechow (eds.). IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation. Cambridge, Cambridge University Press.

OECD and International Energy Agency (2010). Energy Poverty. How to Make Modern Energy Access Universal? Special Early Excerpt of the World Energy Outlook 2010 for the UN General Assembly on the Millennium Development Goals (September). Available at: http://content.undp.org/go/cmsservice/stream/asset/?asset_id=2822269 (Accessed May 2013).

Renewable Energy Ventures (2012). “Powering Africa through feed-in tariffs”. Study for the World Future Council (WFC), the Heinrich Böll Foundation (HBF) and Friends of the Earth England, Wales & Northern Ireland (FoE).

Robert K, Jutta K, Ingmar M, Walter K, Jürgen B, Dietmar E, Wolf-Peter S, Christian S, Rainer W (2013). Ecological Modernization of the German Economy by a modern environmental policy. Dessau-Roßlau: German Federal Environment Agency.

United Nations Environment Programme (UNEP) (2012). Feed-in Tariffs as a Policy Instrument for Promoting Renewable Energies and Green Economies in Developing Countries. Nairobi: UNEP.

Wei M, Patadia SS, Kammen D (2010). “Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US?”. Energy Policy 38: 919-931.

World Bank (2012). Africa’s Pulse: An Analysis of Issues Shaping Africa’s Economic Future, Volume 5. Washington, DC: World Bank.

Yergin D (2006). Ensuring Energy Security. Foreign Affairs. Issue March/April 2006.