Deploying RE in Eastern Africa: what does it take?



RES4AFRICA
RENEWABLE ENERGY SOLUTIONS FOR AFRICA
PROJECT

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Demand-supply coordination in Sub-Saharan African electricity sector development

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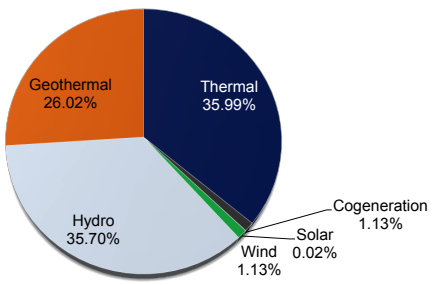
Abstract

Currently Eastern African countries average electrification rate is slightly above 20%, due to the lack of urbanization infrastructure and low level of GDP per capita of residents in rural areas, representing around 70% of total population. On the supply side generation capacity experienced a significant increase over recent years and has ambitious future growth targets. In order to avoid the risk of oversupply, new demand should be properly stimulated and appropriately coordinated with the supply evolution. The most promising solutions to achieve these goals could be related to the efficient electrification of rural and isolated areas through off-grid renewable solutions and the development of the agro-food chain potential. Strengthening regional cooperation and power trades among Eastern African countries could also have positive effects on the efficiency of the electricity sector. This coordinated approach could lead to sustainable demand growth for the next decade, close to 10% per year on average.

Market context

Kenyan generation mix is dominated by hydroelectric power, geothermal and thermal generation[1]. Other renewables, like wind and solar, still represent a negligible share of the total capacity (less than 2%).

2015 Installed Capacity Mix (MW)



Source: KPLC Annual Report and Financial Statement, 2015

[1] Mainly diesel and kerosene

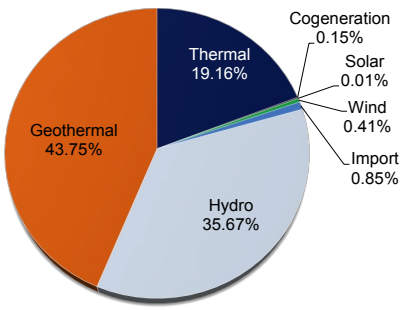
As of June 2015 Kenya's total installed generation capacity reached 2,299 MW, with 414 MW of new generation capacity added from the previous year. Geothermal experienced the highest annual growth rate with 235 MW added over last year. Almost the entire growth in geothermal capacity is attributable to the Olkaria expansion, the world's largest geothermal power plant.

Installed capacity [MW]	2015	2014	Added capacity
Thermal	827.4	671.5	+155.9
Hydro	820.7	817.8	+2.9
Geothermal	598.2	363.0	+235.2
Wind	26.0	5.9	+20.1
Cogeneration	25.9	25.9	~
Solar	0.5	0.7	--0,1
TOTAL	**2,299**	**1,885**	**414.1**

Source: KPLC Annual Report and Financial Statement, 2014 and 2015

In terms of energy generation, the picture is slightly different, due to the Capacity Factor of geothermal plant that is higher than 70%.

2015 Installed Generation Mix (GWh)



Generation [GWh]	2015	2014	Added capacity
Geothermal	4,059	2,007	+2,052
Hydro	3,310	3,945	-634
Thermal	1,778	2,726	-948
Import	79	87	-8
Wind	38	5.9	+20.1
Cogeneration	14	57	-43
Solar	1	1	~
TOTAL	**9,279**	**8,840**	**+439**

Source: KPLC Annual Report and Financial Statement, 2015

It confirms the predominant role of geothermal in the Kenya's energy matrix.

Potential evolution

According to the KenGen (Kenya Electricity Generating Company), the country aims at increasing geothermal capacity by another 460 MW by 2018 to reduce the weight of hydro-power in its mix in order to decrease the exposure of Kenya's electricity consumers to the consequences of drought which results in power supply reduction from hydro power plants forcing the country to draw energy from the costly thermal power plants.

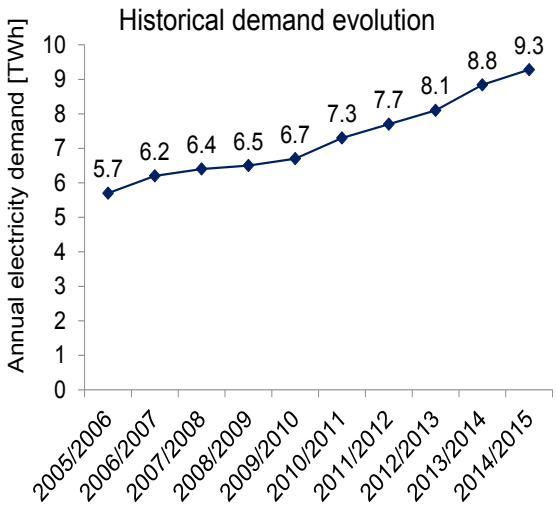
In 2013, the Government launched the 5,000+ MW plan, with the ambitious target of adding more than 5,000 MW of new capacity to the national grid by the end of 2016. Main objectives of the plan were to reduce the country's electricity generation cost, trigger industrial growth and increase electrification. In order to achieve these goals, the new capacity would be mainly developed from geothermal (additional 1,650 MW), wind (additional 630 MW) and fossil fuels available in the country (coal with 1,920 MW and natural gas with around 1,250 MW). At the end of 2015, around 600 additional MW have been added installed, making geothermal power the main electricity source of the country.

The expansion target[2] (with the addition of 1,000 MW of nuclear capacity[3] by 2025) is expected to be postponed between 2017 and 2019, but the government is keeping the target to reduce total imports (mainly from Uganda).

[2] Published in the second medium term plan 2013-2017
[3] In 2015 Kenya signed a deal with China for the development of skills and technical support for nuclear energy while in 2016 Kenya signed a Memorandum of Understanding with both Russia and Korea to identify nuclear projects

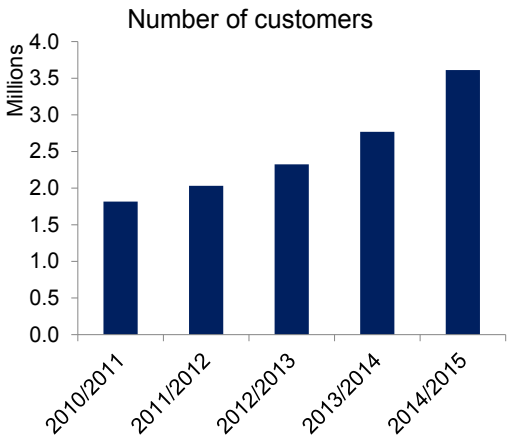
A snapshot of electricity demand

Electricity demand has almost doubled in the last ten years (5% CAGR), reaching an all-time high of 9.28 TWh in 2015.



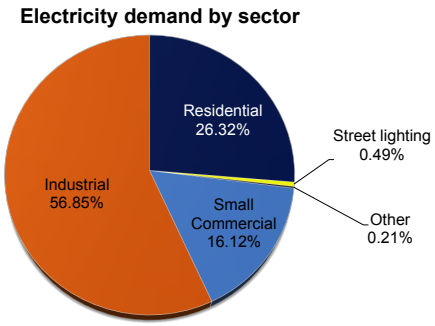
Source: KPLC Annual Report and Financial Statement, 2015

The increased customer base has been the main driver behind the electricity demand growth, with total customer connections reaching 3,611,904 at the end of June 2015 (843,899 new customers connected to the grid in 2015 - +90% compared to 2014).



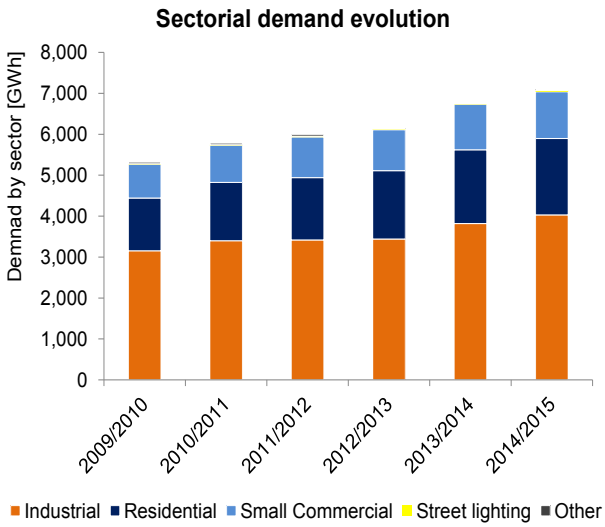
Source: KPLC Annual Report and Financial Statement, 2015

Currently industrial demand accounts for more than a half of Kenya's total demand and experienced the highest annual growth rate with additional 200 GWh in 2015. Residential demand accounts for approximately one fourth of total demand in 2015 and is expected to grow even further in the upcoming years.



Source: KPLC Annual Report and Financial Statement, 2015

The economic upturn, with an average annual GDP growth rate of +5.6% over the 2010-2015 periods, is the main driver behind the growth in industrial electricity demand.



Source: KPLC Annual Report and Financial Statement, 2015

In the future, in addition to the growth in customer base thanks to the electrification plan, major expected demand drivers include the creation of industrial parks, the LAPPSET projects[4], resort cities, iron and steel smelting industry, the standard

[4] Lamu Port Southern Sudan-Ethiopia Transport (LAPPSET) it's a new transport corridor project with the aim of strengthening Kenya's regional Hub status in Eastern Africa. The project envisages the construction of port, railway, highways, airports and oil pipeline connecting Kenya with Ethiopia and South Sudan.

gauge railway and the light rail and the streets lighting program.

Structure of the energy sector

In order to improve the institutional and legal framework of the energy sector, the Kenyan Government has introduced a number of strategic policies and some fundamental liberalization reforms in the energy sector. In 2006 the Energy Act consolidated all laws relating to the energy sector and provided for the establishment of the ERC (Energy Regulatory Commission) as a single sector regulator.

The Government is focused on continuous institutional reforms in the energy field, including a strong regulatory framework, encouraging private power generators and unbundling generation from distribution. Renewable Energy Sources (RES) are encouraged, as well as the connection of Kenya to energy-surplus countries in the region.

The MoEP (Ministry of Energy and Petroleum) is in charge of policies setting the strategic direction of the energy sector and providing a long term vision.

The ERC is responsible for the regulation of the energy sector, tariff setting and monitoring, coordination of the development of energy plants, monitoring and enforcement of sector regulation.

The KenGen is the main player in electricity generation with a current combined installed capacity of 1,337 MW[5] from hydro, thermal, geothermal and wind technologies.

Currently there are also 12 active Independent Power Producers (IPPs). All these players together account for about one fourth of the country's total installed capacity. Further IPP generation projects are under development and expected to start operation in the medium term.

KPLC (Kenya Power and Lighting Company) owns and operates most of the electricity transmission and distribution system in the country and sell electricity to almost 4 million customers. It is the off-taker in the power market, buying power from all power generators on the basis of negotiated power purchase agreements (PPA).

KETRACO (Kenya Electricity Transmission Company) is 100% Government owned established to develop new high voltage electricity transmission infrastructure that will form the backbone of the National Transmission Grid, in line with Kenya Vision 2030[6]. The mandate of KETRACO is to plan, design, build and maintain electricity transmission lines and associated substations. The creation of new transmission lines will facilitate the evolution of an open-access-system in the country.

GDC (Geothermal Development Company) is 100% state-owned, established by Government of Kenya in 2008 as a Special Purpose Vehicle (SPV) to fast track the development of geothermal resources in the country.

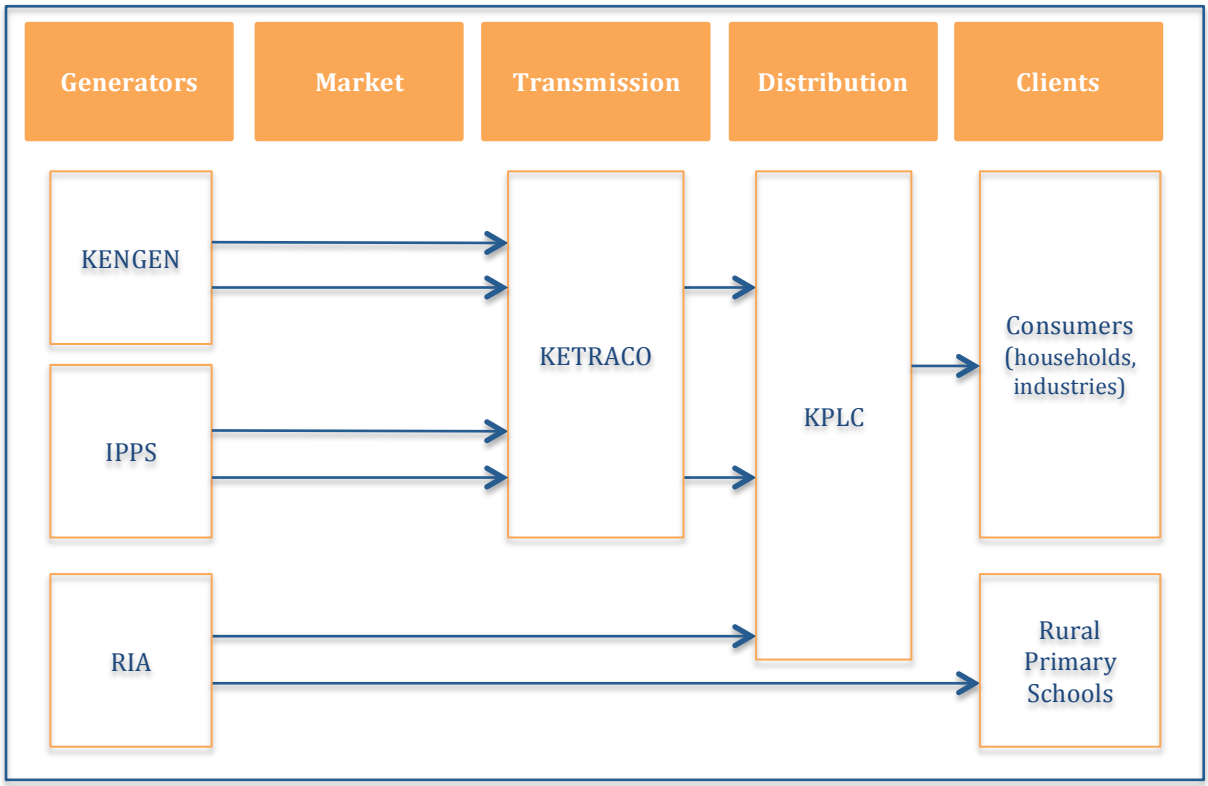
Rural Electrification Authority (REA)[7] was established following the Energy Act in order to develop and update the rural electrification master plan, promote the use of RES and manage the tendering and award of contracts for licenses and permits for rural electrification.

[5] http://www.kengen.co.ke/

[6] http://www.ketraco.co.ke/

[7] Transformed into Rural Electrification and Renewable Energy Corporation (RERC)

Structure of the Electricity Market



Renewable plans in Kenya

Currently the Renewable Energy (RE) sector in Kenya is among the most active in Africa and is one of the six pilot countries selected to benefit from Scaling-Up Renewable Energy Program (SREP). The SREP program will support Kenya's initiatives towards achieving a transformational change that will lead the country towards a low greenhouse gas emission development pathway by harnessing the abundant renewable energy resources in the country.

Wind power

Wind power in Kenya contributes only to a small amount of the country's electrical power. Only a small number of renewable projects have been approved under the Feed-in Tariff (FiT) scheme[8]. However, its share in energy production is increasing. Kenya aims to generate 2,036 MW of wind power, or 9% of the country's total capacity, by 2030[9].

Hydropower

Between 2011 and 2014, KenGen added 53 MW of new and upgraded hydropower capacity, The MoEP has indicated its intent to finance prefeasibility studies for the identification of potential hydropower sites and 290 MW of new hydropower projects have been identified as public-private partnerships (PPPs).

Geothermal Development

The GDC, was given all mining rights in the country with the task of handle the most risky part of geothermal activity (namely, exploration, appraisal and production drilling) and thereby remove much risk

[8] Kinangop Wind Farm (60 MW), Kipeto Wind (100 MW), Kwale Sugar Mill (18 MW) and several small projects in the range of 0.5 - 2.0 MW. In 2011 a PPA (Power Purchase Agreement) was directly negotiated with the government as an unsolicited bid with the Lake Turkana Wind Project (LTWP).

[9] Plans for new wind installations, including feasibility study for a 150 MW wind farm, Marsabit Wind, and the 50 MW Isiolo are under way (KenGen 2014).

from project development. The GDC and geothermal activities in Kenya have been supported by a diverse array of multilateral, bilateral and regional development partners.

Solar Energy

A vibrant solar energy market has developed in Kenya over the years for providing electricity to homes and institutions remote from the national grid (off-grid solutions) and for medium temperature water heaters for domestic and commercial usage. A government programme that started in 2005 to provide basic electricity to boarding schools and health facilities in remote areas has increased the annual demand for PV panels by 400 kilowatt peak.

Instruments adopted: incentives in RE sector and PPAs

In order to attract investments in RE sector, the Government of Kenya has developed and put in place three main policy tools:

- Feed-in tariffs and Power Purchase Agreements
- 0% import duties
- VAT exemption.

While the VAT exemption and 0% import duty will ease the financial burden for active RE companies, the feed-in tariff will have the biggest impact on overall installed renewable capacity.

The FiT policy was issued in March 2008 and has been revised in 2010 and 2012. It is an instrument aiming at promoting power generation from RES including wind power, biomass, small hydro, solar, biogas and geothermal.

The FiTs system focuses on:

- Resource mobilization by providing investment security and market stability for investors in electricity generation from RES;
- Reduction of transaction, administrative costs and delays associated with the conventional procurement processes;
- Private investors' involvement to operate their power plants reasonably and efficiently so as to maximize returns.

The PPA enables independent power producers to sell electricity to Kenya Power at the FiT price for a fixed term of 20 years from the date of the project's first commissioning.

Once the PPA has been signed the applicant is due to apply for a generation license or permit from the National Energy Regulator to be issued in accordance with the Energy Act and Energy (licensing) Regulations. All the PPAs are approved and regulated by the Energy Regulatory Commission, with the following criteria:

- Proof of land acquisition, access or usage rights
- Full technical and economic feasibility study
- Grid connection plan
- Environmental Impact Assessment (EIA) License
- Other relevant permits and approvals engineering, procurement and construction Plan
- Evidence of financial capability.

The projects with capacity greater than 10 MW will be subject also to dispatch instructions by the system operator.

Lesson learned from mature markets and their local application

Examples from more mature markets like Europe and South America could be very useful for local application in Sub-Saharan region.

Europe RES incentive policy: oversupply and grid enhancement cost

In several European mature markets, like Germany, Denmark, Spain and Italy, high subsidies and generous incentive schemes triggered an unprecedented growth of RES over the last decade. Political willingness, increasing emphasis on offsetting climate change and adapting to its impacts together with a stable and growing electricity demand have further contributed to the renewables momentum.

After the world economic crisis of 2008, electricity demand plunged consistently creating an unpredicted oversupply situation that unveiled some of the drawbacks behind the rapid capacity growth, exacerbated by years of enduring economic stagnation.

With a fall in aggregate demand, conventional power plants face a long lasting decreasing load factor forcing them to remain idle for most of the time and unable to recover their fixed costs during peak demand period, due to the depressive effect of renewables generation (with low or zero marginal cost) on prices. As a consequence, many conventional power plants were forced to shut down or mothballing. This occurred in a situation where the larger participation of intermittent renewables increased the required reserve margins and the need of reliable and flexible generating capacity typically offered by conventional power plants.

The decrease in power prices has in turn put pressure on the long term incentives granted to RES. Over the past few years, several EU countries, like Romania, Bulgaria, Greece, Spain and Italy have cut incentives for renewables with the aim of reducing government spending and electricity bills as the heritage of past long term commitments were perceived as non-sustainable (also thanks to the sharp fall in RES costs that the long term commitments have allowed) due to the economic growth slowdown and demand stagnation. This while, at the same time, other European countries were lagging behind in reaching their own targets.

This, apart from leading to several international arbitration cases against governments, with a waste of time and money, has severely hit the credibility of governments *vis a vis* foreign investors.

In addition, many countries now face the issue of how to distribute the costs related to grid enhancements (which have been neglected in determining the cost of policies), indirectly caused by the rise of renewables.

Choosing the perfect technology, Chile 2000-2007

Up to 1990, Chile was developing its energy matrix with large scale hydro-dam energy, considering the abundance of natural gas in Argentina (located next to Chile), an energy interconnection protocol was signed between the countries in 1991. From that date the development of the Chilean energy matrix was mainly focused on the construction of combined cycles fuelled by natural gas; in the 1990-2007 period, three gas pipelines were constructed between Chile and Argentina, together with over 2,000 MW Combined Cycle (CC) plants.

However, in 2007, the gas supply for electrical energy production from Argentina was cut-off, as a result of an internal on going crisis.

As a result, in Chile natural gas had to be replaced by fuel-oil, increasing dramatically the energy production cost (from 25 USD/MWh to over 160 USD/MWh, depending on international oil prices[10]).

After this, the idea of a well-diversified and flexible generation mix became a priority of energies policy. From 2007 up to date, energy growth has been developed by mixing several technologies, such as coal (over 1000 MW), hydro (over 600 MW), 2 Liquid Natural Gas processing plants and over 2,000 MW of renewable plants, mainly wind and solar.

Oversupply and correct planning of transmission system, Chile 2012-2018

In Chile, the transmission system development is regulated by the government, also, considering that Chile is more than 3000 km long, the transmission projects are expensive and construction time is around 3-5 years.

The new transmission system investments were defined every 4 years, considering the generation and consumption projects informed by each project owner.

Between 2012 and 2014 many new consumption (mostly copper mines) and energy production projects came online, due to high copper prices and RES decreasing costs. However, most of the consumptions projects were not constructed or delayed (due to the decrease of the copper price) and the energy projects were far more than expected.

The result was an oversupply situation with the transmission system not capable of transporting all the energy production across the country, losing cost-efficient energy sources, such as coal and renewable energy, to supply the consumption.

As a result important modifications of the transmission plans were implemented:

- Introduction of a yearly review of the transmission planning;
- New investments can be introduced only if its importance for the transmission system it is clearly demonstrated;
- More information about new projects is now required, to each project owner;
- Transmission system had been strengthened with over 1,000 km of new lines (that will be ready in 2018), to fully use the country energy resources and not depend on a particular project for saving a transmission system investment.

Lessons learned

Developing a national energy infrastructure with a perfect balance between investments and end user tariff is a great challenge, no matter what, country, region or culture are involved. Large scale investment are required (e.g. the total installed capacity in Kenya can be valued to at least 2 billion USD of total investments) together with a stable regulatory framework and long term commitments. Every energy source has its strengths and weaknesses (in terms of predictability, associated grid costs, optimal scale, etc.) and the system needs and relevant conditions can vary over time.

To tackle all these issues energy policies should aim at coordinating all the system participants to develop the system as a whole, including demand, transmission and power plants.

[10] In 2009, combined with a lack of hydro energy production, due to a drought, raised the spot energy price to over 250 USD/MWh

The most common way to coordinate investments in generation supply and electricity demand is to call for energy supply tenders according to properly assessed demand forecast. However, with the blossom of RES, such as wind and PV, and they very short time to market, new problems arise, like oversupply in solar hours and displacement of efficient thermal units (fuelled by coal or natural gas). Pre-defined target levels of capacity per technology and for each network system node could help avoiding local oversupply and matching supply with demand profile. In addition transparency and predictability together with a market-based approach should characterize any RES incentive policy.

Supply/demand coordination

Which demand?

GDP growth, industrialization, extensive urbanization, electricity access, population growth, rising standard of living and the modernization of the agricultural and agro-food sector are the main drivers of electricity demand in Kenya.

Electricity access could be done by expanding the national grid, which requires large investments and cannot be done rapidly. Small scale and diffused generation (off-grid and mini grid) can help overcome the issue. When talking about off-grid solutions renewables could be the best answer in particular solar PV with battery back-up or AC solar micro-grids to distribute electricity to nearby homes and businesses. Also small wind turbines and bioenergy are potentially viable solutions for off-grid application.

The replacement of lighting system based on kerosene and biomass (dominant in rural and off-grid consumers) with PV battery based systems and modern technologies could further boost the electricity demand.

In Kenya an additional source of electricity demand could come from the modernization of the agro-food industry value chain that has a great potential in the country.

Increasing the electricity demand in a sensible way corresponds to a concept in which, the higher economic value of using more electricity is related to a profit gain by the user according to his own profit criteria that can be driven by economic profit, comfort, health, family, pleasure and/or other factors.

Some of the ideas that can be applied to Sub-Saharan Africa may be:

Seeding the demand through off grid solutions or focal points

The Ollague town in Chile, through a hybrid power plant solution (batteries, diesel, PV and wind), gain full 24/7 access to electricity and became a focal point for development of the area. After the full electricity access was achieved, consumption has grown 30% more than expected and families of towns nearby, moved to Ollague lure by the electricity availability.

Replacing other energy sources

Replacing open fire or burning biomass with electrical stove and heaters could be efficient instruments to increase electricity demand, security and quality of life.

Around 3 billion people cook and heat their homes using open fires and simple stoves burning biomass (wood, animal dung and crop waste) and coal. Over 4 million people die prematurely from illness attributable to the household air pollution from cooking with solid fuels [WHO,2016].

The potential gain in health for the user can be an important upside, that can help to get the funds necessary to cover the

appliances cost. Also, this new demand of electric appliances can foster local "entrepreneurs" to develop new homemade solution to address the problem.

Combining technologies to profit from renewable energy

A combined system of a solar thermal collector and electrical resistance [11] combines a renewable resource such as the sun, with electricity through the internal thermo resistance. This is a great solution for systems that use hot water with temperatures less than 60°C, producing savings around 50% of water heating cost.

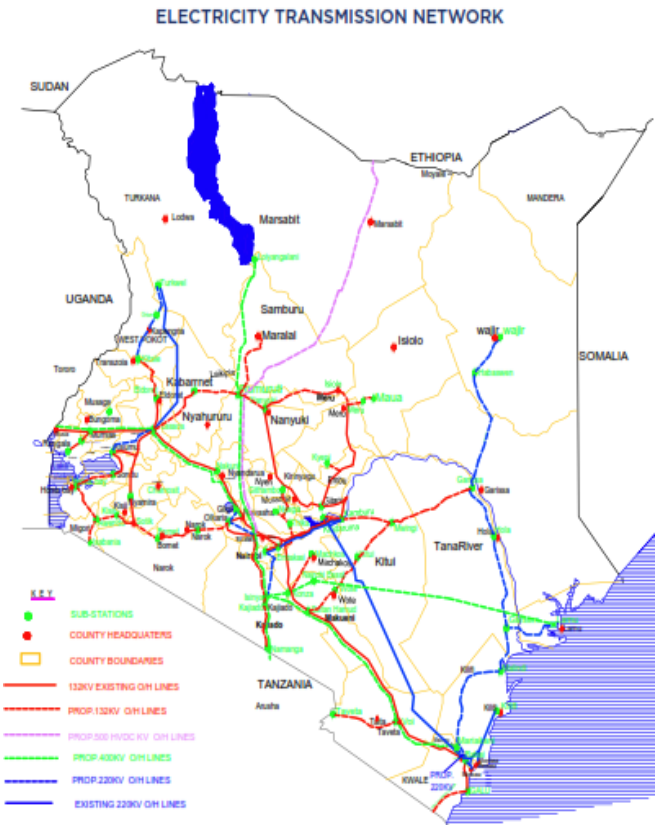


Developing electricity demand thought new economic activities

Electricity is one of the key drivers of sustainable economic growth (EU, 2011, Agenda for change); a better understanding of the local activities and economics can lead the way to make small but high impact investment for increasing economic growth and electricity demand. For example, a simple economic activity such as the gathering and sell of algae, done by a fisherman's village can be greatly impacted with a hatching system to breed the algae seed and improve its production and availability. Also, chopping and packaging system can be introduced to produce a higher value product. Now, thinking about solution that can be applied for the Sub-Saharan area and considering the over 3 million users of rudimentary stove, an interesting idea could be to design and develop the use of a basic electrical stove. There are some designs based on the use of a brick and electrical resistance that can be upgraded to produce a safe electric stove. Furthermore, there is possibility to create a new local industry of these appliances that can aid to develop wealth of families and increase electricity demand.

Electricity exchanges and regional cooperation: a risk mitigation tool

Currently Kenya's electricity transmission network is interconnected with Uganda, Tanzania and Ethiopia and has set up an ambitious grid development plan in order to achieve the electrification target (universal access by 2030).



Source: Kenya Electricity Transmission Company Limited (KETRACO)

[11] The electrical resistance is used as heater to maintain the water temperature during non-solar hours.

Government's goal is to significantly cut electricity import from Uganda and stop importing electricity from Tanzania, while import from Ethiopia could be stopped only after the construction of a new 500 kV DC line that will link the Moyale County to the national electricity grid.

Empowering the grid and extending the interconnections and trades with neighbouring countries has significant positive effects that include:

- Higher security of supply and system stability through an increased and more differentiated generation mix;
- Lower level of reserve margins required that could be shared among obtaining higher economic efficiency;
- Lower country specific risks;
- Capital saving, as the need to invest in new power stations is reduced, spare capacity could be shared and power could flow from areas with surplus to areas of deficit
- Higher level of competition
- Cheaper tariff for end users
- Higher electrification rates of remote areas
- More organic development with greater absorption of intermittent RES.

It was exactly with the aim of exploiting these benefits related to higher regional cooperation, that in 2005 was established the Eastern Africa Power Pool (EAPP). Today the power pool has 10 countries as members, namely Burundi, Democratic Republic of Congo (DRC), Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, Libya and Uganda. The EAPP is being supported by the US government, the World Bank, African Development Bank and the region's governments.

Today total power trades are still limited between EAPP members as some requirements are still lagging behind. Nowadays there is still no sufficient transmission capacity between countries and the development of major cross-border transmission lines is fundamental to foster cross-countries power trades. In addition the funding of these required investments must be properly assessed. Eventually, as the investments require several years to be completed, a certain level of political stability and acceptability are essential for the success of the power pool.

Final recommendations

Currently more than 70% of Eastern African countries population (around 180 million people) is without electricity access, due to lack of urbanization infrastructure (i.e. transmission and distribution grid) and low GDP per capita in the rural areas. This framework determines an apparent no-energy consumption or no-energy demand in rural areas. So far, about 50 % of energy demand has been absorbed by light industry with a double-digit increase in the last decade that is expected to continue also in the future with a growth rate around 6-10 %/year.

On the generation side, the governments' focus and priority have been to increase the supply of reliable and competitive power, primarily through indigenous resources (hydro, coal, geothermal and, until recently, LNG formed the bulk of proposed capacity). RES, notably wind and to a lesser extent solar, are part of the scheme and are increasingly important but do not enjoy a prominent role in the energy mix at the present time. RES could have a great potential also for the off-grid electrification of the country, acting as the most suitable substitute for biomass that is the main energy source of household in isolated and rural area. However electrification alone will not be sufficient as electricity access

must be linked with consumption that must be properly assessed and stimulated (e.g. by replacing other energy sources or by developing new economic activities).

Another key driver for the increase of the energy demand will be the development of the agro-food chain that, together with the continuation of industrial demand growth could prevent the risk of future oversupply.

Long term and well designed planning combined with a real coordination between supply and demand are essential in order to avoid unnecessary investment (e.g. oversupply) and/or a waste of resources. To manage the transition from a "non electrified" contest to a full energy access, the conventional business model, based on a top down centralized approach, will probably need the support of an innovative business model deployed through the installation of RES and off-grid systems.

With the support of proper stimulus measures on the demand side, this bottom up approach could lead to sustainable demand growth for the next decade close to 10%/year.

Lastly, regional cooperation will provide the region with an unparalleled opportunity to provide low cost power and triggering the economic growth, but key institutional and planning challenges must be addressed. Along with investments on the grid, interconnections and generation capacity, governments should ensure a business friendly environment to foster local and foreign investors. Only in that case more electricity will lead to increased economic activities otherwise it would be costly.

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De-risking Renewable Energy Investments

Lessons to learn, steps to take

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Abstract

Renewable Energy (RE) sector represents an important source of sustainable economic growth possibility for developing countries, such as those in Sub-Saharan Africa region. In order to boost RE sector and draw attention of foreign investments, an attractive and reliable market design is required. Policy framework with specific support mechanisms, as well as all economic agents involved in electricity generation, transmission, distribution, retailing and trading, constitute market design and therefore their influence needs to be taken into consideration. Moreover, different political or social characteristics and specific technicalities of the power sector vary from country to country resulting in different set of risks. This paper identifies thirty-six potential risk-issues grouping them in five main areas and elaborating them on practical examples (both outside and inside SSA region). In order to mitigate the risks and encourage investments in RE, Governments have been implementing diverse policy instruments. Feed-in Tariff Fit) and auctions have emerged as currently two most popular support measures. The paper focuses on presenting pros and cons of each of them, both theoretically and with the real examples and makes recommendations on when and how they should be implemented.

Background

RE technologies have experienced rapid deployment over the past few years, mainly driven by the ambition to improve energy security,

enhance energy access and mitigate climate change.

Many countries are now exploring ways to stimulate social and economic growth through the development of the RE sector, in particular in developing countries such as Sub-Saharan African (SSA) area. Investment in RE can generate new sources of growth, increase income, improve trade balance and contribute to industrial development and jobs creation. However, investments in RE require large up-front investments. With scarce public funds, governments rarely can afford the entire cost of RE deployment.

Thus, RE strategies have to take into account the involvement of private sector investors and their requests in order to benefit fully from the socio-economic impacts of RE.

Private investors are motivated by profits and, in order to embed RE projects and further their development in the SSA region, government has to ensure a proper and reliable framework, both in regulatory and economic terms, ensuring investors with an economic viability and profitability.

There is an identifiable need for well-targeted government investment incentives and support mechanisms in order to develop private investment in RE in SSA. Investment promotion, a reliable and stable policy framework, and facilitation measures and incentives, if well-managed, are effective instruments to attract investments.

Objectives

This position paper intends to highlight pros and cons of the known RE investments-related policies in the African countries and, in general, all over the countries where successful policies have been implemented so far.

The objective is to provide the best and the worst practices to learn by when developing RE enabling policies, avoiding experienced mistakes.

Furthermore, the paper identifies all relevant risks faced by investors and aims to explain how they affect successfulness of a policy.

Main Issues

RE technologies have been publicly supported for several decades but the specific reasons saw a number of changes over time.

Support policies to the development of biofuels and RE generation were part of the public effort aimed at ensuring and diversifying energy supplies and providing technical solutions during wars and oil crises, or to mitigate air pollution and climate change effects. Those policies brought in the years sound programmes for R&D of photovoltaic cells and wind turbines in Europe and the US, as an effective tool to reduce dependence for instance from high and volatile oil prices.

However RE support policies are only part of a wider concept of *market design*, where also wholesale/retail market design and essential system services contribute to define regulatory and policy frameworks for the power sector.

Market design therefore, requires a set of rules governing the interaction of all the economic agents involved in electricity generation, transmission, distribution, retailing, and trading to reach the ultimate goal of the ***economic welfare***.

The achievement of final goal is indeed an optimisation problem with three major constraints to be taken into account, necessarily:

- Policy objectives;
- Operational constraints;
- Wider energy system

IEA[12] for instance has recently structured a logical scheme to describe this framework by using five criteria to define a good *market design* and policy framework for the whole electricity sector. Each of these criteria would bring **potential pros and cons** to be analysed when designing regulatory solutions.

1. **Short-term efficient operation** and dispatch of existing assets. This means a given service should be provided, once defined the level of quality, at the lowest economic cost.

	Pros	*Cons*
Demand	Enjoys a good standard at a reasonable price	Suffers a quality service lower than the price charged
Offer	Avoiding extra operational profits	Inability to create margins and market depression

2. **Long-term efficient investments** in new assets where the market design should incentivise the right (cost-efficient) amount, the right type and the right location of assets. In this case social welfare should be optimised.

	Pros	*Cons*
Demand	Enjoys externalities as security of supply and low carbon emission	Side effects by system constraints and no cost effective service
Offer	Fair profitability of investments	Difficulty to find financial resources

3. **Appropriate allocation of market, project and political risks** between generators investing in conventional and renewable generators, customers, other market players and the government. Regulatory risk shall be used as a threshold to ensure the correct level of investments and to avoid market entrance barriers or free lunch.

	Pros	*Cons*
Demand	Sound contribution to the development of RE	Uncertainty in tariff and price to be paid
Offer	Willingness to invest and to operate	Uncertainty in cash flow and business plan

4. **Efficient long-term rent allocation** between different market players that are unsustainable in the long term. *Market design* should be proof of potential arbitrage or strategic behaviour.

	Pros	*Cons*
Demand	Fair payment maintaining the business profitable	Cross subsidisation from customers to generators
Offer	Avoiding distortion among players and ensuring equity in the market	Potential creation of stranded assets

5. **Pricing externalities** including for instance carbon emissions or more general power system externalities such as security of supply.

	Pros	*Cons*
Demand	Pays and enjoys externalities as security of supply and low carbon emission	Suffers the negative externalities or over pays the service
Offer	Receives fair incentive to investment and operation	Creates negative externalities

[12] IEA-RETD, Electricity Market Design and RE Deployment (RES-E-MARKETS), *September 2016*

All these criteria are required from the several parties (both public and private) in the power and RE market: consumers, producers, investors, financers, technological suppliers, market operators, public authorities and external stakeholders.

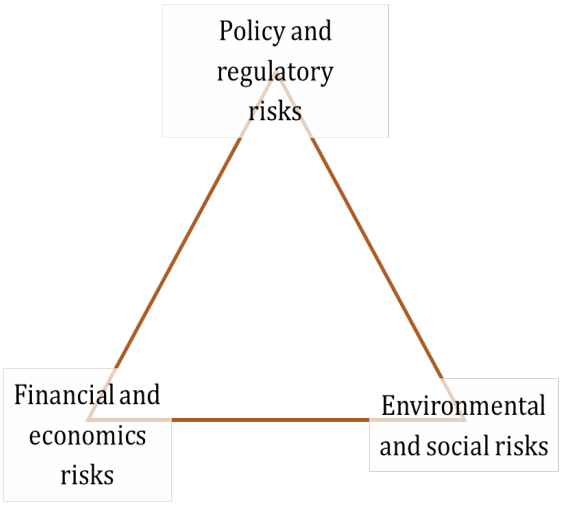
Since public funding in renewables is unlikely to increase above its current level of 15%, as foreseen by IRENA, private finance will have a crucial role for new investments. In particular, institutional investors will be able to scale up RE investment.

The OECD estimates that around USD 2.80 trillion per annum is potentially available from pension funds and insurance companies for new clean energy investment in developed countries. However, this amount of money needs to encounter favourable regulatory frameworks to be employed; otherwise, it will find new paths of use.

Risks

Given the different political or social characteristics and specific technicalities of the power sector in each country, it is often impossible to reconcile the several constraints and to find an optimal regulatory design solution.

This may **enhance the business risks** to be taken into account when deciding to perform new RE investments in a given country. Risk perception of a country is a "*three-headed monster*".



Five main risk areas may precisely give shape to the perception, namely:

1. **Risks related to the legal framework** enabling generic and RE investments;
2. **Risks affecting the revenues** side of RE investment;
3. **Risks affecting the costs** side of RE investment, both during construction and operation;
4. **Risks affecting financial structuring** of RE investment; and finally
5. **Risks related to environmental and social issues**.

Area		#	Issue
1 Legal framework enabling	Business Environment Framework	1	Starting a business
		2	Property/concession rights
		3	Labour issues
		4	Dispute resolution issues
		5	Business travel rules
	RE Investment framework	6	RE regulatory framework reliability
		7	Rules favouring market opening to IPP
		8	Grid capacity and reliability
		9	Grid access rules
		10	PPA/FiT schemes
		11	Competing policies
		12	Institutional actors' roles and responsibilities
2 Risks affecting Revenues		13	Revenue stability
		14	Availability studies covering resource assessment
		15	Risk of curtailment
		16	Ease of profits repatriation
3 Risks affecting Costs	Construction	17	Permitting
		18	Availability of local skilled workforce (construction phase)
		19	Availability of experienced local manufacturers (construction phase)
		20	Logistics (construction phase)
		21	Security (construction phase)
	Operation	22	O&M weight due to local conditions
		23	Spare parts availability
		24	Availability of local skilled workforce (Operational phase)
		25	Availability of experienced local manufacturers (operational phase)
		26	Logistics (operational phase)
		27	Security (operational phase)
4 Risks affecting financial structuring		28	Long term financing availability
		29	Short term credit availability
		30	Interest rate risks
		31	Exchange rate risks
		32	Currency convertibility
		33	Inflation risk
		34	Tax regime
5 Environmental and social issues		35	Environmental impact assessment procedures clarity
		36	Social acceptance

These areas can be then decomposed in **36 relevant issues** in order to get a more complete and detailed view of the risk perception of each one.

It is interesting to notice how the risk perception of a certain issue can influence the perception of risk on the other issues and overall of the country, either in positive or negative way. Correlation among the risk perception is often strong when considering issues in the same area, however risk perception may also affect other areas. This is especially true when two issues have a common direct object.

Practical examples

Let's examine the influence of *currency convertibility* issue. A negative influence of this risk-issue can be observed on the case of **Egypt**. The country has carried out strong and investment-attractive RE reform by opening the power market for competition, implementing ambitious RE

targets and offering the highest Feed-in Tariff (FiT) among all the countries in the region. Despite all the appealing efforts by policy makers, many international developers decided not to invest in Egypt due to lack of foreign reserves and extreme difficulty for currency convertibility. This had negative slipover effect on the whole financial area and significantly decreased overall evaluation of country's attractiveness.

On the other side, case of **Jordan** can demonstrate how with a right approach by policy makers currency convertibility risk can be completely mitigated, and even further, how it can be used to increase attractiveness of a country. Namely, the Kingdom has set prices in dollars, instead of local currency. Moreover PPA payments are directly in U.S. dollars, avoiding in this way, risks concerned the currency convertibility and exchange rate. Beside developers, many multilateral development banks appreciated this possibility and increased their presence in the Kingdom. In recent years, for example, it has been addressed by one of the most innovate financing scheme "Seven Sisters", aggregating for seven smaller scale PV plants for a total amount of $207,5 million.

Across the **East Africa** region the most often identified risks include poor grid infrastructure, low levels of liberalisation in both power and renewable sector, low diversification of sources in energy mix (instead remain reliant on hydropower sources), policy instability and difficulty related to access to finance.

Kenya emerges as one of the leading countries for RE in the region. The level of privatisation is improving but still remains relatively limited. The regulatory framework enabling investments is favourable, due to attractive subsidies offered to developers. The country has successfully dealt with the financial risk area by decreasing the inflation rate and arranging support from multilateral development banks. For example, together with Tanzania, it has received an USD145mn loan from the African Development Bank (AfDB) for construction of transmission line between the two countries, as well as an USD457.5mn loan from the World Bank to improve its grid infrastructure.

On the other hand, projects typically face time-consuming delays, stemming from local opposition to projects, such as in the case of Lake Turkana Wind Power project. Taking into account comprehensive evaluation of the labour, logistics and security risks, Kenya lags slightly behind the regional average.

Moving beyond, the main issue in **Ethiopia** is the overreliance on hydropower, which combined with climate change and droughts creates the risk of disruptions to the electricity supply. Although Ethiopia still does not have a notable number of non-hydropower RE projects, it is expected to become one of the leaders in terms of installed RE capacity, especially wind and geothermal, as the potential resource bases are largely untapped. The country has started upgrading the infrastructure under Growth and Transformation Plan (GTP) that aims to improve low electrification rates.

Ethiopia experienced impressive GDP growth in recent years and it's economy is expected to be one of the fastest growing in SSA region over next 10 years. It enjoys presence of development bank funding and Chinese credit. While still relatively elevated, inflation has been stabilized during 2012 and 2013. The Government has taken various measures including strict monetary and fiscal policies to overcome inflation issue. Therefore, the country does not experience particular financial risk.

Despite some initial steps toward liberalisation and greater presence of IPPs have been taken, the country remains limited for private investment in the RE sector.

As most of the countries in the region, **Tanzania** largely depends on hydropower that contributes almost 40% of total electricity generation. Furthermore, electricity grid necessitates improvements and RE sector requires higher level of liberalization. Recently, many projects have advanced to the construction phase, as a consequence of an announcement by Tanzania Electric Supply Company (Tanesco) that it will follow a strategy diversifying from hydropower.

Regarding the risks affecting legal framework, Tanzania took various steps such as creation of the One Stop Investment Center, which unifies all relevant governmental agencies in one location to facilitate the provision of services to investors. Moreover, the country is a member of the Multilateral Investment Guarantee Agency and International Centre for Settlement of Investment Disputes.

Mitigation measures

In the previous chapters, risks that developers may face during an investment process and their influence on policy outcome have been identified. Governments are implementing public instruments aiming at reducing the related investments risks, as for example:

- Feed-in Tariff schemes (FiT);
- Auctions;
- Third Party Access (TPA);
- Net Metering;
- Quota Systems, etc.

Following the slogan *"any risk should be properly remunerated"* both in European, US or Mediterranean countries as well as SSA countries, FiT and auctions, are necessary features to attract private sector requiring sustainable, profitable and bankable investments.

Over the past decade **FiT** has been characterized as one of the most successful support mechanisms to incentivise deployment of RE and its application has been rapidly spreading. Although it is important to keep in mind the extensive experience in policy design already acquired, there is also a crucial need to keep up with innovation.

RE sector is particularly prone to often changes and technology advances. Lately, there has been a notable shift of factors that have influence on RE policy, such as evidently lower costs of RE technologies. Consequently, determination of right level of support (right level of tariff in FiT case) has become even more challenging and policies more unstable.

In several markets, **auctions** are substituting FiTs as the solar procurement policy of choice. The recent report from GTM Research notes that the number of countries with FiT has dropped by 22% since 2014. By contrast, the number of countries utilising auctions to boost solar demand has spiked by 92% in the same period, jumping from 14 countries to 27.

Besides finances, the success of FiTs has also refreshed grid-integration concerns. As much as anything, FiTs have lost favour because they do not incentivise the cost reductions essential to make solar competitive with other sources of generation.

Auctions provide the downward pressure on costs and also have added transparency benefits. On the other side,

there are valid issues about auctions. In particular, there is little dispute that auctions offer an effective tool for signing

lots of PPAs at attractive prices, it's less clear whether the solar power plants will reliably produce electricity over the long term.

Tariff-based support schemes for RE have been used in an increasing number of countries over the last 10 years. Although FiT is still the most popular mechanisms, the use of auctions is increasing worldwide. Policy learning between countries is an important driver for improving policy design.

	Strengths	Weakness
FiT	Generally attractive even for low-risk investors	Costly when high deployment rates are achieved
	Reduces the risks for investors also in emerging technologies	In case of large premium offered, high system cost
	Simple structure, applicable to mass market technologies	Tariff setting and tariff adjustment process is challenging and complex
	Accelerates the penetration of new players in the market	Generation is not exposed to electricity market prices
	Can be flexibly designed to accommodate different policy objectives	No really meritocratic approach
	Often funded by consumers and not exposed to public budget cuts	-
	Drives industrial improvement in RE technologies	-
Auctions	High cost efficiency due to price competition	Discontinuous market development (stop-and-go cycles)
	Useful to establish competitive pricing	Remuneration value strongly linked to competition level
	High investor security if auctions are linked to long-term PPAs	Relatively high risks of not winning the project for high investment costs from bidders
	Useful for volume and budget control	High administrative cost make them not adequate for small size projects
	Well scheduled auctions can increase the predictability RE supply	Underbidding and need for penalties
	Specific capacity targets can be set in short span of time	-
	Meritocratic mechanism with cheapest and higher quality projects selected	-
	Learning effect over time for both parties	-

South Africa: Lesson learned

South Africa can offer a valuable lesson for other developing and emerging market economies regarding supporting mechanisms for RE projects, due to it's experience with both FiT and auctions. In 2009 National Energy Regulator of South Africa (NERSA) launched a *Renewable Energy Feed-In Tariff (REFIT)* policy. The initial tariffs were perceived as quite generous by developers and policy makers soon had to drastically decrease tariffs (25% lower for wind, 13% lower for concentrated solar and 41% lower for photovoltaic). The period was characterized by policy and regulatory uncertainty.

Not long after, during 2011 NERSA decided to change policy and approved *Renewable Energy Independent Power Producer Procurement (REIPPP)* programme. Until the time of writing this paper two rounds have been launched and both are considered as a big successes: they caught interest of multiple international developers and attracted sound investments (53 bids in round one and 79 in round two, out of which 28 met the minimum qualification thresholds in round one and 51 in round two). Following the first round, second even

further fostered competition and pushed prices still down. It is believed that those prices and short time in which they were achieved would not have been reached with FiT programme.

Critical factor for success and main results:

- **Long term** (2030) capacity development **planning** (Integrated Resource Plan);
- **Public confrontation** and timely engagement on critical issues;
- **Extremely detailed RES plan**, with clear yearly planning by technology;
- **5.2 GW approved** in four bid rounds;
- **USD 3.1 billion investments** attracted only in the Q1 2015;
- In round IV awarded 1,1 GW at some of **the cheapest tariffs globally** (Wind 52$/MWh, PV 66 $/MWh) and planned auction for additional 6.3 GW.

Recommendations

All evidences reported above clearly state that, in the optimisation of market design, the three major constraints might create risks area to be addressed before investing in a country. By experience, despite many risks can be related to the macroeconomic and legislative environment, public incentives strongly helped to overcome a number of barriers and remunerate risks.

Especially in the era in which skills and expertise can be transferred at low cost, it is necessary for SSA countries, extremely rich in renewable potential, to build on lessons learned by the other countries and make decisions accordingly.

As a **first point**, internationalisation and market openness are essential to create the correct investment environment and to better receive foreign investors.

SSA countries often suffer from a lack of bankable projects that are large enough to justify commercial loan syndication and remain non-investable without comprehensive risk coverage. The main financial risks to slow down the investment are:

Currency. Tariffs in local currency cannot go unhedged. To manage this risk Nigeria had signed a currency swap with China.

Sovereign. The continent is a hub of sovereign risk for wars, civil unrest and exposure to commodity prices volatility. To manage this risks Angola used the MIGA (Multilateral Investment Guarantee Agency) political risk insurance for a hydro project.

OFF-taker. Off-takers in Africa are often not bankable. To manage this risk Kenya offers the World Bank PRG guarantee.

As a **second point**, technical assets and dispatching potential shall be adequate to RE targets. Governments that want to rapidly address infrastructure shortfalls in the region should remove regulatory barriers to customer-sited generation (both on and off grid) and encourage greater grid development.

The **third point** refers to incentive mechanism. On this issue, it is essential to dynamically optimise the use of the two mechanisms (FiT and auctions) in perspective of an evolutionary regulation to avoid poor results, or even worse, the unjustified extra costs for the systems.

Experiences in fact, suggest considering FiT incentives as a "*transition mechanism*" acting as an essential tool behind the creation of the main requirements for a sustainable RE market, efficient and fair. Foreign investors and industrial players, although with great expertise and financial capabilities, might be accustomed to "familiar standards" and contexts more similar to their home

country. To remedy this natural divergence with SSA countries, a FiT mechanism, whose **strength and duration** is able to properly stimulate those players, might also allow an easier and rapid transition from a nascent to a launched and mature RE market.

If market signals show need for a secure stimulus to find the optimal allocations and to achieve the appropriate competition levels, it is then the case for a structured FiT mechanism. Otherwise, in case signals push to open the market, after a deep evaluation of the status of learning curves and of the real costs for the several RE technologies, auction system will be more appropriate to ensure the correct development of RE in SSA countries.

It is not even excluded that those *well-advised* auctions will not link additional capacity to a specific technology, but rather make technologies competing with each other in order to ensure the greatest levelling of costs. This would be particularly effective in case of utility scale projects and not for small scale distributed generation.

In conclusion, while competitive auctions have lately proven more successful at ensuring fair PPA prices especially for large-scale projects, both FiTs and auctions will continue to play an important role for SSA energy sector in coming years if rolled out in a stable and transparent way.

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Unleashing the power of human capital for effective deployment of RES in East Africa

This paper has been prepared by

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Abstract

Capacity building at both individual and institutional levels plays a key role in ensuring the success of energy access strategies and complementing the technical, financial and political efforts. Capacity building needs to go beyond adding a training component to any intervention. It needs to be designed to fully deploy the power of human capital as one of the crucial assets of any community. As highlighted by Agenda 2030, innovation and shared knowledge, as well as new competencies, capacities and skills, are deeply needed to cope with today's challenges. The role and centrality of human capital is especially relevant within a transformative path for universal energy access. People-oriented and people-driven approaches need to be designed and adopted. In this context, capacity building becomes the leverage to achieve local ownership and long-term empowerment – the true engines of the needed transformative path.

Background and Introduction[13]

A paradigm change is requested if we wish to support the **penetration or Renewable Energies (RE) within the Eastern African region** and more in general in the whole Sub-Saharan Africa.

In line with the vision of the 2030 Agenda for Sustainable Development **"no one be left behind"** and the clear focus on people, the cross-cutting role of human capital (individually and collectively, as communities and institutions) has been awarded with a crucial role.

Indeed, without the proper **human resources**, it is recognized that it will be not easy to achieve the **transformative change for sustainable energy**

[13] The contents of this position paper are a short summary of a more extensive work: E. Colombo, L. Mattarolo, S. Bologna, D. Masera, "The Power of Human Capital: Multi-level capacity building for energy access", Special Feature Paper to the Sustainable Energy Annual Report, (expected) 2016, The World Bank

strategies that is requested by the today challenges of the African continent. The **right skills** and **competencies** are needed for the design, uptake, and sustainable management of technologies, business models, and enabling policy framework. At the same time, the introduction and adoption of new or improved RE technologies require new skills for installation, maintenance, and service. The **new and diverse energy markets** require that different players understand their role. Among them we count consumers, communities, policy makers, regulators, and financial institutions.

In strengthening the **role of people throughout the entire energy supply chain** – from production to users – capacity building and training activities may develop the local expertise needed to replicate and scale-up successful initiatives, support ownership of stakeholders, and **foster long term sustainability.**

Objective: human capacity and sustainable energy strategies

Sustainable Energy Solutions are pre-requisites for improving the quality of life and enabling the socio-economic development. Appropriate energy solutions and technology choices must respond to the **needs, capacities and aspirations** of people and **be absorbed within the indigenous culture**, adapted and later improved at local level. For these reasons, people should be at the centre of any energy solutions and capacity building an asset for long term strategy.

Over the past 20 years, there has been a major rethink of the concept of capacity building. To begin with, the notion of "capacity" has evolved from one that focuses on the ability of organizations and people to be resilient and successful to one that focuses on self-reliance. Here, the emphasis is on the **ability of individuals**, organizations, and societies to set and achieve their **own development objectives**, and the **ability of human beings to perform, self-sustain, and self-renew**. There is also a recognized need to go beyond the direct equivalence that defined **"capacity building as training"** and to extend the functional dependency of capacity building toward a wider vision of **education as a fundamental human right**. This approach is also in line with the original statement included in the 1992 UN Sustainable Development Agenda 21: "*The ability of a country to follow sustainable development paths is determined to a large extent by the capacity of its people and its institutions that complements its ecological and geographical conditions*." Such a holistic vision includes various sets of actions like: (i) **building abilities**, relationships and values; (ii) strengthening **the processes and the rules that influence collective and individual behaviour**; and (iii) **enhancing technical competences, soft skills, and attitudes** to enable them to be proactive players for development. This viewpoint is also highlighted in the report by the International Energy Agency (IEA) and World Bank's **"Sustainable Energy for All 2015 – Progress Toward Sustainable Energy,"** which includes capacity building as one of the four complementary themes that are crucial for making any progress in broadening energy access solutions.

Main task: learning from international experiences

Despite a common framework suggesting the most relevant action to be done in the field, the experience of four international entities may provide some general insights and approaches to drive future

strategies for capacity building and empowerment.

UNEP: energy & environmental nexus

UNEP (United Nations Environmental Program) has a strong interest in energy. On the one hand, the production and use of energy may induce **a number of environmental problems** at the local, national, regional, and global level. On the other hand, a lack of access to energy **hinders the economic and social development** of billions people. UNEP is working with countries to help them meet the challenge of sustainable energy from a **life-cycle perspective**. This includes varied approaches, like analysing energy policies, climate change mitigation, energy sector reform, and industrial energy efficiency. UNEP focuses on enabling decision makers to deepen the link between energy choices and sustainable development, and helping financial institutions profit from the good investment opportunities available. It also works on strengthening an informal network to build a global community of sustainable energy practitioners.

IRENA: renewable energies

The International Renewable Energy Agency (IRENA) is an intergovernmental organization that supports countries in their transition to a sustainable energy future and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource, and financial knowledge on Renewable Energy (RE).

IRENA operates on the principle that the process of **empowerment needs to be comprehensive, issue-based, regional, participative and accountable**. In keeping with this principle, it supports that readiness and capacity need to be assessed, given that RE requires a **systemic shift and additional skills and competencies** that can: (i) apply to off-grid or on-grid, and (ii) be used at a variety of levels, such as residential, industrial, and small or large scale.

UNHCR: energy in humanitarian aid

UNHCR (United Nations High Commissioner for Refugees) has recently defined a first strategy to promote appropriate household fuel and energy technologies (including the expanded use of RE) to improve the protection and well-being of refugees. **Capacity building** is recognized as one of the essential elements to ensure the strategy's success.

The strategy will seek to integrate energy requirements into **emergency preparedness and response**. Moreover, **innovation** needs to play a crucial role in humanitarian settings, either for technological solutions or for funding opportunities. UNHCR believes that an effective strategy needs to be based on multi-stakeholder partnerships (including national entities) and should empower the humanitarian actors as well as the refugee community by also creating synergies with other sectors.

GEF: from environment to energy

The Global Environment Facility (GEF) was established on the eve of the 1992 Rio Earth Summit to help tackle our planet's most pressing environmental problems. Its interest in energy is thus mainly focused on the impact that the energy sector may create on the environment. The GEF strategy on capacity building is designed around a number of principles: partenership so that multi-stakeholder consultations and decision-making processes can be held at the regional level; a comprehensive and holistic approach so that the dynamic nature of capacity building may be acknowledged by adopting a learning-by-doing approach; national ownership and leadership need to be acknowledged so

that capacity building efforts are based on a sort of self-needs assessment.

UNIDO: from consumer to prosumer

Energy is a means to achieve sustainable development and **not an end in itself**. Rather, the success of energy initiatives will be measured by the improved health of the beneficiaries, number of new jobs created locally, number of lives saved, increased local/national economic output, and increased level of education – and not just kilowatts per hour of energy generated.

Within this frame, **the traditional energy chain will soon no longer exist**. The energy supply chain from the generation plant to the consumer, once fairly switching away from a few large centralized power plants coupled with widely extended distribution lines, is evolving into a more flexible, upgradable, and diverse model that focuses on distributed energy generation based on Renewable Energy Technologies (RETs). **Consumers are turning into producers,** transforming the energy conversion chain into **a multi-dimensional, multi-layered energy matrix** that is growing more complex and articulated. The search for effective solutions to increase energy access in developing countries has led to the recognition that industries can and should play a crucial role. **Industries that generate their own energy can also increase their income** by selling excess energy and providing an essential community service. A win-win situation can be established by increasing the **efficiency of energy processes** in industries through the **use of waste**; or applying any **source of RE**, along with introducing **electricity as a revenue stream**. The diversification of products and services by local industries increases their resilience and market competitiveness and simultaneously contributes to developing the local community. Local industries that both produce and use Renewable Energy Sources (RES)s (such as solar, wind, and bioenergy) for their own needs, along with selling the excess energy to the surrounding community, can be defined as "industrial prosumers." This innovative model is based on the fact that local industries possess the necessary business capacities to run an enterprise and therefore represent a low hanging fruit in the expansion of energy services for the local community. Nevertheless, on top of the business capacities, local industries need the support of energy specialists, technicians, operators, researchers, investors, and supporting institutions (such as governments, universities, and financial organizations) to become effective industrial prosumers. Expanding capacity building initiatives to develop and retain a skilled workforce to meet these new opportunities will be critical to ensure that new energy markets are developed to achieve the goal of sustainable energy for all.

Recommendations: innovation and creativitiy for capacity building

To facilitate the transformative change that is required to scale up Sustainable Energy Strategies, promoting the penetration of Renewable Energies and assuring Universal Access to all, from the case studies presented, some recommendations might be drawn. They will be essential for fully unleashing the power of human capital and the pillars around which any future innovative scheme need to be developed

- **Diversified targets**. Capacity building should address different beneficiary groups, which may have different access to training opportunities at technical, vocational, or institutional levels.

- **Different skills**. Capacity building interventions should be diversified to address the different needs for skills existing at different levels of the energy supply chain and within different local contexts – and be aligned with the ability of the different target groups.
- **Multitude of stakeholders**. Due to the diverse nature of the required competences, a variety of local, national, and international stakeholders should be involved (even beyond the traditional players of the educational systems).
- **Life-cycle perspective**. People are the catalyst and the drivers of change. Their capacity needs to be developed all along the supply chain of the design solution, and within this approach, linking skills and work needs to be a guiding principle.
- **Comprehensive approach**. Capacity building for energy access should encompass a comprehensive approach based on human, scientific, organizational, and institutional capabilities.
- **National/regional and local strategies.** The need to strengthen national capacities should be shared by all countries and should be able both to drive national-based priority definition and regional coordination and to assure the support to project-based or specific local actions.
- **Teaching tools**. A mix of tools may be used, varying with the targets and the expected learning outcomes (including training, seminars, workshops, on-the-job tutoring, and site visits).

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Fact Sheet presented by

Performance and Impact Evaluation

An integrated framework for energy projects

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Abstract

The global society is facing a number of interconnected challenges which are highlighted by the Agenda 2030 of the United Nations and the associated 17 Sustainable Development Goals. Within these global challenges, energy plays a relevant role, essential to the achievement of basic human needs, to the socio-economic development of countries, to environmental protection and global security at international level. Given this interconnection, a proper evaluation metric able to assess the effects of energy projects on a comprehensive base becomes necessary, not only in terms of energy provided, but rather on the changes of community livelihoods and the positive effects on social, economic and environmental levels brought by the actions on the long term.

Starting from this perspective and relying on the most recognized and utilized evaluation frameworks, as the criteria of DAC-OECD, the Results Chain and the Sustainable Livelihoods Approach by DfID, this study proposes an Integrated Performance and Impact Evaluation Framework, structured in two phases: an internal, project-based, which assesses projects in terms of performance, and an external one, people-based, focused on the project impact on the beneficiary communities in terms of livelihoods changes.

This model provides information and quantitative results for comparative analyses among projects and feedback for decision making, in order to orient policies and strategies in the field of sustainable energy initiatives.

What is Energy for?

Over the last decades, the interest of the international community for sustainable development and the multiple interconnections among energy, environment and society has widely i

ncreased. Different initiatives have been promoted, though with a common feature of overcoming the fragmentation of different competences and disciplines in favour of the integration of economic,

environmental, and social objectives across sectors, territories, and generations. This holistic approach of sustainable development, embracing complex systems such as global economy, social interactions, change in earth process, governance regulation, has been clearly remarked in the 2030 Agenda recently launched, where interlinkages are embedded within the new paradigm of the 17 Sustainable Development Goals.

The centrality of energy within sustainable development is definitely marked: energy has started to be considered as a key mean for unleashing development, supporting local enterprises and creating new jobs, improving health and education, in addition to assure sustainable and equitable access to basic needs. Despite the relevance of energy in the development framework, 1.3 billion people today still do not have access to electricity, 2.7 billion depend on traditional biomass for their own domestic use and around a billion do not have access to a reliable electricity grid. These numbers are not likely to change significantly in the near future, even under the most optimistic scenarios in terms of population growth and energy strategies.

An evaluation metric for assessing impact from people's perspective

In this framework, the adoption of an evaluation metric able to address the complexity and interconnections of current challenges has become necessary. Indeed, proper communication and reporting of undertaken programmes represent useful instruments for involved stakeholders, in terms of accountability, for setting priorities and to guide and better address future interventions.

Starting from this perspective, in the field of energy it is therefore important to assess performance of actions and their long-term impact, not only in terms of energy services provided, rather in terms of their contribution to local development and improvements in the community livelihoods. These evaluation metrics may then allow proper formulation of incoming projects and targeting future strategies. However, today no standardized and shared evaluation frameworks yet exist and most evaluation metrics are not only qualitative and poorly structured but are also difficult to compare, differing one from each other.

In the attempt of harmonization, the Development Assistance Committee (DAC) of the OECD has proposed some evaluation criteria, which are globally recognized and utilized and which can be assessed along Results Chain of a project (input, activities, output, outcome, impact). Such criteria constitutes the starting point of the new Performance and Impact Evaluation Framework here described.

A new and integrated evaluation framework

The evaluation methodology developed by the UNESCO Chair in Energy for Sustainable Development at Politecnico di Milano, in collaboration with Enel Foundation, aims at providing an integrated framework, which enables to understand performance and impact of energy development projects.

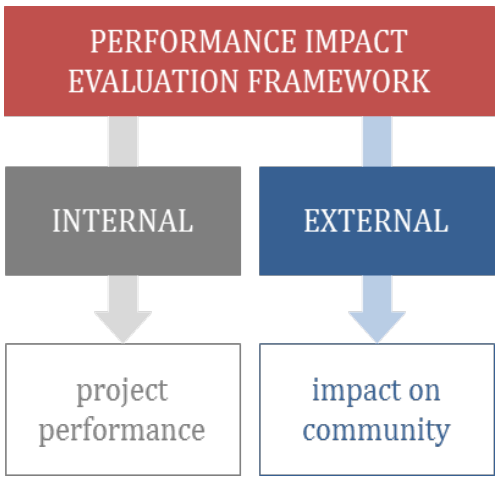


Fig. 1 - The DAC-OECD result chain

It is structured in two phases: an internal, project-based, which assesses projects in terms of performance, and an external one, people-based, which assesses the project impact on the beneficiary communities in terms of livelihoods changes, shifting the attention from the project itself to the context concerned. The objectives and timeframes of the two analyses are different and require different approaches and tools in order to perform an integrated assessment of the cooperation projects in the energy area.

In the first phase, four DAC-OECD criterias (effectiveness, efficiency, relevance and sustainability) are calculated with a common metric, adopting exergy analysis and recent Life Cycle extensions of this methodology. In this way, exergy becomes a 'proxy' of the primary resources total consumption undertaken during the project.

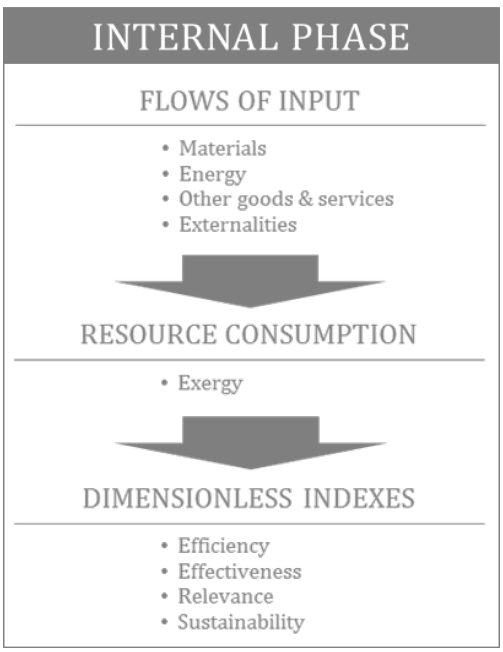


Fig. 2 - Internal phase, performance assessment

This homogeneous unit measures the different input flows, all expressed in terms of resource consumption, leading to a quantification of four criteria through dimensionless indexes. The application of this analysis to several projects allows the creation of a benchmark useful for comparing the results from different projects – especially in terms of resources consumption – and identifying the best strategies based on each result category (education, health, agriculture, entrepreneurship, etc.).

The second phase is dedicated to the fifth criterion, the impact, which aims at measuring the effects that the project has on the local livelihoods, assessed in terms of target community's five capitals: natural, physical, human, social and financial. The model is an original re-elaboration of the "Sustainable Livelihoods Framework", adopted by the Department for International Development and investigated by the Imperial College.

This phase has been defined starting from two necessities: on the one hand to allow the model customization and applicability to different contexts, allowing to design a proper indicators' set, on the other to provide a common structured metric which may be utilized for different projects and may enable their comparisons.

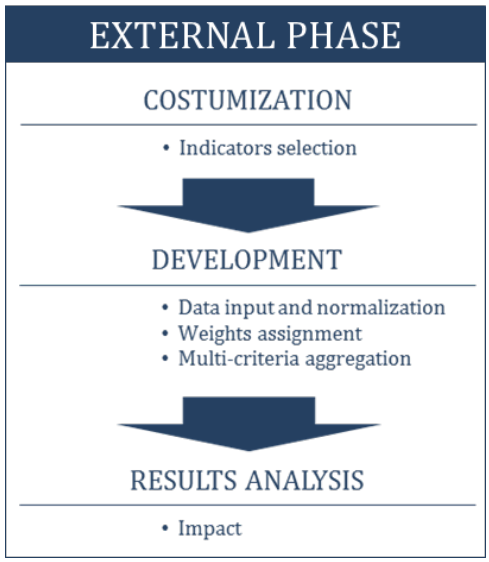


Fig. 3 - External phase, procedure to follow

A schematization of the proposed methodology for the impact assessment is

based on: (i) an application procedure (figure 3) structured into three steps, customization, development and results analysis, (ii) an evaluation hierarchy, made of five capitals, representing community livelihoods and dimensions, i.e. those topics and themes relevant to be monitored for a complete impact evaluation, covering both tangible and intangible aspects of a community and helpful to get a comprehensive overview of changes (figure 4). Firstly, the most relevant dimensions for each capital are identified. Then, individual indicators are designed and selected within each dimension, being specific and adaptable to each project.

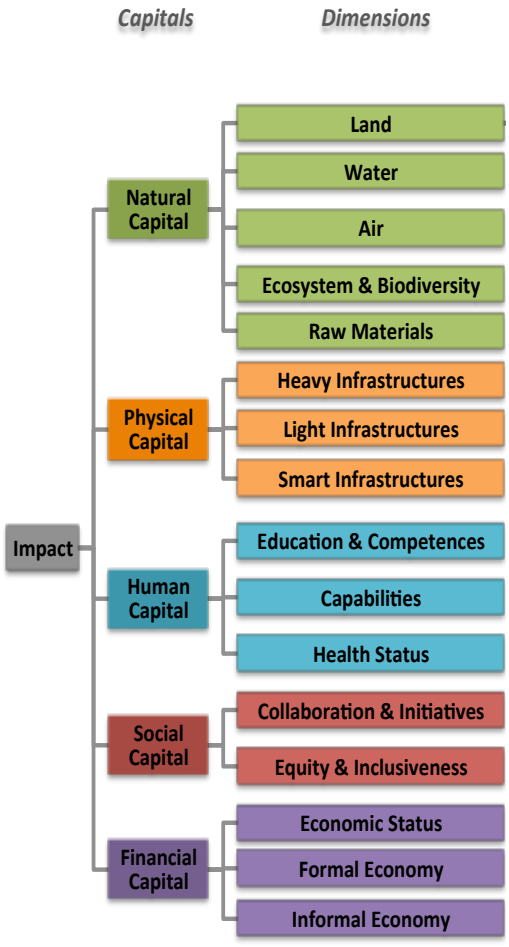


Fig. 4 - The Evaluation Hierarchy

A defined procedure then follows, to normalize and weigh such indicators.

The impact evaluation methodology, by measuring the indicators status before and after the project, allows the identification of those dimensions over which the intervention has had an improvement or worsening. The aggregation procedure of indicators then quantifies the contribution of each dimension to each capital.

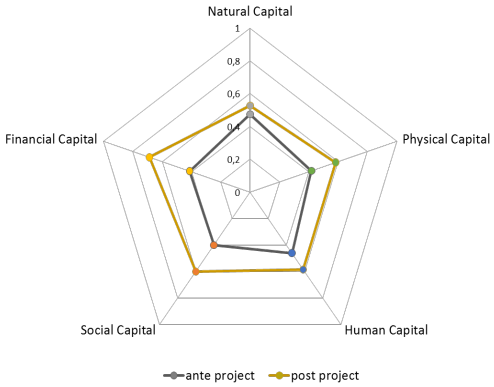


Fig. 5 – Example of impact assessment

The methodology may have different utilization. The methodology may represent an ex-post analysis, assessing already completed projects by comparing the measure of capitals in the baseline situation with the changes brought by the project and assessed at its end. It may also be used for ex-ante analysis, at an appraisal phase, during the selection process among possible project alternatives; in this case the result gives an expected impact of the intervention.

Application to case studies

A series of case study to real-world projects have been performed. Initially, projects implemented by Enel Green Power were assessed: the Ollagüe project (Ollagüe is a small village in Chile where a hybrid mini-grid has been installed), the Powering Education project (consisting in the distribution of solar lamps to 180 Kenyan students) and the Barefoot College project (training Mexican women as solar engineers, providing domestic solar kits and establishing a solar committee in

charge of the panels' management and maintenance).

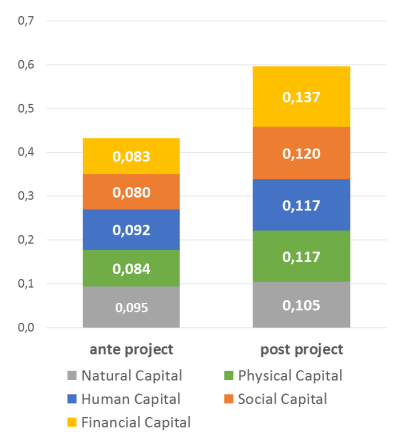


Fig. 6 - Impact assessment of the Ollague project

Conclusions and further steps

This Integrated Performance and Impact Framework takes its rationale from the literature and covers all relevant issues for a comprehensive evaluation through a holistic and transversal perspective. It represents a common structure applicable to any project, with also features of flexibility and customization to each specific case, with the own socio-economic and cultural diversities.

Results are easily interpretable and analysable in graphical terms. Indeed, they allow trade-offs among possible improvements or deteriorations of dimensions within same capitals or among different capitals. Moreover, data are suitable for comparisons among projects. In terms of communication and reporting, this framework may divulgate results to donors or stakeholders, as well as may give indications to address future interventions and strategies.

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Integration of Renewable Energy in electricity grid

This paper has been prepared by



in collaboration with





Modesto Gabrieli Francescato, *Terna*, Pierluigi Di Cicco, *Terna,* Bruno Cova, *CESI*, Paolo Marino, *Poyry,* Fjoralba Koci, *Poyry*

Abstract

RES deployment and grid enhancement should follow a parallel development path. A "fit and forget" approach is not imaginable in Sub-Saharan Africa were the grid is one of the barriers to RES development, both from the TSO's as well as from the investor's perspective. The introduction of necessary regulation and legislation to let the generators be in the network without physical constraints and allow RES power producer to access to third–party buyers is a priority.

Background

In Sub-Saharan Africa out of around 900 million inhabitants (13% of the world population), only a third has effectively access to electricity, leaving over 600 million people into darkness, especially in rural areas. In some Countries, like Niger or Chad, the percentage of people connected to the grid does not reach 10%.

Unfortunately these impressive numbers aren't improving, as the population is growing faster than the effort to provide electricity access.

Moreover, for the minority connected to the grid, supply is often uncertain, with recurring outages due to compelling needs of investments in transmission and distribution infrastructures.

Nevertheless, despite its poorness in energy supply, Sub-Saharan Africa is tremendously rich in energy sources.

Talking about traditional energy sources, from 2009 on, almost 30% of world discoveries of oil and gas were made in Sub-Saharan Africa. Overall, Sub-Saharan Africa holds around 7% of world conventional oil sources and 6% of world gas sources, enough to meet regional needs, both now and in the next decades.

Also from the Renewable Energy (RE) resources point of view, Sub-Saharan geography presents an amazing range of

opportunities. Suffice to say that the technical hydropower potential is estimated at more than 280 GW, able to generate almost 1200 TWh/year, more than 3 times the current Sub-Saharan Africa electricity consumption, while only 10% of this potential is currently unlocked.

The role of European utilities might be crucial in advising local authorities and companies for the integration of Renewable Energy Sources (RES) into the systems. Best practices and methodologies may be a common ground for training programs (in order to setup experts) and technical assistance (in order to perform technical studies).

As already explored in several past projects, the experience and skills of European utilities like Terna, as electricity system operator, may represent an important tool for African parties. We can bring the example of Angola and Mozambico, where Terna with CESI's support has collected data for technical assessment of electricity system in the current situation and, thanks to a fruitful cooperation with local authorities, built and simulated long term energy scenarios that will be a useful footprint for a coordinated future approach between Authorities and utilities.

Currently there is also a JV Terna – CESI for a Technical Assistance to KETRACO. The overall objective of the JV is aimed at (a) creating a framework for setting up a division to operate and maintain Transmission Infrastructures, (b) drawing up a road map to transform KETRACO into a future System and Market Operator and (c) training KETRACO's staff accordingly. Over the next three years the Terna – CESI team, composed of around 20 experts, will be accompanying KETRACO to become a major player in the future Eastern African Power Pool.

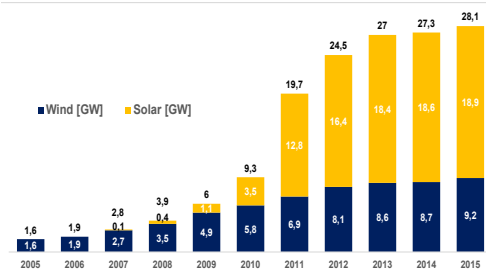
Italian experience at a glance

Considering the Italian situation, as consequence of green policies developed in the European contest and the introduction of subsidies in 2006 by Italian government, Italy experienced a rapid build of RE projects and today the country has 18.6GW of operational PV and 8.7GW of wind systems.

Three main phases of the RES integration into the system could be considered:

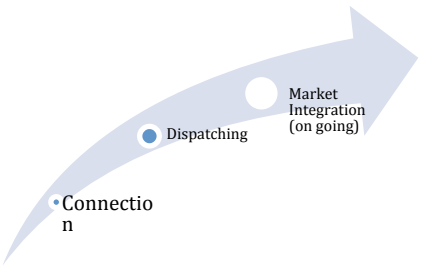
1. Connection to the grid
2. Fully dispatchability
3. Market Integration

Figure 1 – Wind and Solar development in Italy.



The first two phases are already completed; the third one is still on going.

Figure 2 – RES integration phases.



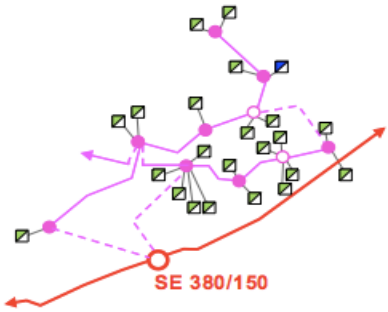
1) Terna reacted to the impressive phase of connection requests through
   - **local solutions** (Figure 3) Connecting the single plant with specific grid study;
   - and **system solutions** (Figure 4): 150 kV collection station vs 380 kV collection stations, connecting a cluster of

plants with System grid study.

Figure 3 - Local solution for RES integration.



Figure 4 - System solution for RES integration.



2) The fully dispatchability of RES power plants is guaranteed only if all of the security conditions are respected. When in 2011, 10.4GW of PV wind capacity came online Terna, warned about congestion and overload risks and called for immediate interventions: Terna, supported by an adequate regulatory framework has fixed most of those issues both with software and hardware solutions In particular but further improvements could be needed considering future system developments. Following requests by the Regional Group Continental Europe of Entso-E, AEEGSI initiated a programme to ensure the grid's security via a series of grid codes.

3) The last phase is the full integration of RES into the Energy Market. At this aims, in compliance with European Network Codes, a process for an organic reform of Italian ancillary service market (ASM) is on-going and recently the Italian Regulator issued a consultation document to allow distributed generation, demand, non-programmable renewable sources to enter the ASM.

Recommendation from RES4Africa: the connection to the grid, the fully dispatchability and market integration need to be commonly taken into account and developed step by step to not jeopardize a rapid integration of RES into the system.

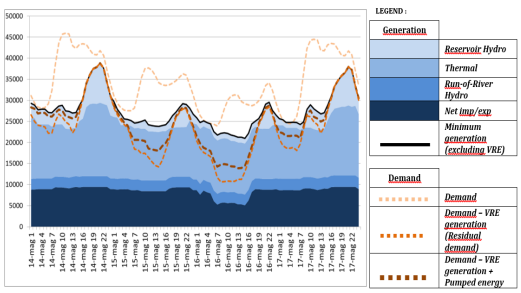
Operating power systems in presence of non-programmable RES generation

The impact of non-programmable RES (or VRE: Variable Renewable Energy) generation, namely wind and PV, shall be addressed not only at the planning stage, but it shall be kept into account also when operating the power system in order to ensure appropriate security margins necessary to face outages on grid components or on generating units.

According to the experience gained by the European TSO's that are sometimes operating their power system with a share of VRE generation exceeding 50% of the load the main issues to be addressed in advance are the following.

Risk of "over-generation" The excess of VRE generation, particularly PV, in days with low demand is revealing to be a critical factor, as shown in the diagram of Figure 5 referred to the Italian system [1].

Figure 5 - Example of load and generation profiles corresponding to expected OG situation.



The sum of scheduled power import and minimum dispatchable conventional generation may exceed during some hours the residual demand, i.e. the net demand deducting the non-programmable RES generation. To balance the system, structural long-term measures shall be adopted, like building new pumping stations when feasible, or market-based measures, like the cross-border coupling of balancing markets to avoid reducing NTC's (Net Transfer Capacities) with a consequent market fragmentation. Reduction of NTC in import can be adopted only as an emergency short-term measure. Similar risks of "over-generation" are being experienced also in other EU Member States [2].

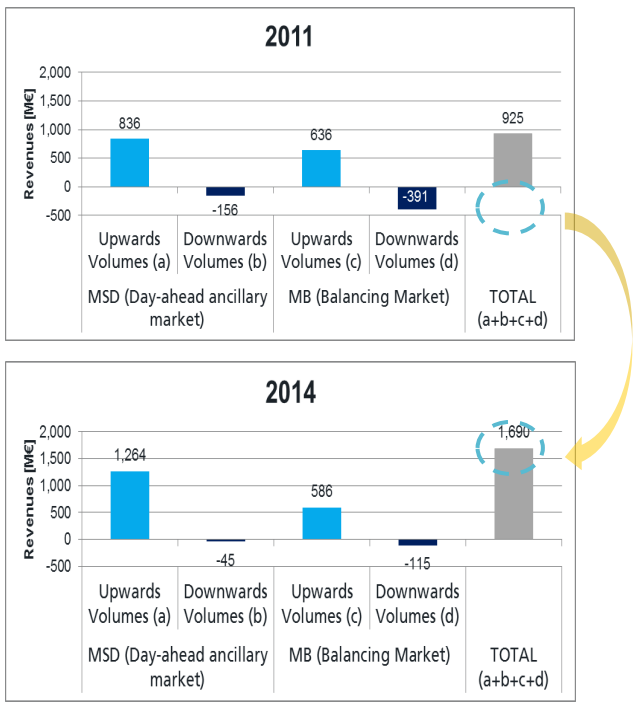
Recommendation from RES4Africa: the unit commitment policy of conventional generation shall be suitably reviewed to minimise the number of must-run units, while ensuring the security margins according to the provisions of the national/regional Grid Codes. In interconnected systems, possible bilateral/multilateral agreements can be established to exploit the cross-border power transfer capacity for exporting surplus VRE generation (or, conversely, to import power in case of power shortfall in situation of poor VRE generation).

Need for additional reserve Due to a higher volatility of intermittent RES generation and consequent higher forecast errors, system operators should ensure an additional amount of upward and downward reserve provided by conventional generation to balance the system. Problem arises when at the occurrence of a remarkable penetration of RES generation, a reduced set of conventional units is dispatched. The dispatched units shall be sufficiently flexible to ensure the requested reserve. Thus, flexibility enhancement of conventional generation is becoming a key priority to operate the system in an efficient way together with possible application of storage devices.

To this purpose, it is worth underlining that the massive deployment of VRE generation, besides an impact on the day-market prices, reveals an adverse effect on the ancillary services markets (ASM), the costs of which are strongly increasing due to the following reasons:

- The variability and the uncertainty that is inherent in the VRE generation is added to the variability and the uncertainty in the existing system: as a consequence, the TSO has to create larger reserve margins than in the past, with higher costs for the power system;
- The reduction of the thermal generation in favour of the RES generation decreases the number of the thermal power units dispatched in the energy markets. Therefore, it is less likely that the reserve margins are available without re dispatching actions in the ASM.

Figure 6 - Evolution of the costs in the ASM in Italy.



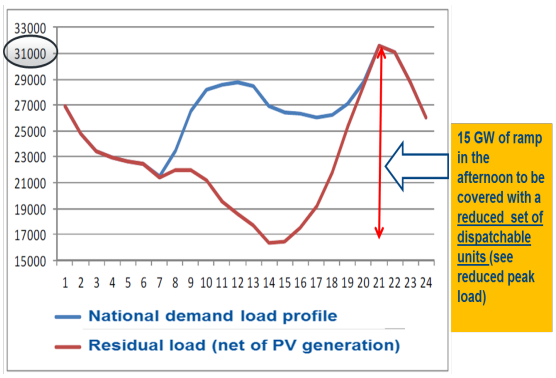
Indeed, as Figure 6 clearly shows, in Italy the costs for re-dispatching in the ASM have almost doubled over three years. For these reasons, in order to accommodate more RES generation in the power system, the trend nowadays is to ask also VRE generation to contribute

to the ASM. The most promising services that RES could provide are the downward tertiary reserve and the downward balancing services. Recently, TSOs are also asking for the instantaneous contribution of VRE generation to frequency regulation through the "synthetic inertia", i.e. by properly equipping the generations of control devices able to react to frequency deviations from the rated value. Obviously, necessary communications and control systems should be realized and this can be achieved with low expenditures both for the renewable power units connected to the high voltage grid and for units connected to the distribution grid by enhancing the automation and intelligent data exchanges ("smart distribution grid" concept).

Recommendation from RES4Africa: RES power plants to be equipped with control systems helping to supply ancillary services.

Load Following The PV generation pattern as well as that of other VRE are fully decoupled from the daily load behaviour. Particularly in the late afternoon / early evening, PV generation is originating high load gradients to be followed by the conventional generation.

Figure 7 - Italian demand profile in a typical Summer Sunday in 2014

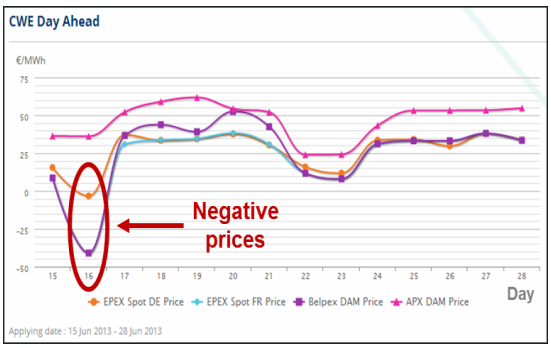


The diagram of Figure 7 depicts a real case referred to the Italian system. The load gradient may be even steeper than 10 GW/hour in case of wind generation decrease in the late afternoon/early evening. Hence, the enhancement of the conventional generation flexibility is becoming a key priority to operate the system, associated, when possible and necessary, to a modulation of RES generation.

Recommendation from RES4Africa: enhancement of conventional unit flexibility jointly with possible contributions from VRE generation.

Impact on the day-ahead power market The priority dispatch granted to VRE generation in the European markets has caused a non-negligible distortion of the day-ahead hourly market prices whenever the amount of this energy is significant compared with the conventional generation. Starting from 2013 in some occurrences the European power markets recorded negative prices, that certainly are not cost-reflective, but are caused by the priority dispatch granted to VRE generation (Figure 8).

Figure 8 - Market negative prices recorded in Europe on June 16th, 2013

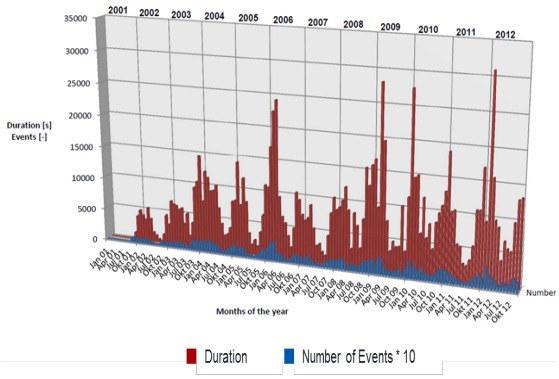


Furthermore, the reduction of market prices in daylight hours, caused by a massive PV generation, is compensated by owners of conventional generators, particularly CCGT, by increasing their biddings in the late afternoon / early evening hours to recover their margins. This trend, already evident in the current situation, is estimated to continue widening the gap between the daylight and evening hourly prices

Recommendation from RES4Africa: market design giving appropriate local price signals forcing also RES plants to react and actively participated to the power markets.

Dynamic stability and quality of supply A large share of RES generation is connected to the system through static converters. As a consequence, a higher penetration of non-synchronous RES generation entails a reduction of inertia, whose contribution is essential to smooth the frequency deviations in the first instants after a disturbance. This situation is evident in the interconnected continental European system where the situations of non-negligible frequency deviations and duration of frequency deviations are increased over the last decade (Fig. 5)

Figure 9 - Main events and duration of frequency deviations in Europe between 2001 and 2012



Therefore, the conventional generating units are called to faster actions, particularly primary frequency control, to avoid excessive frequency deviations. In general, the presence of non-synchronous generation risks weakening the system, which suffers larger frequency deviations at the occurrence of a disturbance. In addition, voltage drops caused by a fault are spread over a very wide area, impacting quality of supply even hundreds of km far from the fault location.

Recommendation from RES4Africa: VRE generators shall contribute as far as possible to voltage control and reactive power management as well as to frequency control from the instantaneous reaction at the occurrence of a frequency error (concept of "synthetic inertia") to primary and secondary frequency control.

Further, VRE generation shall not disconnect facing large perturbations (e.g.: short circuits) cleared in the normal intervention time of protective relays (concept of LVRT/OVRT[14] capability).

TSO/DSO coordination

In many cases, VRE generation is connected to the distribution systems leading sometimes to power flow reversal from MV to HV/EHV system. F.i. in Italy 60% of PV is installed in MV and 20% in LV grids. Hence, an appropriate coordination of power dispatch and voltage control policies between TSO and DSO becomes mandatory in presence of a massive deployment of VRE. This entails the need for enhanced data exchanges and a better observability and controllability of at least the MV grid.

Several aspects have to be addressed such as: confidentiality of exchanged information, accountability, investment burden sharing between TSO and DSO, dispatching policy of generating units connected to the distribution grids.

Concerning this latter aspect, three possible dispatch modes can be adopted:

(1) *Extended Central Dispatching Model* – The totality of production units, connected at the transmission as well as the distribution levels, are enabled to provide ancillary services and dispatched by the TSO acting as a market operator.

(2) *DSOs Local Dispatching Model* – Under this framework, the TSO, both in the operational planning and in the real time phase, should no longer act on each RES unit, but it directly acquires ancillary service in the ASM from RES resources connected to the transmission grid and of course from conventional units. RES power plants connected at distribution levels must provide ancillary services which would be managed by DSOs. In this sense DSOs, acting as operator in the ASM

[14] LVRT: Low Voltage Ride Through; OVRT: Over Voltage Ride Through

should not only procure resources to satisfy its own needs at distribution level but also provide the TSO with resources for system services.

(3) *Scheduled Program at HV/MV interface Model* – The DSOs are responsible for maintaining a scheduled program at HV/MV interface while, differently from the second model, they will not offer ancillary services to the TSO.

Recommendation from RES4Africa: to adopt a clear regulatory framework for the TSO/DSO coordination in presence of RES generation installed in the distribution grids.

Connection rules of RES generation

In the early stage of RES installations, the European countries set their own connection rules. These were usually far less binding than in the case of conventional generation. F.i.: in Germany PV plants could disconnect when the frequency error exceeded 0.2 Hz, whilst conventional generation was required to stay connected in a frequency bandwidth of 47.5÷51.5 Hz. Similarly happened in terms of voltage control where no fault ride through capability was required from VRE generation. The massive deployment of VRE generation in the last decade has led to the urgent need to review the connection rules to avoid the risk of PV and wind farms disconnection cascade at the occurrence of credible contingencies, leading eventually to widespread blackouts.

To tackle this issue the European association of TSOs (ENTSO-E) has formulated common requirements for grid connection applicable to all generators, including those based on RES [3]. In such a way the system security margins are maintained also in presence of a substantial penetration of VRE generation. Unfortunately this measure has been taken rather late in Europe and a non-negligible retrofitting effort on existing RES plants had to be undertaken to adopt their performances to the new connection rules and this turned out to be possible only on a subset of generators.

Recommendation from RES4Africa: To adopt since the beginning connection rules for RES generator as far as possible similar to those of the conventional generators.

Lessons learned from EU markets

To encourage the transition to a more secure, affordable and decarbonized energy system the EU adopted climate and energy targets for 2020 and 2030. Single Member States implemented Renewable Action Plans and ad-hoc regulations translating targets into yearly RES capacity planning and providing policy measures to sustain their achievement.

Renewable installed capacity started to grow exponentially with Europe leading the way towards clean energy. The EU contributed significantly to the worldwide demonstration and commercialization of progressive (RETs), such as solar PV and wind power. Countries such as Germany and Italy heavily invested in the development of RES becoming, for example, the first and second country worldwide in terms of total solar PV installed capacity.

In the early years of targets' definition, single Member States designed incentive schemes able to get investors' interested eye. Incentives offered to support RES were generous and the sector immediately experienced a significant boost, particularly true for solar PV. In most EU countries RES had (and still have) priority of dispatch, meaning that all their generation is directly fed into the grid with all other technologies following suit. All-inclusive feed-in tariffs set for 20 years offered high returns to investors. As the speed of technological progress exceeded that of the political machine, incentives were not immediately adapted to the decreasing cost of technologies contributing in increasing public spending with tariffs not being properly

redesigned to reflect these fundamental changes.

To avoid additional overspending, all-inclusive tariffs were progressively phased out and replaced with market based auction procedures where the incentive awarded is a function of the electricity price. The structure of the support mechanism with mandatory market bidding aimed also at promoting the integration of renewable generation which did not actively participate in the market. The wholesale market was mainly a pass-through for renewables and they would typically bid at zero price to get dispatched and receive the incentive on all their generation. The change in the incentive scheme lead to a more responsible, increasingly active market participation from renewables.

Power Purchase Agreements (PPAs) did not see a particular development in Europe. Schemes aimed at promoting their development (i.e. the Green Certificates scheme placing a renewable energy obligation either on conventional generation or retailers/distributors proved badly designed and left the market long for many years before being phased out). The presence of an EU competitive law that shies away this type of contract and liquid spot markets that make it easier for demand to find a counterparty did not promote PPAs development either.

As renewable generation grew, a series of issues started to emerge not only market-wise but also from a physical network perspective. Across Europe TSO's connected RES to the network adopting a "fit and forget" approach. This meant that most plants got connected regardless of the need for grid reinforcement. Most of solar PV capacity was connected to the Medium and Low voltage grid making it harder for the TSO to control their generation remotely. This, in addition to the typical intermittency of renewables and to the challenges in forecasting them properly, increased the need for back-up capacity and the cost for keeping the system balanced.

The development of RE in Africa may not follow the textbook rules that have been forged by the more integrated European markets, but it can be written learning from their mistakes and success stories.

A series of lessons can be thus drawn from EU renewables development both from a market as well as from a physical prospective.

1. **RES deployment and grid enhancement should follow a parallel development path**. A "fit and forget" approach is not imaginable in Sub-Saharan Africa were the grid is one of the barriers to RES development, both from the TSO's as well as from the investor's perspective. Regulated grid access rules and grid cost allocation schemes need to be developed in parallel with RES development plans. Tariffs need to be design in order to reflect these costs. Lessons regarding this topic can be learned from the UK experience, where plant's connection to the main grid depends on its capacity to accommodate additional generation while a given plant operator may be also contractually entitled to a grid development by the grid operator. Moreover, for countries with a underdeveloped grid, the regulation of Closed Distribution Systems (CDS) and Private Networks is of fundamental importance. EU regulation could provide a basis for drawing rules proper to the Sub-Saharan African context where focus is more on electrification. The use of closed systems connecting for example RES generation plants and households, allowing them access to electricity, needs to be accompanied by the definition of tariffs allowing better security for investments.

   Grid extension and power pooling takes however time. With 645 million people in Sub-Saharan Africa lacking energy access today, decentralised solutions will be required, notably in rural areas where stand-alone and mini-grid solutions are expected to meet 70% of the demand of newly connected customers over the next 25

years, according to the International Energy Agency.

2. **Design of support mechanisms for renewables** should reflect the cost of technologies and the structure of the energy sector **leading to cost reflective electricity prices** for all costumers, while protecting vulnerable consumers through tariff or fiscal shield. Drawing from relevant experiences in EU power systems, an auction-based, technology-specific mechanism should be preferred.
   A fundamental distinction can be made between direct and indirect policy instruments. Direct policy measures aim at stimulating the installation of RES technologies immediately. They can address either price or quantity while providing support either for investments or generation.

Table 1. Type of direct RES support mechanisms

	Price-driven	Quantity-driven
Generation based	- Feed-in tariff (fixed or variable) - Premium system (fixed or variable)	- Tendering system for long-term contracts Tradable Green Certificate system
Investment based	- Investment incentives - Tax credits - Low interest/Soft loans	- Tendering system for investment grant

Support mechanisms that promote active market participation and service offering have been largely applied in Europe. Feed-in tariffs linked to the wholesale electricity market price are an example. Another important aspect in RES market integration is their participation to the provision of ancillary services to the TSO, particularly relevant in systems with a high share of RES generation.
Market integration is possible only if RES have been equipped with the necessary physical instruments allowing them to be remotely controlled and to respect orders sent by the TSO and based on their market offering.
While direct instruments aim at quickly boosting RES development, indirect instruments focus on improving long-term framework conditions, providing investors with security and sustainability. In the Sub-Saharan context a combination of the two together with a simplification of authorisation procedures would allow for a structured sector development.

3. The introduction of necessary legislation to allow RES independent power producer (IPPs), auto producer schemes and access to third–party buyers is another important topic. IPPs are a major source of new power generation capacity in Africa although regulation varies across countries. In the past years in Sub-Saharan Africa the structure of regulatory schemes seems to have favoured large and centralized power projects thereby somehow precluding growth of small and medium-scale renewables.
   In recent years, off-grid solutions are being increasingly sought after as the costs of technologies fall. However, regulation on auto-production is fragmented and that of CDS in its early stages in most Sub-Saharan countries.
   Micro-grids development in Africa remains an interesting concept, particularly when deploying RES technologies in the form of wind or solar power. Both these energy sources are however intermittent and storage of electricity is still costly. One solution to this would be to supplement the micro-grid with a biogas fuelled engine operating as back-up.
   Last year, at the East Africa Power Industry Convention in Nairobi a "round table" discussed the

development of Africa's power generation network and whether to opt for a centralised or decentralised system. Parties agreed that a hybrid solution was the optimal one as it would allow for a better integration of renewables in the system.

A combination between centralized and distributed power generation would mean a more balanced and stable transmission network and reduced investment costs. However, regulatory uncertainty or lack of enforcement is a major draw-back for investments.

The development of Sub-Saharan Africa's power generation infrastructure is still largely a blank sheet of paper and the maximisation of valuable energy resources and their proper integration, both from a market as well as from a physical perspective, will play a key part in the region's future development.

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Fact Sheet presented by

Environmental, Social and Governance in Renewable Energy Projects in East Africa

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Abstract

Interest in and support for Renewable Energy (RE) projects to address the energy supply gap in East Africa is growing. Opportunities for investors within this space are plenty but come with unique challenges that require careful evaluation early in the project lifecycle. The focus of this paper is specifically on the non-technical risks associated with such developments, related to environmental and social challenges that require as careful evaluation as do financial and technical risks to avoid potentially substantial costs and complications.

Background

Renewable Energy is rapidly becoming a cost-effective solution for overcoming energy supply challenges faced within East Africa and indeed elsewhere in Africa.

In Kenya for example, with a GDP growth of between 5 and 7% from 2004 to 2014, peak power demand grew from 867MW to 1,468MW, at approximately 8% per year. Power demand projections, as provided in Kenya's Vision 2030, indicate a peak demand projection in 2030 of 26,500MW. To address the energy gap and to meet the projected demand for power, the Government of Kenya (GoK), in its updated Least Cost Power Development Plan (2013 to 2033), promotes growth in the mix of energy generation capacity, with a focus on renewables, such as wind, solar and geothermal.

In Uganda, GDP growth of around 6% during the past two decades has resulted in a growth in electricity demand of approximately 10% per annum. Access to electricity at national level in Uganda is very low, with 15% of the population having access to electricity in 2013; this figure is even lower in the rural areas at approximately 7%. Currently, about 90% of the total primary energy consumption in Uganda is generated through biomass, including firewood, charcoal and crop residues, which results in deforestation at alarming rates.

Given these examples, an important focus area for investors in East Africa is power generation; specifically the private sector funding of RE power generation. Opportunities for Independent Power Producers (IPPs) are exciting, but are not without their challenges. This is because

although IPPs are well-positioned to assess both financial and technical risks, non-technical risks, the subject of this Position Paper, are often not adequately assessed, or are considered late in the transaction or development cycle. Experience confirms that not considering and managing these risks (which relate to environmental and social aspects) during the early planning stages of such projects may result in significant costs, complications, unforeseen changes to project design and delays for project developers.

Objectives

Greater awareness of non-technical risk is becoming increasingly important as effective mitigation of environmental and social risk is vital if East Africa is to capitalise on current investor appetite in the power sector.

In addition, better understanding of such risks will help to minimise community impacts and enable communities to benefit directly from such investments.

Criticalities

There is scope for investment in a host of RE power projects in East Africa; generating not only power but significant revenue streams. But before capital can be committed, risks must be assessed.

Some painful lessons were learnt at the beginning of the new millennium. So much so that major providers of project finance are today unwilling to commit funding unless non-technical risk is thoroughly assessed and appropriate mitigation strategies are put in place.

Environmental risks are relatively easily assessed, although in hydropower projects for example, the calculation of environmental flows is not an exact science, leading often to a more give and take approach between ecologists and project developers. With social risks however, these are compounded in Africa as there is generally no standard approach in addressing these risks. Another factor that warrants the attention of funders and project developers is the growing stakeholder demand in many emerging markets that commercial interests not only meet legal and regulatory requirements, but establish a *'social licence to operate'* through on-going community investment. Terminology differs across Africa, but there is common focus on local content, skills transfer, local procurement and recruitment, and community development.

It is easy to assume that the higher purpose of improved electricity access for a country will be so obvious that local community buy-in is assured. This strategic view – while valid – ignores local priorities and concerns. Typically, RE projects in East Africa are developed in remote rural areas, with poverty entrenched in many of these areas. Access to electricity is only one area of need. Communities near to project sites may also have limited access to schools, water, sanitation, health care and social services. Each site is different so a standardised approach is simply not possible. Therefore, compliance cannot be achieved by simply ticking a series of well-established boxes. An environmental and social impact assessment (ESIA) is a crucial component of the process, but it is just one element in a complex set of variables.

The mere prospect of project development is enough to generate numerous expectations around social service delivery and job creation within neighbouring communities. Therefore, stakeholder engagement, face to face and one to one, is necessary to understand expectations and establish priorities. Simultaneously, fear and suspicion can be aroused. Will development necessitate resettlement? What about use rights to

various paths and water resources? Will graves and burial sites be disturbed? Social risk mitigation entails continual communication to manage expectations and fears. Interaction must be constant, honest and consistent. The developmental aim may be to generate power, but the local aim is to instil trust. Government in the national capital may create the market for electricity consumption by guaranteeing predictable pricing over 20 years, but they can rarely guarantee total community acceptance at a remote rural site.

It is also important to realise that long-term community support is unlikely to be secured by a once-off investment in local services. Local needs won't go away; nor does the need for a sympathetic corporate response. The social licence to operate comes up for metaphorical renewal month after month, year after year. On-going engagement is required.

Experience shows that big gains can often be achieved by relatively small community investments. It is also critical to ensure that community institutions and local government are empowered to run and maintain installed facilities. Africa is littered with abandoned community projects that have failed because of the lack of a plan for their upkeep shortly after being commissioned.

Mitigation methodologies have been established by several international bodies, including the Equator Principles and the International Finance Corporation's Performance Standards. These methodologies provide good guidance but are often not easy to implement and cost both time and money.

Recommendations

RE developers need to do more than just address their direct impacts; for example, by implementing community development projects that go beyond mitigating ESIA impacts. Developers are well-advised to improve their understanding of environmental and social risks, the business case for a social licence to operate and the evolution of corporate social investment programmes, in Africa and elsewhere.

Those developers who take their social and environmental responsibilities seriously are not only positioned to avoid unnecessary risks and unforeseen costs, they also improve the potential for long-term profit and enhanced return on investment (ROI).

Social and environmental risk deserves proactive scrutiny from the outset and throughout the project lifecycle, all the way through to decommissioning. These risks affect site selection, access to funding, ROI projections, operational efficiencies, actual investment returns, corporate reputation and company valuation. It is therefore in the interest of developers that they identify key non-technical risks as early as possible in their investment/ project decision-making cycle and manage them through a structured Environmental and Social Management System; this is not only a requirement of many international lenders but supports a structured approach to risk management.

Risk management of this scale and duration is a strategic imperative. In fact, it is a leadership issue. Issues affecting the long-term success of major capital projects cannot be delegated. The leadership team has to take ownership and demonstrate its commitment to all stakeholders.

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Regulatory study for Mini grid system developments in the Eastern Africa

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Abstract

Renewable Mini-grid systems have a great potential to meet energy demand in rural areas and play a central role in reaching the electrification target set by Governments. Despite the presence of a policy and a regulation supporting mini grid development in all Eastern Africa countries, the lack of a dedicated regulatory framework hinders the active participation of private investors in the sector. Governments play a significant role to accelerate their participation as partner in the mission of meeting electrification targets and therefore should create a conducive environment to attract and facilitate their involvement. The regulatory framework should be clear, reliable, effective as well as transparent. A regulatory framework including few key elements would contribute in de-risking the investments and attract an increasing number of credible players in the rural electrification activity, guaranteeing access to electricity to a larger number of people in a sustainable way.

Background

Eastern Africa region is extremely abundant in **all** Renewable Energy Sources (RES)s, though clean energy currently represents a very limited percentage of the national productions (i.e. 36% in Kenya, 5% in Ethiopia, 1% in Tanzania and totally absent in Uganda and Rwanda[15]).

The GDP in the region, more than doubled over the last decade whilst the population grew by 80% over the same period so pushing the Regional electricity demand to grow at a sustained path of

[15] Figures exclude large hydro data.

around 10% per year, trend that is expected to continue up to 2020.

As of today **over 0.6 billion** people in the Sub-Saharan African countries have **no access to electricity**. Among these, around 200 million people live in the Eastern African countries[16], which record an average national electrification rate slightly above 20% with a significant concentration in urban areas. Indeed, rural electrification rate does not exceed 7%.

This, in combination with the fact that ever-growing population is mostly settled in isolated rural communities [17] and existing infrastructures are insufficient to meet current consumption needs, highlights that **Eastern Africa is facing a huge electricity demand challenge**. Therefore, a specific Government intervention is needed to implement reliable and affordable electrification plans.

In truth, many countries are willing to provide universal access to electricity in the short and medium run by deploying renewables powered plants and targeting people living in suburban and rural areas too.

Increase access to electricity, especially in rural areas, through the extension of the national grid, does not always represent the most efficient way, not only under the economic perspective but also in practical term, because of morphological characteristics of the territories.

In this context, off-grid renewable systems can provide a valuable and effective option to increase the local electricity access. In the recent past renewable solutions gained in competitiveness as compared to traditional energy sources mainly thanks to technological advancements and they proved to be cheaper, cleaner and a better solution to produce electricity without reliance on imported/transported fuels. In particular, the recent cost declines in solar photovoltaic and storage technologies provide cost-effective options for addressing energy needs in remote areas where on-grid electrification is technically or economically difficult to achieve. However, the development of off-grid initiatives would not be possible if not supported by an **appropriate national regulatory framework** from licensing to operation and tariff determination.

Overview of regulatory frameworks for off-grid systems in Eastern Africa

Mini-grids have a great potential to meet demand in rural areas and to play a central role in reaching the target of universal electricity access in a timely and sustainable manner. In order to accelerate such development it is very important to recognize the lack of dedicated regulatory framework and the absence of de-risking mechanisms as the main obstacles for the private sector.

In all Eastern African countries, Governments aim to achieve 100% rural electrification and have prepared multiannual dedicated Master Plans or specific electrification programmes setting intermediate targets. National plans are absolutely crucial, but they should be accompanied by operational action plans defining clear alternative options according to economic convenience: main grid extension, distribution grid densification, mini-grid and off-grid projects.

[16] Eastern Africa region includes Ethiopia, Kenya, Uganda, Tanzania and Rwanda.
[17] In the selected countries, rural population represents in average over 70% of total current population.

Indeed, grid extension makes economic sense only when the associated costs are reasonable, while mini-grids opportunities should be exploited in villages where grid infrastructure costs are too high.

Even though the realization of mini-grid projects is generally allowed by the current regulations, providing in some cases simplification and/or exemptions, specific operational rules are missing and therefore uncertainties still persist.

As an example, in **Tanzania**, as per the current regulation for Small Power Producers 2016, rural projects below 100 kW are exempted from licensing requirements and only need to register to the Regulatory Authority (EWURA). These projects may sell electricity directly to retail customers at negotiated tariffs without EWURA approval. However, projects above that threshold need to follow the standard licensing procedure and obtain generation and distribution licenses.

In **Kenya**, the Authority is supporting the development of mini-grid in rural areas and has granted to a private player the permit to generate, distribute and supply energy to 100 rural villages in the western region of the country, through a simplified application process, allowed for project < 3 MW according the Energy Act 2006. This simplified process for smaller projects is not contemplated under the new Energy Bill 2015, therefore the introduction of a dedicated framework for mini-grid projects in rural areas, on which Government is actively working, is greatly welcomed.

An example of a specific regulation on mini grid is the one issued in 2015 in **Rwanda** to streamline the development of rural investments through a simplified Electricity License application process (for projects up to 1 MW) and the issuance of a combined generation, distribution and trade license providing also and exclusive right of supply in the selected area. Clear rules are also set in terms of required documentation, approval process, length of license, tariff setting and option in case of main grid arrival.

Financial and economic aspects also play an important role in promoting the development and safe operation of mini-grids from private players.

Generally, the assumed tariff model aims to allow a "reasonable" return for the investor through a "fair tariff" for end users, allowing the recovering of operating costs, depreciation on capital, debt payments, plus a "reasonable" return on capital. For this reason Authority's need to approve the proposed tariff to consumers.

In **Uganda**, for example, the Regulatory Authority issues every 3 years a price schedule for rural electrification systems that contains also the formula for indexation. Exemption from the application of the regulatory price schedule may be requested to the Regulatory Authority and duly justified.

Investors return is of course strictly related to the time needed to recover the investment, given the high upfront costs. For this reason, guarantees should be provided to the investor to operate for a minimum period of time and clear exit options should be set up in advance in case of arrival of the main grid.

As a matter of example on this crucial topic, current applicable regulation in Kenya does not provide any details, while Rwanda and Tanzania foresees alternative options (i.e. convert the license for remaining period in Small Power Producer License and Small Power Distribution License or negotiate the sale of assets and rights) but operational

aspects are not always clear and/or not provide enough protection to the private investor (i.e. price definition, minimum timing, etc.).

The role of Governments and national Authorities in promoting development of off-grid systems

Governments play a significant role to accelerate the participation of the private sector as partner in the mission of meeting electrification targets and therefore should create a conducive environment to attract and facilitate their involvement.

The key roles that the Government should play are:

i. Set up a clear and reliable regulatory framework to create a right balance between affordable prices for consumers and reasonable return for investors

ii. Provide assistance and simplification to investors in permitting and licensing processes

iii. Cooperate in order to support the identification of areas of the country where the program can be economically implemented (i.e. morphological data, demographic data - volume, density, income- identification of communities with potential economic development, potential anchor customers). As a matter of fact, extension of the area, its population density and consumption load are key drivers for the economical sustainability of the mini-grid business plan, given the significant impact of the cost for building the distribution network on the overall capital expenditure of the project

iv. Gather and provide information on the presence of interesting markets. In this context, Rural Electrification Agencies (REA) could perform pre-feasibility studies and public them so that the private sector can see where the interesting options are

v. Provide clarity on grid extension plans in the medium/long term and cooperate at central and local level to identify villages and communities not expected to be served by the national grid since, for a private investor, timing is very relevant to evaluate the investments return. These plans should be reliable and abrupt change of plans should be avoided

vi. Identify clear roles and mandates among all the involved stakeholders (i.e. Governments, Transmission System Operator, Distribution System Operator, Rural Electrification Agency, Electricity Authority, Local authorities and communities etc.) and cooperation at central and local level. An excessive level of regulatory complexity, overlapping responsibilities may result in unclear or contradictory regulations or lead to a regulatory vacuum, which may put on-hold investor decision

vii. Support the creation of external enabling conditions such as local communities awareness and access to micro-financing, in order to increase the willingness and ability to pay. Investment promotion measures are needed to attract both domestic and foreign investors. In parallel, there is a need to raise awareness among local financial institutions about the grid-connected and off-grid renewable energy market. Public financing can be most effective if used to reduce risk perceptions

Regulatory recommendations

A sound policy and regulatory framework is a prerequisite for the deployment of mini-grids projects to contribute to rural electrification and energy access.

The regulatory framework should be clear, reliable, effective as well as transparent in order to support the increasing access to electricity in a sustainable way, ensuring high quality of service for community whilst reducing investment risks.

Key recommendations for an effective regulation would be:

i. Streamlined land acquisition and permitting procedures, especially for micro and mini grid (< 100 kW)

ii. Standard set of permits and clearance required (i.e. District Authorizations, environmental impact assessment and social impact assessment, application fees, etc.)

iii. Creation of a single window support channel interface (one-stop shop) to process the above mentioned permits with clarity on responsibilities and timeline (i.e. issuance and facilitation of desired Government orders, necessary certification and authorization, clearances and right of way, other approvals, provide information on taxes and exemptions etc.)

iv. Issuance of a combined generation, distribution and supply license for the mini grid operator

v. Guaranteed exclusive area of supply for the mini-grid operator, confined to the time necessary to recover investment costs and reasonable returns

vi. Clear exit options in case of main grid arrival, after a minimum period of operation, defining duties and rights on involved parties

vii. Clear agreements with the local Distributor Network Operator to manage the possible coexistence of the main grid and the mini grid

viii. Technical & Safety standard and minimum Standard of Performance to allow for flexibility and innovation without creating approval bottleneck

ix. Clear rules for managing electrification programs carried out by Rural Electrification Agency overlapping with private projects developing

x. Flexible tariff setting rules and financing mechanisms to ensure reasonable return to investors and affordable prices for consumers

A regulatory framework including all the above elements would contribute in de-risking the investments and attract more and more credible players in the rural electrification activity, guaranteeing access to electricity to a larger number of people in a sustainable way.

A sustainable and productive use of energy to a larger portion of people would represent a huge benefit to economic growth of any country.

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Scaling up Renewable Energy in Sub-Saharan Africa

Barriers and Recommendations

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Abstract

The extent to which Renewable Energy (RE) can contribute to efforts to address the energy challenges facing Africa and its role in meeting Africa's energy demand has been undermined by bad experiences, misinformation, technology push and consequent negative perceptions; certain technologies have so far been disseminated in circumstances that compromise their further adoption, as beneficiaries have been dissatisfied and the mismatch between energy service provision and income generation to meet the cost of services has been particularly disadvantageous for the promotion of RE.

The main goal of the present paper is to spot the existing barriers preventing the extension of the renewable electricity coverage of the area and identify a high level set of recommendations to facilitate the deployment of Renewable Energy Technologies (RETs) with the final aim of improving the quality and stability of energy supply and therefore improve living conditions in the urban and remote areas, as well as fostering the on-going efforts made by the national Governments of the region and by the international players towards the sustainable economic development and achievement of the ambitious goals set by the United Nations Millennium Development goals.

Furthermore, based on the experience of energy solutions providers at least three common situations need to be faced in the electrification of emerging countries:

- Industrial connection to existing high voltage grid;
- Voltage dips in industrial plants connected to weak grid;
- Off-grid generation with hybrid diesel-RES.
- Hydropower production increase linked with the enlargement of an existing university campus.

Success stories delivered in the African context concerning the above circumstances are given in the present paper in order to display the main lessons learnt.

The Renewable Energy Sector in Sub-Saharan Africa

Africa is endowed with a huge potential for the generation of RE; the continent, in fact, has approximately 285 GW of estimated potential for Hydropower and 15 GW for geothermal, it receives abundant solar radiation through the year with most of the continent enjoying an average of more than 320 days/year of bright sunlight with irradiance level ranging from 2,000 to 2,500 kWh/m2 and some of the coastal and inland areas have available significant wind energy resources specifically in the Sub-Saharan area where it is estimated a potential for generation of approximately 13 GW.

In addition bioenergy, mainly accounted for by the traditional use of solid biomass in the residential sector, dominates the energy mix of many African regions, especially the Sub-Saharan, with estimates from different studies indicating the potential availability by 2020 of up to 13,900 PJ/yr. from energy crops, up to 5,400 PJ/yr. from forestry biomass and approximately 5,250 PJ/yr. from residues and waste.

However, these energy sources remain largely underutilized, for instance only 5% of the continent's potential of hydropower and less than 1% of the geothermal one have been exploited, undermining the efforts towards the economic growth and the sustainable development of the African continent displayed by local Governments and international players.

A closer look to the energy data of the Sub-Saharan region shows that despite the area accounts for approximately 15% of the total world population the regional energy demand represents less than 4% of the global one. It has therefore to be noted that the lack of reliable and affordable energy supply remains a serious impediment to economic and human development in most parts of the region, the energy sector of which continues to face critical challenges being characterized by lack of access to modern energy services (especially in rural areas), poor infrastructure, low purchasing power, low investments and over-dependence on traditional biomass to meet basic energy needs. Furthermore, energy use across the different sectors remains quite inefficient, with the continent still having the highest energy intensity per unit of GDP.

Recent trends indicate that over 60% of Sub-Saharan Africans will still not have access to electricity by 2020 and traditional biomass, despite the associated environmental, social and health problems, still remains the main source of energy, accounting for 70-90% of primary energy supply in some countries and as much as 86% of energy consumption.

In addition to low levels of access to electricity throughout the region, the energy sector is harassed by low capacity utilization and availability, deficient maintenance and high transmission and distribution losses ranging from 15 per cent to 45 per cent of electricity distributed which make power utilities in Africa hardly viable from a commercial perspective as they charge tariffs that are below costs to promote access to energy by the poor majority. As a result, the utilities are not able to mobilize external capital for maintenance and expansion projects.

In this framework, the attraction of private sector is being the focus of power sector reform orientation, thereby prioritizing profit while neglecting the need to electrify rural areas and poorer urban neighbourhoods.

Objectives of the Paper

The extent to which RE can contribute to efforts to address the energy challenges facing Africa and its role in meeting Africa's energy demand has been undermined by bad experiences, misinformation, technology push and consequent negative perceptions; certain technologies have so far been disseminated in circumstances that compromise their further adoption, as beneficiaries have been dissatisfied and the mismatch between energy service provision and income generation to meet the cost of services has been particularly disadvantageous for the promotion of RE.

The main goal of the present paper is to spot the existing barriers preventing the extension of the renewable electricity coverage of the area and identify a high level set of recommendations to facilitate the deployment of RET with the final aim of improving the quality and stability of energy supply and therefore improve living conditions in the urban and remote areas, as well as fostering the on-going efforts made by the national Governments of the region and by the international players towards the sustainable economic development and achievement of the ambitious goals set by the United Nations Millennium Development goals.

Furthermore, based on the experience of energy solutions providers at least three common situations need to be faced in the electrification of emerging countries:

- Industrial connection to existing high voltage grid;
- Voltage dips in industrial plants connected to weak grid;
- Off-grid generation with hybrid diesel-RES.

Success stories delivered in the African context concerning the above circumstances are given in the present paper in order to display the main lessons learnt.

Barriers to Renewable Energy Development in Sub-Saharan Africa

Although major technical and financial breakthroughs have been achieved internationally with respect to RE, besides large hydropower their contribution to Africa's energy problems remains minimal. Major barriers to the wider dissemination of RE on the African continent will need to be overcome. These barriers can be categorized as follows:

- policy, regulation and institutional;
- information and technical capacity;
- financial.

Policy, Regulation & Institutional

Consistent policy and regulatory frameworks are central to the successful dissemination of RE in technologies in Sub-Saharan Africa, but in general such frameworks are absent in most of the African countries and where suitable policies for promoting RE do exist, their impact is weakened by a lack of enforcement mechanisms which makes very challenging for the private and industrial sector to operate effectively and expand their RE investments.

Furthermore, the lack of policy focus on the RE is the relatively low budgetary allocations at Country level for the promotion of RE in many African countries; the majority of energy projects are therefore externally financed. Despite the recent development of several RE

policies in many developing countries, including African ones the successful development and deployment of any technology, especially relatively new ones such as RET, need several institutions covering the different technical, economic to market aspects; this institutional capacity is not always available in most parts of Africa.

Moreover ancillary technical institutions for testing, operation and maintenance of technologies have a limited presence in African countries especially with reference to National Systems of Innovation (NSI) which have proved to be crucial in increasing technological receptivity in most developed and emerging economies.

Information and technical capacity

Ensuring secure sustainable commercial success of RE depends on institutional and human capacities as well as business and market capabilities.

A major technical barrier is the unavailability of accurate and well-organized RE resource data. The data on RE, especially for solar and wind, are very scanty and the poor technical skills in the continent affect the development of renewable technologies.

Inadequate domestic technical skills account for poor maintenance of imported systems and lack of provision of adequate after-sales service. Hence, there is need for high and middle level technical manpower in business development, manufacturing and overall management.

The public sector also lacks adequate personnel to undertake effective monitoring and evaluation.

Financing and investments

Scenarios developed by International Financing Institutions such as the African Development Bank has estimated at approximately US$ 550 billion the total investment required to ensure universal access to reliable and increasingly cleaner electric power in Africa by 2030 thus estimating an average investment of approximately US$ 30 billion per year; at present the total funding to the energy sector in Sub-Saharan African has averaged only about US$ 2 billion every year thus showing how serious are the challenges which shall be faced to mobilize financing for an effective deployment of the RE potential in the area.

Moreover many economies in Africa are performing badly and this only makes the situation more difficult when seen in the context of on-going context of the on-going food and financial crisis, high volatility in oil prices and climate change.

Lacking of government support, the private sector remains a small player overall and more prevalent in small-scale RE systems; whereas the bulk of the private sector financing is “Foreign” and mostly linked with international financing institutions supporting the local beneficiaries governments while on the other side it is registered a scarce support from financial institutions such as insurance companies and broker institutions that assist to reduce the very high transaction costs of clean technologies in African countries.

Recommendations

Major technical progress and policy development along with financial and institutional innovations are needed to scale up the production of RE in Sub-Saharan

Africa where it should be recognized that RETs are at different stages of development and deployment. Therefore, in order to be effective a comprehensive deployment strategy should give priority

to technologies that will deliver on the huge and immediate energy needs of the continent.

In this context, the setting of policies with clear targets are crucial in facilitating investments in RE and so are also the adoption of policy instruments such as quotas, feed-in tariffs, capital subsidies or rebates, investment or other tax credits, tradable RE certificates and public investment loans.

In developing countries, feed-in tariffs; capital subsidies, grants or rebates; tax credits and public investment loans or tax credits, have all been applied successfully.

There region is generally characterized by very high transaction costs, which arise from several factors including relatively small markets for RE resulting in few suppliers and monopolistic prices, the time lag between project formulation, conceptualization and actual implementation, and the poor manufacturing base that makes the retail price far higher than the cost price.

Several national and international policies have so far been used to promote the use of RETs and it is clear that policy successes are likely to be achieved when used in combination and adapted to the local, regional or national situation. Based on these experiences, policies to be considered for implementation at the national level are: regulation measures (i.e., performance standards, equipment standards, etc.); subsidies and financial incentives (feed-in tariffs, rebates, grants, loans, production incentives, government purchasing agreements, insurance) that are targeted and have a clear sunset clause; voluntary agreements (e.g. between government and private sector). At regional and sub-regional levels, policy measures that have been successful and can be considered for development in Africa include focused use emission targets and trading systems; technology co-operation; financial systems (ODA, FDI, commercial bank loans). In selecting appropriate policy options, it is important that these policy options be evaluated for their environmental impacts and cost effectiveness; distributional aspects; institutional feasibility; and suitability to the local context. In addition, RE policy development should be well integrated into policies of other sectors

Using well designed policies and stronger institutions can encourage RE producers to sell their products to the national grid, provided the revenue collected covers the cost and interest payments. However, smaller-scale producers may need special policies such as using dedicated funds or project bundling.

Off-grid renewable energy systems need policy attention such as customer financing to protect them from high upfront costs. RE markets can be promoted if governments take decisions to promote investments in RE for powering social infrastructure such as schools, medical centres, hostels etc.

Energy markets at the country level tend to be too small and fragmented to attract meaningful investments. As such, there is an increasing drive for integrated energy markets at the sub-regional level, as demonstrated by regional projects such as power pooling and energy access programmes that are led by Regional Economic Communities (RECs).

The continent should develop regional, sub-regional and national strategies to acquire renewable technologies by developing their R&D capacity and skills of technology adaptation and development and manufacturing capacity. African countries should now enter into two-way relationships with

technology suppliers using different instruments including co-production, standardization of components across models, modularization and exploring new forms of sub-contracting.

Furthermore, policies will be required to foster technology transfer and also assist to build capacities. These will include those that promote and strengthen the domestic knowledge base, stimulate learning and innovation, and create the support structures to sustain these processes. Another set of policies will be those that create facilities for starting up small and medium-sized enterprises, as these will prove useful for sub-contracting.

Specific skills are required for operating, modifying, producing and innovating renewable energy and energy efficiency technologies. In selecting and prioritizing RETs to focus on, Africa needs to consider technological maturity, reliability and financial feasibility. As such Africa is, in the immediate term, better off concentrating on RETs that are mature and will have immediate and direct benefits on the energy situation of the continent.

There is a need to address the fluctuations and intermittency of energy supply from RETs through integrated systems, pooling of several decentralized renewable energy systems to form energy generating clusters so that the grid is always supplied with minimum power in case of failure by one system. Equally important is the need to use modern storage technologies to address the intermittency of power generation from RETs.

African countries can exploit new financing options to improve investments in RE in the continent. The new financing options include: mobilizing local financing, aid and grants; foreign direct investments; carbon financing, GEF, etc. Local sources of funding that should be considered include public offer of shares by power utilities to implement specific projects, use of pensions funds to leverage local bank financing for new projects, use of emerging local bond markets.

Success Stories

The challenge for access to modern energy in Sub-Saharan Africa is really huge because even the average rate of households with access to an electricity supply is growing; the number of people without access to electricity has actually risen due to population growth. In the electrification process both the development of the grid and of generating facilities are critical and Renewables can have a role for generation, but also – together with Energy Storage - to overcome grid capillarity in OFF-GRID solution. Renewables and Storage technologies offer many advantages in Sub-Saharan Africa, but widespread deployment will require strong endogenous innovation capabilities: this is the challenge of RES4AFRICA.

CASE 1: MOZAMBIQUE Industrial connection to existing high voltage grid

The deployment of industrial facilities in an emerging country normally requests to solve feeding problem, being necessary safe and reliable electrical power to ensure industrial operation and productivity. This is the case of cement plant of Cementos de Beira in Beira, Mozambique, requiring 10MW power feeding. Being Beira, the second city of Mozambique, provided with electricity from national grid operator, the case was reduced to ensuring a proper connection to the existing grid.

An initial step was required to understand local grid code, requiring for the plant a direct connection to the high voltage grid while in a European context a simple medium voltage connection would have been required. Once defined the need of a direct connection between the cement plant and a 110kV line a standard solution based on two substations was adopted.

From a technical stand point the main need was then to guarantee the connection of the cement plant avoiding as much as possible inefficiencies on the line and foreseeing the possibility of a connection upgrade in case of further feeding points on the line. More than from a technical stand point the critical part of the project was related to local conditions that resulted to be the most challenging part to afford. Lack of infrastructures resulted in transportation issues that together with difficulties in purchasing local materials required additional logistic efforts. In addition, lack of specialized local manpower required to include proper training and longer on site activities.

If an existing grid represents a step forward in the deployment of industrial facilities in the Sub-Saharan Africa, the quality of the grid itself can be often too poor to ensure proper working conditions for industrial plant

CASE 2: ETHIOPIA Voltage dips in industrial plants connected to weak grid

This is the case of a cement plant in Ethiopia powered from a 110 kV "weak" line. Under normal operating conditions the 110 kV line feeds the cement mill and provides power for the power full output load plus all auxiliaries and Programmable Logic Controller.

Transients in the power supply have different consequences in the loads of the cement plant: voltage dips have consequences in the control equipment, while power interruptions have consequences in the process. A combined solution of UPS for the control and a 5MW-2,5 MWh Energy Storage System (ESS) with the function of "voltage support" for the process has been implemented. The ESS system gets a solution for the recovery of the power supply after a failure in order to limit the maximum voltage drop. ESS capacity has been calculated in order to supply max power for about 30 minutes. A suitable 2MWp PV generation is used to restore the energy while a 2MW diesel is used for emergency.

CASE 3: ERITREA Off-grid generation with hybrid diesel-RES

Whenever grid is not available, different solutions based on off-grid generation are required to provide power to industrial or private users. In this context hybrid diesel-RES micro grid are becoming more and more a key element in the electrification of emerging countries being a sustainable and robust solution to bring power even far away from existing grid and exploiting as much as possible existing natural sources. This is the case of the electrification of two rural towns in Debub region in Eritrea where to bring access to electricity to about 43000 people the adoption of a hybrid micro grid solution was selected.

The target of the project was to exploit soil availability for PV installation to ensure combining solar energy with battery storage, and the possibility of RES feeding minimizing the exploitation of diesel generators. The typical basic issue of these kinds of projects, which is usually the lack of information about load profiles, was overcome by means of a dedicated study enabling the estimation

of peak power demand and average consumptions. This result, together with the study of solar irradiation in the area allowed micro grid system proper sizing. For each town about 1MW PV plant together with 1.5MWh storage and 400kW diesel generators were adopted.

Operational philosophy was to accumulate sufficient excess energy during daylight hours to allow diesel generators to be switched off during low consumption periods in the night when stored energy coming from batteries was available. In this way diesel generators should run within an optimal efficiency range with savings proportional to the amount of solar energy generated during daylight hours. With such an approach a stable and sustainable power supply can be granted instead of expensive grid extensions or simple but unsustainable use of diesel generators. Like in Mozambique case, even for this project key elements result to be logistic aspects together with the need to develop local manpower able to support plant construction and then deal with its maintenance as well.

CASE 4: NIGERIA Hydro Power Production linked with the expansion project of a University Campus

An International Financing Institution is exploring the possibility of providing a long-term corporate financing to the expansion Project of the Afe Babalola University in Ado Ekiti, Nigeria.

The Project includes construction of the following new facilities:

- a small scale hydro power installation;
- an industrial research park; and
- other infrastructure assets including a 400 beds' teaching hospital.

The Project is sponsored by the Afe Babalola University (ABUAD), a private university established in 2010 with the current enrolment of over 5,000 students. The University aims to double its capacity by 2025 across 5 colleges - Sciences, Social and Management Sciences, Law, Engineering, and Medicine & Health Sciences - and 1 post-graduate school.

While the development of Phase I encompassed creating adequate infrastructures to accommodate the expected capacity of c.10,000 students by 2025, Phase II is primarily focused on enhancing the quality and competitiveness of the University to further attract students.

The activities performed were based on the comprehensive analysis of the full project with specific focus on the inter linkages of the different infrastructures and facilities and their financial aspects as well as the energy demand scenario to fine tune the design and optimize the envisaged investment.

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