RES4AFRICA
RENEWABLE ENERGY SOLUTIONS FOR AFRICA

10 proposals of Res4Africa

"Fostering the deployment of Renewable Energy: a Sustainable Roadmap"



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De-risking Renewable Energy Investments
Addressing risks for a better market design

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Abstract

In order to boost the renewable energy potential in Sub-Saharan Countries, an attractive and reliable market design shall be realised. As well as good renewable resource availability and suitable macroeconomic and financial conditions, a clear policy and regulatory framework is needed to prepare the ground for investment seeding, Political, policy, economic and social (variable) conditions result in different sets of risks across these Countries, significantly affecting investment making decisions. 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), according to the RES4MED's model developed in 2016 and provides a quick assessment of the investment risk in Ethiopia. Furthermore, the paper deal with the policy instruments many Countries all over the world have been implementing to mitigate risks and encourage investments in renewable energies.

Background

Renewable energy (RE) technologies have experienced a rapid development over the past few years, mainly driven by the need to meet an increasing energy demand while mitigating climate change impacts, and to secure energy provision in the long term enhancing energy access.

Many countries are exploring ways to stimulate social and economic growth through stimulating the RE sector, in particular in developing regions such as Sub-Saharan African (SSA) area. Investment in RE can generate new growth opportunities, increase income, improve trade balance, and contribute to industrial development and jobs creation. However, investments in RE sources require large up-front investments.

With scarce public funds, governments rarely can afford the entire cost of RE deployment. Thus, RE strategies shall take into account private sector needs in order to fully benefit from the socio-economic impacts of investment in this field. Such strategies shall aim to provide a reliable framework, both in regulatory and economic terms, ensuring investors the proper viability for their initiatives.

Objectives

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

The objective is to provide examples derived from good and bad 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 policy success.

Main Issues

RE technologies have been publicly supported for several decades but rationale has been changing over time.

Support policies to the development of bio-fuels 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 stimulated sound programmes for R&D in 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[1] 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

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.

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

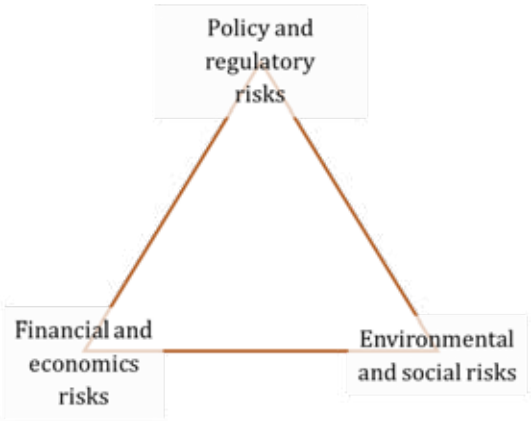
Since public funding in renewables is unlikely to increase above its current level of 15%, as foreseen by IRENA, private finance will have a crucial role for new investments. In particular, institutional investors will be able to scale up renewable energy investment.

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 taking new RE investment decisions 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**.

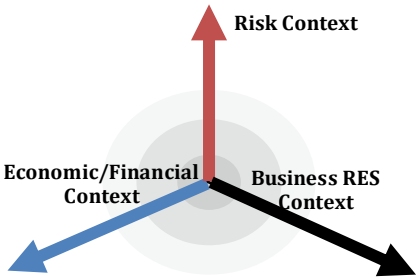
Area		#	Issue
1 Legal framework enabling	Business Environment Framework	1	Starting a business
		2	Property/concession rights
		3	Labour issues
		4	Dispute resolution issues
		5	Business travel rules
	RE Investment framework	6	RE regulatory framework reliability
		7	Rules favouring market opening to IPP
		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.

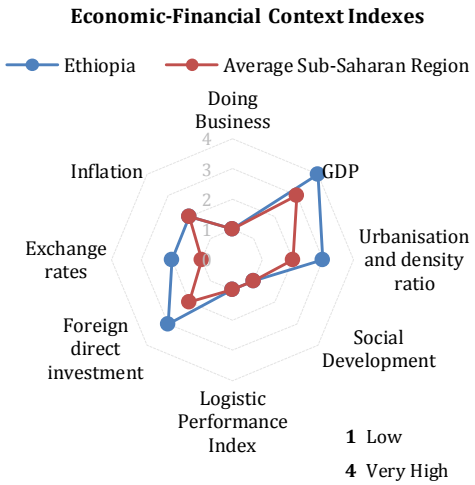
Risk assessment models applied to Ethiopia: a practical example

Based on the risk assessment logical framework developed by RES4MED in 2016, a risk assessment model has been developed by PwC taking into account many dimension affecting investment profitability. This tool allows, by means of a set of indicators, to assign an Attractiveness score, considering the size of Risk in delivering out RES investments in the analysed Country. In detail, 3 domain of analysis are considered:



1. E**conomic/financial,** reporting macroeconomic conditions (growth and stability of the country), financial issues (e.g. currency convertibility, interest rates conditions), together with considerations on social conditions and logistics.
2. **RES Business,** assessing aspects specifically related to renewable energy production and the availability of resources.
3. **Risk context**, its potential impact on profitability of investment generated by natural critical events internal or external to the Country. Thus defining the risks regarding the country's ability to ensure the "promise" made to investors.

Below, results obtained from the risk assessment model applied to **Ethiopia** are presented and analysed in detail. The three set of indicators/sub-indicators are presented per the 3 contexts of analysis and compared to the average results obtained for the **Africa Sub-Saharan Region**.



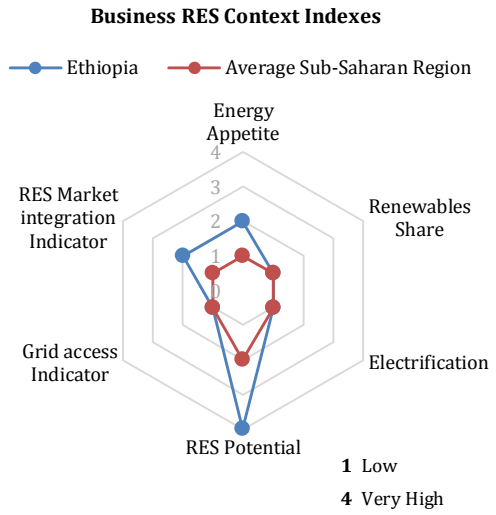
Ethiopia experienced impressive **GDP growth** in recent years and its economy is expected to be one of the fastest growing in Sub-Saharan region over next 10 years. In the last years, the GDP of Ethiopia has maintained a significant average annual growth rate of around 8%, while **Net inflows of foreign investment** in 2015 was 3.5% of GDP, according to World Bank.

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.

The **Urbanisation and density ratio** helps to estimate where and how energy demand must be satisfied. A Country is considered more attractive if the population is concentrated in urban areas as it is easier to serve its demand.

Despite these positive factors, Ethiopia remains one of the poorest countries in the world with a third of the population still living below the poverty line, as can be seen by **Social Development Index**.

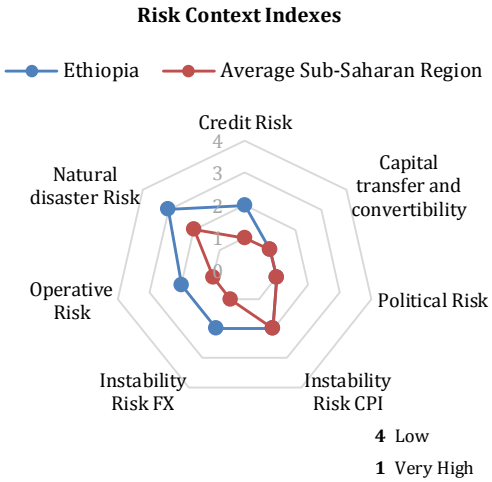
The **Logistics Performance Index** shows the Country still needs to implement the construction of the infrastructure network and the quality of transport.



About the Business context, Ethiopia has a **high potential of resources** in the field of RES. In this regard, the Ministry of Water Irrigation and Electricity Federal Democratic Republic of Ethiopia highlighted that the geothermal potential is around 5000-10000 MW, the average daily number of irradiation to produce electricity from the Sun is around 5.5 kW/m2/day and that the wind potential, with wind speeds greater than 7 m/s, hovers around 1000 GW.

Ethiopia does also have a significant **"Energy Appetite".** BMI forecasts the average electricity consumption growth rate will be around 9% from 2017 to 2021. Nevertheless in 2017, according to IEA and WEF, the per capita consumption is still below the standards base for human needs (about 87 kWh/per capita).

The factors described above suggest a high potential Business Development RES in Ethiopia, but an implementation of mains is still needed (only 25% of the population has access to the network) to enable deployment and integration of the RES. Despite some initial steps toward liberalisation and greater presence of IPPs have been taken, the Country shall move quicker steps to facilitate private investments in the RE sector.



Finally, Risk context indexes have been added to this quick assessment, namely:

- **Political Risk**: associated to political decisions, events or conditions that could affect the profitability of a business
- **Credit Risk**: the risk that a borrower may not repay a loan and that the lender may lose the principal of the loan or the interest associated with it. It is calculated as an average of sovereign risk, banking risk, corporate risk
- **Capital transfer and convertibility Risk**: Restrictions on movements of capital and on repatriation of dividends and profits
- **Instability Risk** (Exchange rates and Inflation): measures the inflation volatility (CPI) and the exchange rate (FX) variance in the Country based on history data
- **Operative Risk**: measures the capability to manage and solve problems linked to the renewable plant operation
- **Natural disaster Risk**: defines the exposure of an entity (population, built-up area, infrastructure component,

environmental area) to one or more natural hazards (earthquakes, cyclones, droughts, floods, and sea level rise).

In Ethiopia, as in all the geographical Area analyzed, there is a considerable high risk regarding the transfer and convertibility of the Capital and of Country Politics, according to SACE.

The current low presence of renewable resources (apart from hydro), contributes to the high operative risk of the country.

Nonetheless, in a final comparison between **Ethiopia** and the Sub-Saharan African area, the Country shows better performances.

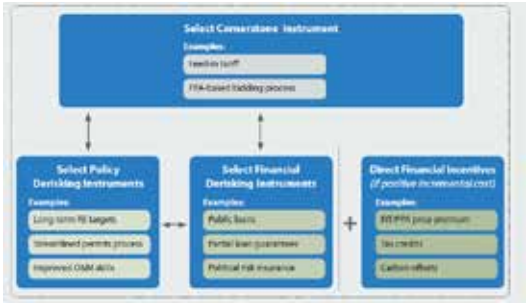
Policy and regulatory measures mitigating risk

In the previous chapters, risks that developers may face during an investment process and their influence on policy outcome have been identified. Policy and regulatory instruments have been built by Governments and Regulatory Authorities, aiming at reducing investments risks and stimulating investments, as, for example:

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

In most Countries, FiT and auctions have been implemented as solutions 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, especially in combination with other public instruments to address the high financing costs for renewable energy in developing countries and mitigate financial risks . In this context, the best outcomes occur when policymakers address the renewable energy investment risk in a systematic and integrated way by putting in place other instruments together with FiT/Auctions, as outlined in the following graph to mitigate the residual risks which can block the investment.



It is important to note that the above approach has generally been applied to large scale investments and should be reshaped to support distributed renewable energy, small scale and energy efficiency investments through aggregative models.

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 and actual technology cost trend.

Renewable energy 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 lower costs of RE technologies.

Consequently, determination of right level of support (right level of tariff in FiT case) is becoming more and more challenging.

In several markets, **auctions** substituted FiTs as the main procurement policy of choice. According to REN 21 over 30 countries in the

world held RES auction in 2016, from just 14 Countries in 2014. Such data show how successful the auction mechanism is becoming without both geography and technological boundaries. 2017 is expected to confirm the trend of the recent years, with additional countries, like Ethiopia, issuing RES auctions.

Auctions provide the downward pressure on costs and add transparency benefits. On the other side, there are valid issues about auctions and the different mechanism through which they shall be implemented.

Policy learning between countries across continents is an important driver for improving policy design, especially in developing countries when it comes to plan and implement the most effective measures also under the socio-economic growth point of view.

It is worth to mention an emerging route to market through which RES developments is currently pursued in an increasing number of countries, in addition to national Government auctions: Corporate Power Purchase Agreement.

Corporate PPAs are long-term agreements according to which medium-large business companies – rather than State-owned utilities – buy power directly from renewable IPPs. Such agreement allows corporate off-takers to purchase power at a fixed price, providing a hedge against the volatility of electricity prices, as well as enhancing their environmental credentials.

Creating a market environment which also allows IPPs and Corporates to set up such kind of energy supply contracts, provides an additional RES deployment opportunity.

From a risk mitigation point of view, PPAs relies on the accountability of the contracting parties and therefore i) avoid Governments to directly provide guarantees and ii) have the IPPs allocating the revenue stream risk on (large) Corporates with proven track records and financial stability, enabling project finance opportunities.

For buyers, such deals offer various advantages such as pursuing a sustainability strategy, locking in a certain price to avoid exposure to inflation and price volatility, or ensuring security of supply.

Competitive Auctions and beyond: Regulation as key market enabler

With RE subsidies mostly phasing out, Corporate PPAs become relevant as they ensure stable revenues through long-term contracts with creditworthy off-takers such as large corporates and provide robust credit security, which helps developers to secure financing.

About Corporate PPAs, we refer mainly to 2 different options: option a) “Private-wire” deal in which renewable developer builds a plant nearby the consumer’s premises and physically supplies energy through a wire; option b) is an “ off-site PPA” in which buyers agrees to buy a certain amount of MWh from a plant located elsewhere. The latter, that is the most commonly used, is also known by the term of “Wheeling” that is the delivery of electricity generated by a private operator in one location to a buyer or off-taker in another location via a third party network.

Wheeling is a natural diversification for the local renewable industry as it was for more mature markets. It enables power producers to harvest prime natural wind or solar resources where they are located and supply

clients in other areas even very far away from the generating point, thereby enabling them to benefit directly from clean and low-cost energy.

Both options provides advantages and disadvantages

In Option a) the agreement is generally quite simple but customer will still be dependent on the grid when the RES plant is not generating enough and, at the same time, regulations should allow for possibility to inject excess of energy into the grid at remunerated price.

Option b) solve those issues but creates others since the agreement would be more complex, involving the main utility to allow third party access into the network, clearly defining the costs to be incurred by the developer and the customers, and balancing the supply of renewable projects and demand from the buyer.

Unfortunately market regulations are still holding back on corporate PPAs in some Countries and opposition is faced by incumbent utilities fearing customers leaking and, consequently, revenues losses. But, in developing countries, where 24/7 supply is not assured and power prices are volatile and expected to increase in the future, this option should be encouraged also by the Government in order to foster countries economic development, ensure security of supply and in some case mitigate the misperceived over-exposure of public sector finance.

Recommendations

Optimisation of market design can be carried out carefully assessing both the Country and specific projects risk profile and this paper suggests an approach that Governments/Authorities can apply as if they were in investors' shoes. When risks are identified, tailored supporting mechanisms can be developed and international experiences show solutions are there to pursue private investments attraction with public interests to get electricity at a fair price. At the outset of many RES policies, public incentives strongly helped to overcome barriers to investments and remunerate risks. Then, instruments, fully integrating renewables into the energy system, can be provided to let RES IPPs operating in the market (e.g. Corporate PPAs).

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, for example, 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 mechanisms currently available and also *under development* (FiT, auctions and Corporate PPAs respectively) 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. Indeed 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.

Drawing successful case histories from international practices, then, helps Governments/Authorities to accelerate learning processes and to adapt their own schemes to minimise energy supply costs while investors' risks perception cools down.

Best practices for wind project development

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Abstract

Ethiopia launched an ambitious program for developing renewable energy capacity, namely the Growth and Transformation Plan II (GTPII). The GTPII's overall goal is to add roughly 6 GW of new capacity by 2020 (excluding the Grand Renaissance Dam, which is already being finalized) exploiting the Country's renewable energy resources potential in hydro, solar, geothermal and wind at most. Whilst hydropower constitutes the backbone of the national generation mix, wind energy has entered the Ethiopian energy system only recently. Going through the typical development stages of a wind project, and looking at the different approaches used by governments concerning energy auctions, this paper will examine key concepts of project bankability and the current Ethiopian strategy. The study will also provide tangible case studies and best practices in Governments approach to tenders. Finally, the development of a 320 MW wind farm project, implemented by Italgen in Egypt, will provide an exhaustive analysis of wind farm permitting process and the steps developers need to take to deliver a project.

Wind project - site development

This paragraph will describe two key elements for a wind site development: Micrositing activities and the role of the Environmental Impact Assessment (EIA).

Micrositing

The definition of the wind turbines positioning, which constitutes a wind farm within a project area is usually referred as "Micrositing" or layout design. A proper

Micrositing is essential in order to maximize the resource exploitation both in terms of energy yield and project economic efficiency.

In a Greenfield project development, the Windfarm layout definition typically follows two macro phases which may be referred here as *Site Screening & Selection* and *Detailed Resource Assessment, Project Design and Optimization*. The first involves the project site selection and preliminary analysis at large scale, the last includes all the exhaustive *on site* studies and design.

The *Site Screening and Selection* phase is carried out through a multi criteria analysis where information, gathered from different sources, is processed to identify sites or areas, which fulfil a group of predefined project development feasibility criteria. In such way promising areas can be identified and further development effort can be focused.
This analysis normally includes the following items:

1. Large area wind resource mapping;
2. Terrain complexity and land cover evaluation;
3. Assessment of constrains due to human life and activities;
4. Assessment of constrains due to land use restrictions;
5. Grid connection and road infrastructure presence.

Figure 1 shows an example of *Site Screening and Selection* phase made through a Geographic Information System (GIS).

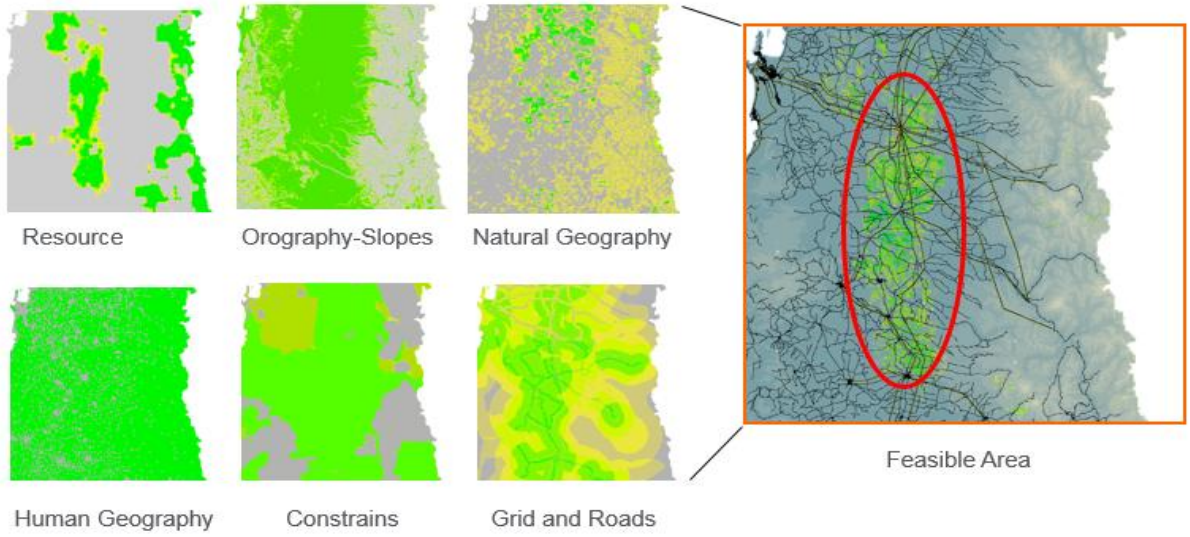


Fig. 1 – Site Screening and Selection phase - *Feasibility Criteria Fulfilment is shown for each topic in a Green-Yellow and Grey colours scale.*

The *Detailed Resource Assessment, Project Design and Optimization phase* focuses in *on site* studies. Among these studies the most important in wind project development is, without doubt, the *on site measurement campaign*. Up to the presence, on site measurements constitute the only way to assess the wind resource with the accuracy needed to properly design and estimate the future possible yield and performance of a wind farm in a pre-construction phase. An effective on site measurement campaign is typically made through the installation and management of Meteorological Masts. Their position, number, configuration and height are chosen in order to be representative of

the site spatial resource variation and the expected turbine size. At least 12 months of measures are needed to characterize the resource, a shorter time is not enough, but more time could be needed to completely investigate the site's resource spatial and time variability.

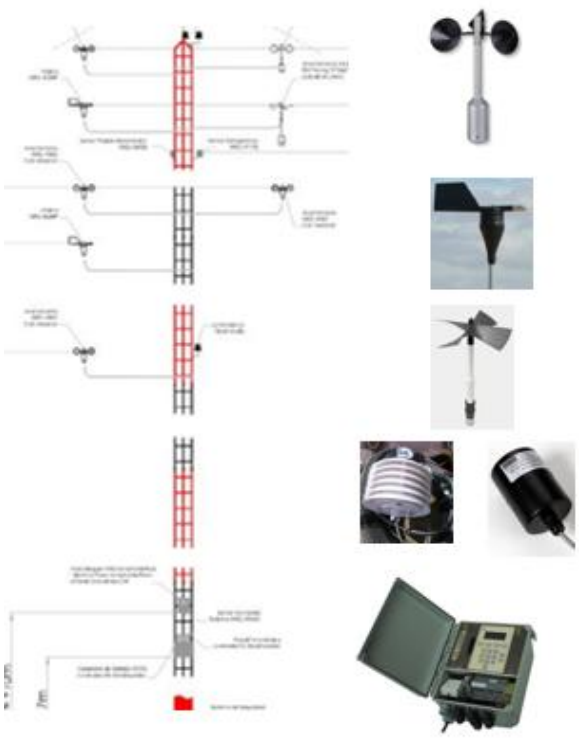


Fig. 2 - Typical Met Mast Sketch and instrumentation types

Once the *on site measurement campaign* is made, a Wind Resource Assessment study (WRA) is performed to obtain a detailed resource spatial distribution of the interested site and the energy yield and a mutual interaction estimation of the wind turbines in the layout under study. The WRA study can be divided in the following activities:

1. Data treatment;
2. Long term climatology definition;
3. Flow modelling;
4. Wake calculation;
5. Loss estimation;
6. Uncertainty estimation.

In the *Detailed Resource Assessment, Project Design and Optimization* phase, the Micrositing or layout design criteria considers the following elements:

- **Project Constraints**
  - Available Land;
  - Maximum power;
  - Permitting / Law requirements;
  - WTG size;
  - Distances from roads, lines, houses;
  - Noise and shadow limits;
  - Restricted areas;
  - Other environmental constrains.
- **Turbine suitability & Energy yield**
  - Construction suitability;
  - Flow and ambient conditions suitability;
  - Wake interactions.
- **Internal procedures**
  - Best practices;
  - Performance;
  - Safety;
  - Cost.

The above elements are generally combined in an optimization process as the one presented in **Figure 3**.

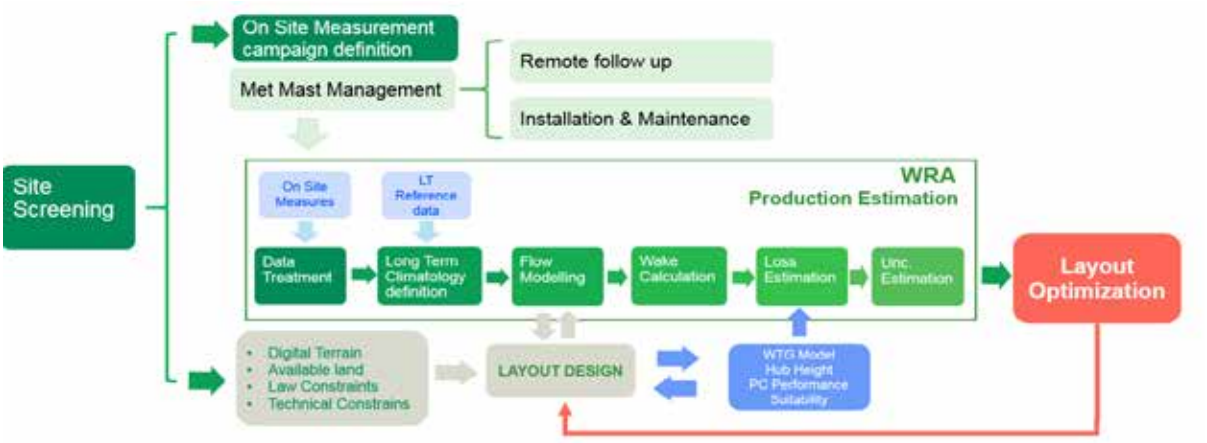


Fig. 3 - WRA study and layout definition & optimization process

The importance of the EIA process within the Permitting procedures

The EIA is typically the first step developers take in demonstrating that they have identified and will be managing environmental and social (E&S) risks.

The EIA process in Ethiopia is determined by the *EIA Proclamation (299/2002)* which is the tool for harmonizing and integrating environmental, economic, cultural and social considerations into the decision-making process in a manner that promotes sustainable development. The Proclamation clearly defines:

1. Why there is a need to prepare an EIA;
2. What procedure is associated with undertaking an EIA;
3. The depth of environmental impact studies required in an EIA;
4. Which projects require the undertaking of a full EIA study;
5. Which projects need partial or no EIA study;
6. To whom the report has to be submitted.

The Ethiopian EIA process is shown in **Figure 4.**

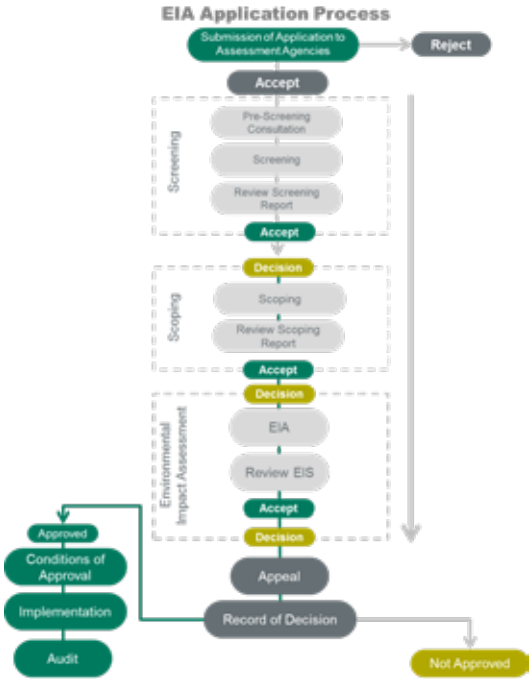


Fig. 4 - Ethiopian EIA Process

Environmental and Social Risks Associated with Greenfield Wind Development

Potential E&S impacts when fostering Greenfield wind developments in Ethiopia are included in **Figure 5** and key risks explained further below.



Fig. 5 - Potential E&S Impacts

1. *Site selection* – a poorly selected site can result in E&S risks causing unnecessary permitting delays, costs and community conflicts.
2. *Stakeholder engagement and resettlement* – one of the main considerations for wind power projects in Ethiopia is access to suitable land for development and consequently, the potential impacts on livelihoods of people using that land through economic and physical displacement.
3. *Risk of impact on bird and bat populations* – bird and bat mortalities due to collisions with wind turbine blades are typically one of the key potential impacts on the environment. Impacts from wind power projects on bird and bat populations can lead to significant development delays, increased costs and challenges in securing permit approval and financing. Impacts from wind farms on bird and bat populations are well documented and include habitat loss, displacement and collision with turbines, all of which can adversely affect species populations.
4. *Noise and Visual impacts* – the presence of the wind turbines can create a visual impact on the landscape. Operating wind turbines also generate noise emissions, which can be disturbing to nearby sensitive receivers.

Best Practice

There are a number of actions that developers should undertake from an E&S perspective to make permitting in Ethiopia as streamlined and efficient as possible; where acting early is key to success:

1. *Perform early screening of potential high risk E&S issues* – this can either be in the form of an early stage due diligence/fatal flaw analysis or red flags assessment. By integrating consideration of potential E&S impacts into early site selection and design decisions, impacts can be minimised or avoided where feasible.
2. *Engage with your lender group early on E&S issues and their requirements* – they usually have good experience on similar projects and are able to share this with the developer.
3. *Robust baseline data collection* – particularly for birds and bats, collection of reliable, robust and representative baseline data is vital to understanding the potential impact of the wind development. Coupled with collision risk assessments and designing mitigation and monitoring measures, bird and bat populations need not be a show-stopper.
4. *Early engagement with government stakeholders* – by discussing the project early with the decision-makers such as the Ministry of Water, Irrigation and Electricity (MoWIE), and Ministry of Environment, Forestry and Climate Change (MEFCC) to agree upon approaches, you can avoid unwanted surprises and reassure government departments that the E&S risks are being robustly managed.

5. *Understanding the importance of social issues* – working to build trust with local communities at the outset, understanding potential impacts on livelihoods, determining if a project will have the potential to affect indigenous people and appointing a community liaison officer, will all help to manage local project risks effectively.
6. *Identify opportunities that can create additional value to affected communities* - by considering E&S issues early in the project life cycle, a risk-based approach can be taken to prioritise the management of key E&S impacts and provide a clear framework of tasks to address potential impacts in stages. The costs associated with addressing these impacts can also be internalised at this early stage, representing the real costs of the project.

Governments approach to project tenders

Renewable energy auctions have proved to be successful mechanisms to support renewable energies development. Several countries around the globe have adopted auction mechanisms aiming to attract a large number of players, to increase competition and ensuring new generation capacity at lower prices.

When designing auctions, policy makers can therefore learn from a vast pool of experiences from other countries and tailor the mechanism to the Country's economic condition, structure of the energy sector, maturity of the power market and to the specific goals they would like to achieve (i.e. reducing entry barrier for new players or maximizing the likelihood of efficient and timely project delivery).

From this point of view, a key element in the hands of the policy makers is the **selection of the project sites**. Two possible approaches exist:

- Sites may be selected by off-takers or Governments. This implies that the off-taker/Government takes the responsibility to perform early development activities, including wind measurement campaigns, geotechnical, hydrological and topographical investigations, obtainment of land rights, initial permits and definition of interconnection solutions. Such approach reduces developer costs and liabilities, lowers the risk of plant construction delays and allows to centrally coordinating sites selection according to grid proximity and demand centres development.
- The alternative approach is that developers select their own project sites bearing all costs for the site scouting and development. Therefore, the developers not only compete on industrial and financial basis, but they are also encouraged to compete in the selection of the best sites in a more efficient way than a centralized off-taker/Government may do.
  An additional benefit of this approach is the creation of a value chain also in the development phase.

The selection of one approach or the other significantly changes the allocation of risks between the off-taker/Government and the developer and by consequence it impacts the level of participation of bidders and, ultimately, the contracted price. The first approach (site selection by the off-taker/government) largely reduces the risks faced by the developers and it may be preferable for Countries at an early stage of renewable energy deployment programs that aim to be more attractive for potential players. On the opposite, the second

approach seems preferable for Countries with a stable regulatory framework and mature renewable energy programs.

Governments could also look at hybrid solutions, like the Brazilian approach for hydro projects, where participants bid on the same site, previously submitted by one private developer (the proponent is allowed to participate in the tender and is refunded the development costs, if not winning). The following **Tables 1, 2 and 3** show respectively: Moroccan, South African and Egyptian governmental approach towards tendering procedures.

Case #1	Morocco – 850 MW wind tender
RFP issue date	February 2014
Awarding date	October 2014
Tender Authority	Kingdom of Morocco
Off-taker	ONEE
Awarded capacity	850 MW
Tender mechanism	Sealed bid competitive tender to award multiple projects based on a specific technology and capacity size to a single bidder.
Site selection	Specific sites are evaluated and selected by the tender authority through ONEE (the Transmission System Operator). Tender documentation includes geotechnical, topographic, seismic and wind studies and preliminary EIA.
Grid	Grid access and tariffs are guaranteed by ONEE
Asset ownership	Developer for the 25-year contract period, then reverts to the Kingdom of Morocco.
Evaluation criteria	1) Prequalification — pass/fail outcome mainly based on project experience, financial background and material disputes. Exclusive agreement with WTG manufacturer as mandatory requirement. 2) Projects evaluated on: (i) Compliance with technical specification and other tender requirements; (ii)Local content; (iii)Price.

Table 1 – Morocco 850 MW wind tender case study

Case #2	South Africa – REIPP Round 3
RFP issue date	May 2013
Awarding date	October 2013
Tender Authority	Ministry of Energy - Department of Energy - IPP Office
Off-taker	Eskom Holding Ltd
Awarded capacity	1457 MW
Tender mechanism	Sealed bid reverse auction to allocate a fixed total capacity to multiple bidders across multiple projects of varying scales. Typically multiple technologies, although each represents a separate auction with capacity caps set per technology (carrying over to next round if not reached).
Site selection	Site selection, access and full permitting are the responsibility of the bidder.
Grid	Grid connection (access and cost) is negotiated by bidders with Eskom and is at developer risk.
Asset ownership	Private sector project developer.
Evaluation criteria	1) Prequalification / Bid Response Compliancy — pass/fail outcome based on various legal, financial, technical and environment requirements. 2) Projects evaluated on: (i) Price (70%); (ii) Local economic development (30%) – Minimum local content requirement of 40% with a portion of black ownership.

Table 2 – South Africa REPP Round 3 case study

Case #3	Egypt – Gulf of Suez
RFP issue date	April 2013
Awarding date	May 2015
Tender Authority	Egyptian Ministry of Electricity and Energy (EMEE)
Off-taker	Egyptian Electricity Transmission Company (EETC)
Awarded capacity	250 MW
Tender mechanism	Sealed bid competitive tender to award one project based on a specific technology with a minimum capacity of 250 MW to a single bidder
Site selection	Specific site evaluated and selected by the tender authority. Land lease signed with New & Renewable Energy Authority (NREA). Tender documentation includes geotechnical, topographic, seismic and wind studies and preliminary EIA.
Grid	Grid access and tariff are guaranteed by Egyptian Electricity Transmission Company (EETC).
Asset ownership	Awarded bidder for 20 years from Plant COD. On expiry of the term, the facility to be decommissioned and dismantled.
Evaluation criteria	1) Prequalification process based on financial and technical capabilities 2) Tender process: the lowest Levelised Electricity Cost identifies the winner

Table 3 – Egypt Gulf of Suez tender case study

An overview of RE market in Egypt

Egypt is one of the hotspots for renewable energy development in the MENA (Middle East North Africa) Region.

The country is facing a rapidly growing energy demand due to population growth, economic expansion and increased industrial output. It additionally suffers from power shortcuts due to ageing infrastructure, lack of adequate generation and transmission capacity, which may lead to a serious energy crisis. A continuous and reliable supply of electricity is required for Egypt's socio-economic development. With a demand growth expected to remain at around 7% per year over the next decades, an exceeding generation capacity of 1,500 MW per year is required and, to this purpose, the development of renewable energy resources has become a priority. Egypt has committed to increase its share of renewables in the country's power mix to 20% by 2022 (Wind 12%, Hydropower 5.8% and Solar 2.2%) and 37% by 2035.

The country currently sources just 3% of its electricity generation from renewables. To achieve its ambitious targets, the Government plans to invest in the renewable energy

sector and to develop wind and solar energy plants across the country.

Case Study – Italgen's wind farm in Egypt

Italgen's 320 MW wind farm project is part of the National Energy Strategy targeting to reach 20% of energy coming from renewables by 2022. Located in one of the windiest regions of the world, about 100 kilometers north of Hurghada, the plant, with a capacity factor of 55%, can reach almost 5,000 hours per year running at full load



Fig. 6 – Egypts RE target RCREEE

Gulf El Zeit wind farm project is the first and most relevant foreign direct investment in the country under BOO (Build-Own-Operate) scheme to get the Generation License and to be fully permitted by the Egyptian Government.

The Memorandum of Understanding established the first formal step and institutional agreement between Italgen and the Government of Egypt, represented by the Ministry of Electricity and, specifically, by NREA, the New and Renewable Energy Authority acting as the national focal point to develop and introduce renewable energy technologies in the country.

This fundamental, preliminary step has been followed by many concrete actions to attain the completion of the authorization process, among which:

- Land Allocation (through the definition of a Usufruct Agreement with NREA)
- Exhaustive Wind Measurement campaigns
- Generation License (issued by Egypt ERA, the Egyptian Electric Utility and Consumer Protection Agency, entitled to determine rules and conditions related to electricity business activities in Egypt as well as sale and distribution and to grant the relevant licenses.
- Grid Connection Agreement and Network Access Contract (signed with the local TSO: EETC - Egyptian Electricity Transmission Company)
- Detailed Environmental and Social Impact Assessments, focused on the possible implications on the environment, biodiversity and birds' migration. The studies obtained the approval of the Ministry of the Environment.

The permitting process has been the result of a continuous dialogues with Ministries, local Authorities and Communities involved.

Once in operation, the plant will produce 1,500 GWh avoiding the emission of about 750,000 tons of CO2 and will allow the saving of 2,000,000 oil barrels per year, resulting among the largest power plants from renewable sources in the MENA region (Middle East North Africa).

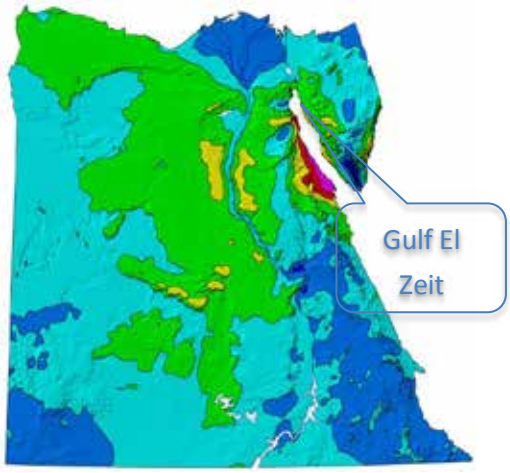


Fig. 7 – Egypt's Wind Atlas

Lessons learned

The Renewable Energy sector is a key driver for a sustainable economic growth in developing countries. To encourage investments by the private sector (either local or international) Governments should ensure a well defined and reliable policy framework both in regulatory and economic terms, ensuring investors with an economic viability and profitability. Well targeted government investment incentive and support mechanism are additionally welcomed to promote private investments.

Reference to incentive mechanisms, it is essential to optimize their use to avoid pure results or, in the worst case, relevant extra costs which, at the end, would have negative impacts on the "project bankability".

Profit@Risk analysis supporting projects bankability

A bankable project is a project whose underlying contracts allocate risks in such a way that is satisfactory to the financing institutions. Generally, financing institutions pose their attention on the presence of specific provisions within the contracts dealing with mitigation of technological, construction, operational, financial and regulatory risks. Macroeconomic and political/policy conditions of destination Countries, significantly affect project success, as well. Therefore, within the investment decision making process the typical Discounted Cash Flow analysis, evaluating investments profitability, shall be enriched by a risk analysis, screening the impact of all the listed factors on the proposed investment.

An effective risk assessment approach can be based on three main analytical dimensions, each of them involving specific sub-dimensions, as follows (sub-dimensions can change depending on specific cases):

- Country Attractiveness (Regulatory environment, Market size, expected growth, Market entry barriers, Competition (number and size of competitors), Technological issues, etc.)
- Profitability (Expected revenues and costs -> Profits, Time-to-market, etc.)
- Risks (Operational risks, Financial risks, Regulatory changes as main categories).

In this approach, market attractiveness and expected profitability help to identify basic feasibility conditions, to be challenged by including risks components in every sub-dimension previously considered.

Such a model can be built reaching different level of complexity, depending on the investment decision maker requirements, which shall incorporate financiers' ones. Consequently, a risk assessment process can be delivered identifying:

- specific sub-dimensions for each risk dimension;
- quantitative indicators (e.g. from 1 to 4, from High to Low) to describe risk levels for each sub-dimension.

A first separate assessment of Attractiveness, Profitability and Risk conditions can be made,

using (weighted) averages of the quantitative indicators previously chosen. Then:

- a first Attractiveness-Profitability matrix can be derived;
- both Attractiveness and Profitability conditions can be assessed against Risk considerations;
- a final matrix resuming the overall process can be drafted, providing the required assessment.

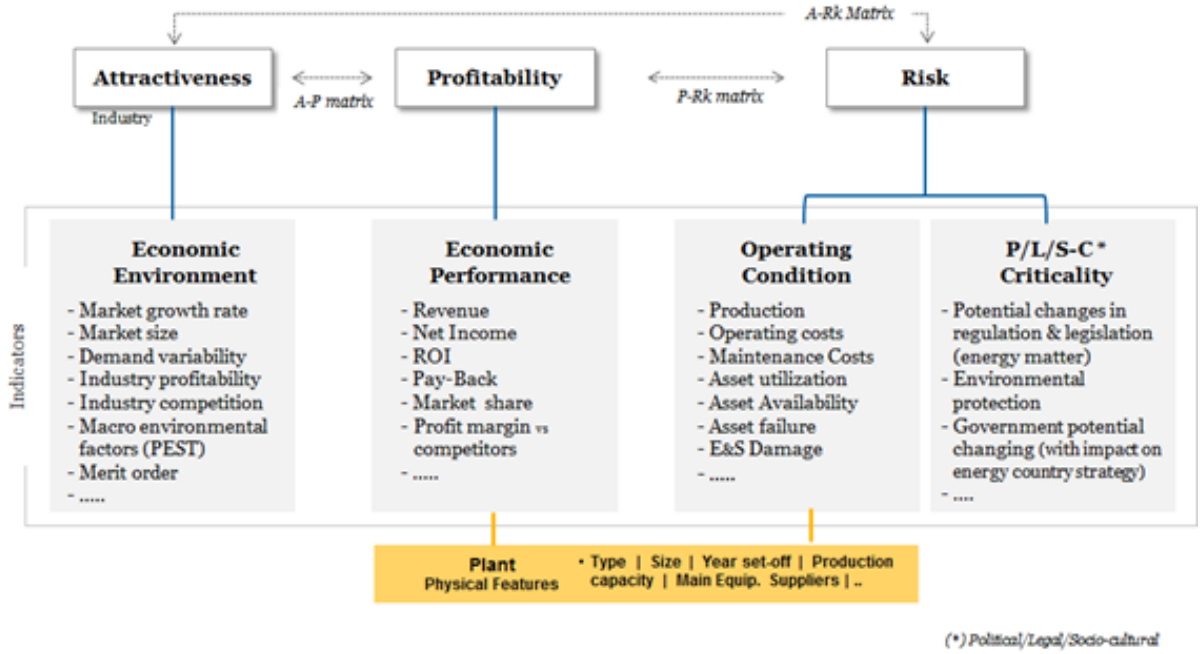


Fig. 8 – Risk assessment matrix (illustrative)

Such a process is expected to be iterative, as many conditions shall be evaluated, until a final fine tuning of the model.

The final objective is to estimate a "strength index" which summarises the investments profitability including risk conditions and, when positively assessed, its bankability.

A Profit@Risk analysis-like view can be applied when making renewable energy policies by Governments. In fact, in order to attract investors, destination Countries' authorities shall aim at creating the most favourable environment which is the one where all the mentioned risks are mitigated by adequate measures. As far as Governments/National authorities are concerned, the following conditions shall be provided, among others, to favour projects bankability:

- Transparency and clarity of procedures;
- Reliability on administrative processes timing and results;
- Clarity of revenue-making conditions (grid access and off take agreements, stable sale prices, compensation of curtailments, etc.);
- Sovereign guarantees on energy payments;
- Comfort on foreign exchange rate fluctuations and currency convertibility.
- Liquidated damages for both delay and performance;
- Reputable and neutral arbitration courts.

As reported in the first part of this paper, technical risks can be managed carrying out proper resource assessment campaigns while the choice of tested assets will ensure minimisation of O&M costs and production

failure. Risk management in both cases is under the project promoter responsibility as well as the adoption of wind plant construction solutions reducing time-to-market.

Ethiopia's strategy to speed up wind penetration

Ethiopia is endowed with abundant wind energy resources, which at the moment remain largely unexploited. Over the last 5 years, however, Ethiopia started moving in the right direction: it inaugurated one of the continent's largest wind farms in 2013, 120-megawatt (MW) Ashedoga plant, which was followed by the even larger 153 MW Adama II facility in 2015.

As mentioned above, wind still accounts for roughly 300 MW of Ethiopia's total output of around 4,300 MW, with the vast majority coming from hydropower. This picture is set to change with the government's second "Growth and Transformation Plan", where the Government of Ethiopia (GoE) has planned for an expansion of its wind power capacity up to 5,200 MW by 2020. The Government of Ethiopia has determined that private sector investment is critical to achieve these aggressive power generation targets. Originally involved in the construction phase only, the private sector will be invited to participate in competitive tenders for Independent Power Producers (IPP) in the near future.

The sites will most likely be pre-selected by the government, who will provide the wind resource measurements as well. This will be possible thanks to the measurement program that the Danish Energy Agency, together with the World Bank, is about to launch. The program entails the installation of 5 to 10 masts, the first ones being installed within 2017. This data acquisition campaign will be used by the Government to select the most suitable sites for the auctions, which will be published no earlier than the end of 2018.

Additionally, potential opportunities might also rise from projects that were originally tendered for Engineering, Procurement and Construction (EPC) with Financing Package and that EEP is currently considering switching to IPP modality.

In general, Ethiopia is following a top-down approach, where the private sector will be involved only once the site development is finalized. If, on the one hand, this approach mitigates part of the risk related to the permitting and licensing, it excludes the private companies from the development phase, where they usually can add significant value (especially in wind). While this approach is understandable at this early stage of wind development in the country (and related regulatory system), a smooth transition to a more bottom-up approach, taking also into consideration the hybrid scheme used in Brazil for hydro projects, could be beneficial.

Decentralized renewable energy solutions to foster economic development

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Abstract

Electricity supply and socio-economic development are closely linked. Innovative, sustainable decentralized energy solutions represent indeed the most efficient instrument to promote electricity access in remote and low load density areas.

Within this framework efficient generation technologies are crucial for the provision of electricity access and, in turn, to foster local development although not yet sufficient to directly spur sustained growth. Inclusive business models able to foster productive uses of energy are necessary, although the cycle jump-start requires many different inputs. The following study will therefore analyze the existing nexus between electrification and development, further highlighting the important role of having a holistic point of view and building strong partnerships to achieve the most efficient and sustainable business model. Finally, systematic know-how dissemination and a consistent regulatory framework for decentralized energy systems will represent key elements for an effective energy policy within emerging economies.

The fundamental role of electrification in economic development

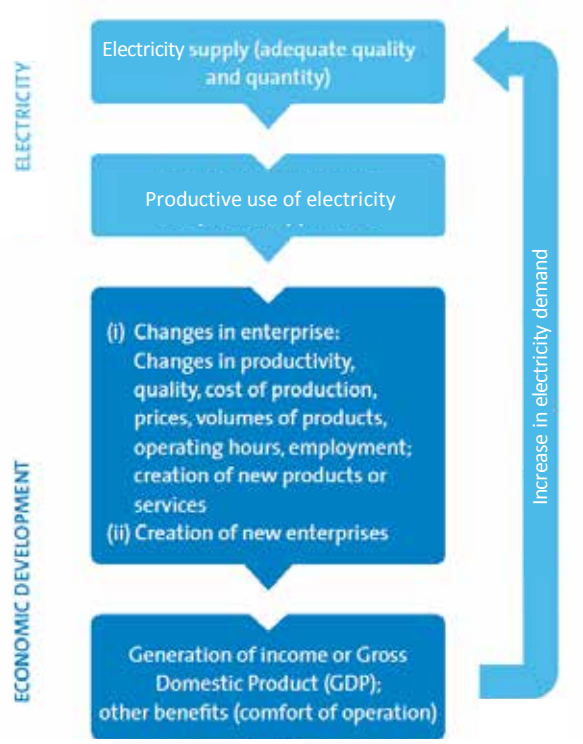
Three key arguments underpin the case for access to electricity as a critical enabler for socio-economic development:

(i) access to energy is of paramount relevance for the achievement of several of the United Nations' Sustainable Development Goals (SDGs);

(ii) "productive use of energy", as opposed to "consumptive use of energy", would enable new income-generating activities for poor populations, igniting the activation of the capital accumulation cycle; and

(iii) lack of access to energy is a direct indicator of poverty based on living standard's measurement criteria

The links between access to energy (in particular electricity supply) and poverty reduction through income generation can be presented as a step by step approach, as shown in the following figure [1] : a household/business benefiting from electricity supply is only the first step towards the user/entrepreneur's decision to make use of it. But it is only the actual use of the power supply, and the step changes that such use of power allows to the user/enterprise (mostly in the form of productivity improvements), that enables income generation and capital accumulation. The following figure is only an example of interaction between electricity supply and socio-economic development. However, it provides a useful conceptual framework for a systemic approach to investigate the benefits of access to energy.



Once recognized the key role of electricity in economic development, criteria must be set out in order to comparatively assess alternative models for the design and implementation of energy systems.

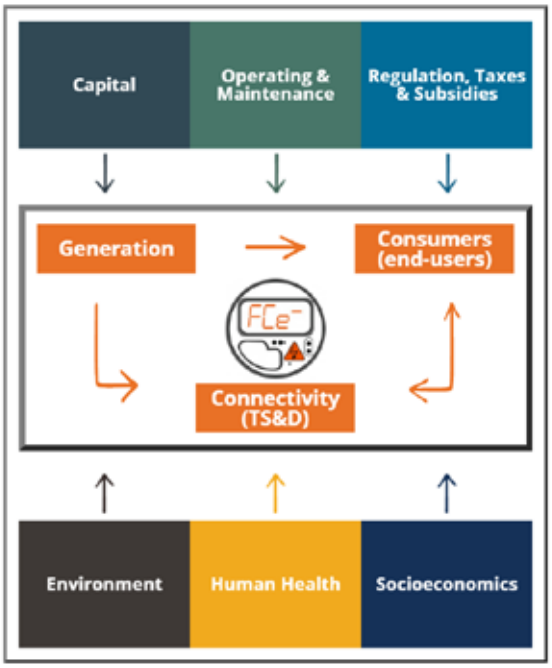
- **Full Cost of Energy**

The *Full Cost of Energy* approach pursues the systematic consideration of all the elements determining the total cost of generating and delivering electricity [2] to the end users, meaning all the direct and indirect costs associated with power generation and delivery, including generation capacity, fuel costs, environmental effects, Transmission & Distribution infrastructure investments, the cost of dispatching and flexibility, the cost of

[1] Adaptation from PRODUSE, The Impact of Electricity Access on Economic Development: A Literature Review, page 6.

[2] The Full Cost of Electricity, The University of Texas at Austin

redundancy as well as the *time-to-market* of the different alternatives.



- **Centralized versus decentralized energy systems**

Adopting the Full Cost of Energy approach enables, *inter alia*, the comparison of two general models to provide secure and sustainable access to electricity: i) centralized power generation and ii) decentralized energy systems.

The first model refers to the generation of electricity at large-scale centralized facilities, whose location is mainly determined by the efficient access to fuel and land availability. High Voltage (HV) networks need to be designed and deployed in order to efficiently transport electricity from the centralized plants to the load centres. Large conventional power stations, such as coal, gas and nuclear plants, as well as large renewable facilities, such as hydroelectric stations and utility-scale wind or solar power stations, are representative of the centralized model.

Decentralized generation refers instead to a variety of technologies to generate electricity at or near the end user(s). Decentralized energy systems are typically based on local renewable energy sources, captured via mini-hydro, biomass, biogas, solar, wind and medium-enthalpy geothermal plants. They are either connected to a single load, such as a home or a SME or, through localized bi-directional medium voltage (MV) and low voltage (LV) networks, to multiple loads in the same area, giving rise to a mini-grid. Decentralized generation systems are modular and flexible, and can include multiple generation and storage elements (in *hybrid* configurations) in order to guarantee supply 24/7.

Historically, the full cost of a *delivered* kilowatt-hour was higher in distributed than in centralized systems. However, the rapid cost digression experienced by decentralized generation, storage and energy management technologies (as well as the quantification of the environmental effects of centralized generation) have bridged such gap, particularly in areas with low initial load density. Such cost advantage, coupled with rapid and flexible delivery, points to decentralized electricity systems as the most efficient instrument to foster access to electricity in areas of low load density. Furthermore, in case of future connection to the main grid, sophisticated and resilient mini-grids can play a fundamental role for the stabilization of the wider electric system.

Distributed energy systems: the technological state-of-the-art

Decentralized energy systems are not a new concept: every day diesel and gasoline generators provide electricity to millions of people and businesses where there is no grid or where the grid is unreliable. What has

changed is the emergence of a wide array of competitive, sustainable and reliable technologies for renewable energy generation and energy storage and management.

Today, decentralized energy systems comprise a variety of technological solutions for different applications and with different performances in terms of dispatchability, availability, etc. such as:

- **Solar Home Systems**

SHS (Solar Home Systems) are stand-alone photovoltaic systems in rural areas, not connected to the grid, designed to meet a household's basic electricity needs.

SHS consist of solar modules connected to a solar charge controller, an inverter and a battery. The energy is stored into the battery bank and supplied to the load via a DC/DC or DC/AC conversion system. They feed low-power appliances such as lights, radios and small TVs for about three to five hours a day.

SHS are a key instrument for basic access to energy (and the creation of initial loads) but not a tool for productive uses of energy, given their limited power and autonomy.

With cost as one of the biggest barriers for SHS uptake, optimizing the system size versus the energy needs is crucial.

While in 2003 only a SHS of 20 Wp was economically competitive with kerosene lamps, in 2015 this was true also for a 70-80 Wp kit. The main contributor of such cost digression has been the decrease in the cost of the photovoltaic modules. The cost of batteries has now also entered a steep descending path, while the cost of the Balance-of-System (BOS – inclusive of inverter, cabling and structure) is expected to significantly decrease with rising volumes.

Much of the challenge in the diffusion of SHS hinges on the successful optimization of battery lifetime. Battery can account for more than 50% of the total SHS costs, while having the least lifetime among the components.

The key advantages, disadvantages and relative challenges of today's two mainstream battery typologies are set forth below:

LEAD-ACID Batteries		
Advantages	**Disadvantages**	**Challenges**
– Mature technolo-gy – Low cost	– Restricted depth of discharge – Low energy density – Electrode corrosion limits useful life	– Battery file-cycle
LITHIUM-ION Batteries		
Advantages	**Disadvantages**	**Challenges**
– High energy density – Long life-cycle – High roundtrip efficiency	– High production cost (but falling) – Safety devices needed	– Cost-effective battery manageme nt system on small scale

- **Single-user hybrid solutions**

Single-user hybrid solutions (mostly for SMEs) combine i) one or more renewable-energy sources, ii) normally a storage system to balance the system and time shift renewable energy production, iii) conventional back-up systems (usually diesel gensets) to ensure 24/7 energy supply; iv) a

BOS inclusive of inverter(s) and an energy management system to ensure stable supply and optimize power flows.

Such single-user systems can be grid-connected (if so, they can source power from the grid when economically convenient and when the grid is considered sufficiently stable), but are designed not to rely on the grid, neither for energy supply, nor for voltage and frequency stabilization. By contrast, they are thought as independent power generation systems, able to provide 24/7 energy supply.

A hybrid solution can be characterized on the basis of the ratio between the capacity of renewable energy sources and the load to feed: low, medium and high renewable penetration require different architectures, different sizing of energy storage systems and the use of different control functions.

Hybrid solutions combine the environmental benefits and short time-to-market of renewable sources with a dispatchable, guaranteed, high-quality power supply.

- **Mini-grids**

Mini-grids can be defined as a set of generators and loads within a limited defined area, operated in a coordinated way. Mini-grids can be run as stand-alone localized electric systems, especially in rural areas, but can also be connected to the wider electric system, in order to efficiently exchange energy, balancing capabilities and cold reserve (*capacity*), i.e. they can be integrated as single active elements in centralized power systems.

Mini-grids cluster multiple loads and distributed generation systems via MV and/or LV by-directional localized networks. The elementary building elements of the mini-grids can be pure loads (households, SMEs), prosumers (households or SMEs with their own hybrid solutions), community or commercial mini-grid-level generation and/or storage facilities. A mini-grid can be privately or community-managed, or else utility-managed.

Presently, most micro-grids adopt conventional AC grid systems. Since many renewable sources generate DC voltages, converters are required to transfer power from these energy sources to the AC grid system. For example, wind turbines require back-to-back power converters to synchronize and adjust the output frequency and voltage level with the AC grid system. In residential and rural segments, grid connected equipment such as computers and battery chargers use DC power. Thus, these devices require an AC-DC conversion stage for AC grid connection. Such multiple conversion stages reduce the overall efficiency and reliability of the systems. Hence a renewed interest in exploring DC grid systems.

Inclusive business model: Productive uses of energy

Fostering productive uses of energy is essential to ignite a virtuous circle of demand growth and increasing local availability to pay, which lays at the basis of mini-grid return on investment.

In fact, despite choosing the most efficient generation technology to provide electricity access is necessary to support local development, it is not sufficient to directly spur economic transformation and sustained growth. Indeed, a sustainable business model shall be created in order to couple electricity supply with other solutions and quality inputs to successfully unleash the

community's inner capacity to develop and trigger a virtuous cycle.

Opportunities and positive impacts related to mini-grid development

Mini-grid implementation through the above mentioned sustainable business model has the potential to generate widespread and transformational benefits, such as:

- Providing critical employment opportunities, particularly in the agricultural/agro-processing industry and Small/Medium Enterprises (SMEs);
- Promoting growth of local economy and private sector, thus presenting opportunities for investors as well;
- Enabling households to achieve a better standard of living, which in turn would enable them to be more productive and generate additional income also used to buy efficient electric equipment (e.g. fans, food processors, refrigerators etc.) that will improve their quality of life;
- Catalyzing training & development of skilled human resources as people acquire new competencies to run new businesses or to take advantage of new employment opportunities;
- Making the investment in electrification sustainable, thanks to the growing local consumption and to the increased community ability to pay.

However, the identification of the potential uses of electricity that could ignite this virtuous circle requires prior analysis and actions. In fact, local businesses development should be done during the whole lifecycle of the electrification project, since it helps both to design the infrastructure and to establish a sustainable business model, which has to be tailored to the specific socio-economic characteristics of local communities. Such characteristics vary from place to place and there is no one-size-fits-all solution that will suit all villages.

Such development should be performed in an inclusive way, building the demand bottom-up, as the involvement of local players is essential from an early stage to build trust between residents, local businesses, the mini-grid developer and operator.

The development model must consider the holistic system to be effective. For example, the identification of solutions to include productive use of electricity and electricity use needs to focus on different inputs, relationships, mechanisms, and dynamics at play, such as:

1) Supply-Demand of electricity, including aspects such as the reflectiveness of electricity tariff and the incurred costs for the electricity supply and the availability to pay for different uses of electricity
2) Competitiveness of mini-grids with existing solutions, such as kerosene, Solar Home System;
3) Desirability and attractiveness of electricity-enabled behaviors, products and services;
4) Business Acceleration, including the capability of the electricity supply to power devices for productive use (e.g. sewing machines, milling machines) and increase the economic productivity, the disposable income and the ability to pay;

5) Sustainability of the business model or all stakeholders, including local communities, investors and national governments.

Potential uses of electricity to foster socio-economic development in rural areas might include, among others: electric pumps for irrigation and increased harvests of crops; electric mills replacing more expensive existing diesel powered mills; fridges and food processors (for fish, meat, dairies..), and power for small roadside business centers providing photocopying, fax machines, and internet.

Mini-grids have an impact on a wide range of stakeholders in rural and peri-urban areas, including:

- Rural/local community households;
- Community schools, clinics, health centers, NGO offices, local government offices and other public buildings;
- Farming/agri-food sector - for irrigation and food processing;
- Private sector and Small and Medium Enterprises (SMEs) as listed above;
- NGOs and the private sector as mini-grid developers;
- Rural electrification agencies – which may act as intermediaries between the mini-grids and consumers (or may be by- passed by them in some models).

For this reason, partnerships among organizations (private sector and NGO's) and local players with different fields of expertise are critical to address all the essential inputs concurrently and to support a sustainable growth of economic activity that drives electricity consumption and that will support the main consumption anchors. An appropriate support system could help villages to channel local resources into economic growth.

Italy, in particular, could provide a strong support with technical expertise and supply of advanced and robust machinery, which represent leading sectors of Italian economy.

Barriers to further development

Decentralized solutions can play a central role in achieving universal electricity access, and represent today a proven, effective alternative to traditional grid expansion.

Policy schemes adopting decentralized energy systems, should compare, at equivalent levels of supply reliability, with the Full Cost of Energy (also in terms of time-to-market) of serving the same loads via a centralized electric system[3] and aim to offer the investor a fair risk-adjusted remuneration.

Policy-makers have historically regarded rural electrification with off-grid technologies as a philanthropic activity, giving priority, for industrial development, to the expansion of existing grids. Even though in the past years it has become clear that the development of off-grid projects does not prevent integrating them in future centralized power systems, gaps in policy and regulation still persist. Therefore, it is necessary to define an enabling framework to scale up the use of

[3] The benchmarking has to consider *cost-reflective* electricity tariffs, *not* tariffs actually in place, that may be not cost reflective.

decentralized systems as a proper way of addressing the electrification challenge.

The widespread assumption that rural electricity supply is to be considered a charity rather than a commercial activity is erroneous, as studies show that spending power in rural areas is high compared with the long-run marginal cost of electricity supply.

The private sector is willing to invest but their generalized involvement is still challenging, because of the lack of a regulatory framework providing enough clarity on operational rules and on key critical issues, and for the absence of de-risking mechanisms. Permitting processes are still long and not streamlined, and too many authorities are involved in the electrification activity, creating overlapping responsibilities or lack of responsibility.

We can summarize in **three** categories the main building blocks of an effective framework to foster decentralized energy systems:

1. Simplified permitting and licensing procedures

Governments should keep mini-grids permitting process streamlined, providing a land registry and a standard set of permits on application form, inclusive of right of ways, environmental impact assessment, district authorizations, etc., enabling regulators to quickly assess projects viability. Such permits should be assessed in a reasonable - and well-known in advance - processing time, through a single window support channel (one-stop shop). In addition, a combined generation, distribution and supply license with an exclusive right of supply should be provided for a determined period of time to avoid the risk of developers paying the significant cost of project preparation and then finding themselves subject to competition from other developers.
Permitting procedures should be linked to technical and safety standard requirements. Therefore, it is very important that countries develop a regulating body able to define Technical connection rules (Grid Codes), to be fulfilled also by mini-grid projects that, although initially off-grid, might be integrated into the main grid in the future.

2. Flexible tariff setting rules

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

Flexible tariff setting rules and financing mechanisms have to be in place to ensure reasonable return to investors and affordable prices for consumers.

Tariffs for mini-grids need to be set independently from the tariffs applied to main grid-connected customers, that are generally highly subsidized by the Government. The tariff level should be flexible enough and based on what will be affordable and acceptable to remote users (for example, for farmers it will be easier to pay electricity after harvest than in other times of the year), balanced with the developer's need to meet operating expenses, including depreciation, and deliver a fair return on investment.

Tariffs levels are therefore expected to provide developers with a suitable financial return, while accounting for the need to deliver high quality service. Governments and development partners can support lower mini-grids tariffs by providing grant subsidies that offset the high initial capital costs and thereby reduce investment risks.

3. Clear "Exit options" in case of main grid arrival

The most critical risk in the development of decentralized solution is represented by the potential arrival of the main grid before the time needed to recover the investment.

Such risk can be mitigated by the diffusion of official Governments plan providing more certainty on grid extension in the medium/long term, that anyway should be reliable and not abruptly changed.

Moreover, clear exit options in case of main grid arrival must be set in advance, identifying duties and rights on involved parties (i.e. developer, Distributor System Operator, Regulator), in order to provide to developers fair guarantees on the return of their investment.

Government regulation can help to mitigate this risk by mandating one of the following possible options: a) the mini-grid operator could become a power generator, selling energy to the main grid, through PPA with a guaranteed tariff, and distribution assets purchased by a DSO. b) the mini-grid operator could become a DSO, that purchases electricity from main grid and resell it to customers (disposing of the legacy generation assets in the mini-grid); c) a combination of power generator and DSO, with a specific regulatory regime for *embedded* generation.

According to the preferred choice done by the mini-grid operator, the DSO must have the obligation to purchase the distribution portion of the mini-grid assets that represents the most capital intensive portion of the total investment, provided that the latter are technically compliant with the Grid Code. A crucial element therefore is represented by the determination of the compensation value for the distribution assets. That value must be based on the expected return of the investors at the time of the investment decision, and therefore on the future cash flows that he was expecting to receive for the time of operating of the projects.

Anyway, the role of the Regulator in managing smoothly the exit option is crucial in order to ensure the fairest solution in the interest of consumers and mini grid operators.

While a consistent regulatory environment is a requisite for decentralized energy systems to become a pillar of government's electrification strategies, in certain areas and applications the private sector is showing the ability to independently develop and fund the deployment of private mini-grids, mainly for captive and own consumption. Such initiatives should not be discouraged in any way: communities and businesses that autonomously mobilize capital to deploy sustainable and reliable decentralized energy systems are a valuable complement, not a threat, to centrally promoted schemes. Fostering entrepreneurship is itself a major contribution of clean energy technologies to economic development.

Conclusions and call for action

The role of electrification in economic development is fundamental.

Innovative, sustainable decentralized energy solutions represent the most efficient instrument to promote access to electricity in areas of low load density or very far from existing national grid.

Fostering productive uses of energy is essential to ignite a virtuous cycle of demand

growth built on an inclusive business model, however, the cycle jump-start requires many different inputs.

Having a holistic point of view and strong partnerships will be important to activate all the inputs simultaneously to achieve the most efficient and sustainable business model, which will be beneficial both for local communities and investors.

Systematic know-how dissemination, a consistent regulatory framework for decentralized energy systems, and an open mind towards entrepreneurship in the energy sector are fundamental elements of an effective energy policy for emerging economies.

ANNEX
RES4Africa members' Offgrid Projects Portfolio

Presented by:

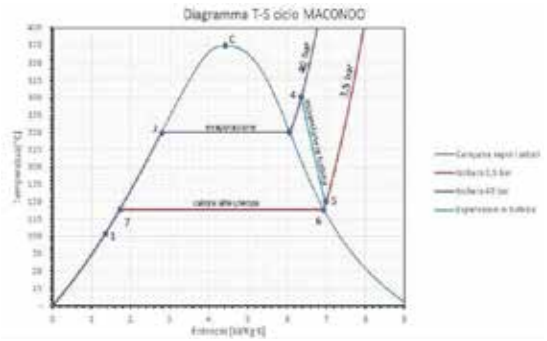
ASJA
Colombia, Macondo

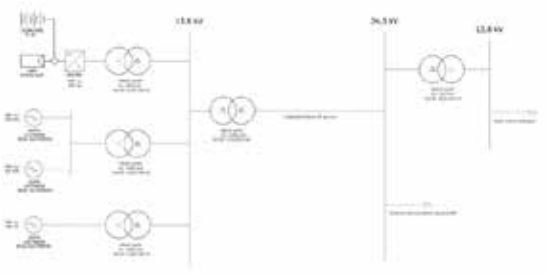
- **PROJECT LOCATION:** Macondo is a rural location in the municipal area of Mapiripan, a small urban center in the Meta region of Colombia.
- **CONTEXT:** Colombian policies favor the distributed generation of energy from renewable sources for the electrification of non-interconnected areas to the national interconnection electrical system. The project also meets the needs of a local production activity that guarantees work for the small rural community.
- **GENERAL DESCRIPTION:** Hybrid renewable energy source plant connected to a local distribution isolated grid. A cogenerative power plant uses residual biomass of palm oil production – Photovoltaic - Diesel for combined generation of electricity and heat. Heat, and part of electricity are used in a near palm oil production infrastructure. The remaining electricity is transported via a new electric transport line for electrification of a non-interconnected rural local distribution grid.



ASJA
Colombia, Macondo

- **TECHNOLOGY:** Rankine cycle thermoelectric plant with direct combustion of residual biomass of palm oil production, with a backpressure steam turbogenerator integrated with a PV plant an two Diesel generator set.
- **POWER:** Steam turbogenerator 1.412 kWe and 17,7 MWt; PV plant 200 kW; Diesel generator set 265 kW + 530 kW.
- **CONTEXT:** Colombian policies favor the distributed generation of energy from renewable sources for the electrification of non-interconnected areas to the national interconnection electrical system. The project also meets the needs of a local production activity that guarantees work for the small rural community.
- **COST:** 4,1 mln USD
- **ENERGY:** Electricity 7800 MWh/year, heat 105000 MWh/year





Electro Power Systems Somalia, Garowe

5.9 MW wind and solar-powered minigrid

Hybrid Power Plant built by EPS for **NECSOM (National Energy Corporation of Somalia)** to power the town of Garowe. Located in the North-East of Somalia, **Garowe** (50,000+ inhabitants) is the administrative capital of the autonomous Puntland region and a fast-growing city.

Somalia has no national grid, so every town is a de facto minigrid.
On a pure commercial basis, EPS provided engineering, supply, turnkey installation and operation of a renewable and storage solution (with conventional back-up) allowing a **reduction in diesel consumption of more than 3,000 liters per day.**

With PV capacity of 1MWp, wind capacity of 750kW, and 3MW of conventional diesel-fueled generation, the Hybrid Power Plant serves a peak **3.5MW load**, securing power supply 24/7 with world-class power quality.

In the current operating regime, EPS is still conservatively keeping one genset running at all times, capping the instant contribution of the renewable energy source to load cover to approx. 90%.

Over the next few months, EPS plans to extend to the Garowe mini-grid the operating technics already proven in other microgrids in Latin America and Europe, allowing the complete switch-off of conventional spinning capacity under favorable wind and solar conditions.

PV
1 MWp

Wind
750 kW

Storage 1 MW/1.8 MWh
Lead acid and Lithium-ion batteries

Diesel Gensets
3.2 MVA

Power Conversion System 1 MW
Full Virtual Inertia DROOP Control Technology

Master Controller
Pool Algorithms & Black Start Function

Connected Users
50,000+ people

Reduction
600 tons/year

Immediate electricity Bill reduction
17% immediate, 50% target

Electro Power Systems Somalia, Garowe









90%	MAX INSTANT LOAD COVER WITH RES	50%	LOAD COVER IN ENERGY DURING WIND SEASON	1.1MLN	LITERS DIESEL FUEL SAVED PER YEAR
20%	DUE TO PV + WIND DIESEL REPLACEMENT	+31%	DUE TO INCREASED DG EFFICIENCY	= 51%	FUEL SAVINGS

Enel Green Power Chile, Ollague

- **PROJECT LOCATION:** Ollagüe is a small cut off village, originally a mine one, 160 km far away from Calama, at the border with Bolivia. Its little more than 200 inhabitants live at an altitude of 3700 m and the village is not connected to the network; previously there was a micro grid circuit powered by a 450 kW diesel generator, supplying electricity for 16 hours a day – none was provided from 1:00-8:00 am. The changes in temperature are extreme, reaching a delta of 22°C in a day time, with minimums of -20°C.







- **SYSTEM CHARACTERISTICS:**

  Solar PV: 205 kWp (Thin film modules)

  Storage: 752kWh (Sodium Nickel Chloride tech.)

  Mini Wind turbine: 30 kW

  Diesel generator: 450 kW

  Dish Stirling Engines (2): 1 kWe +3kWt.

- **AIM OF THE PROJECT:** Supply 24hs/day 7 days/week energy, removing the restriction of the village to having no access to energy during night time, testing advanced renewable technologies and storage system in a harsh environment and developing technical solutions for fast growing market.

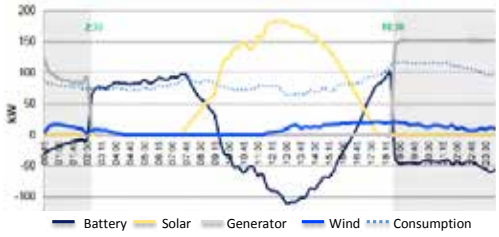
Enel Green Power Chile, Ollague

RESULTS:

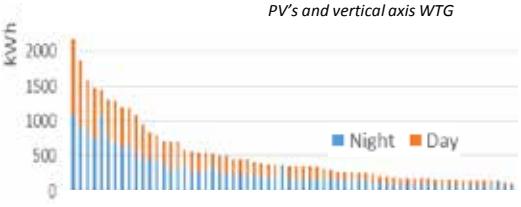
- Hybrid system construction completed in December 2014; in full operation since Q1 2015;
- Installation of the hybrid drastically changed the habits of the inhabitants, also with promising economic benefits;
- The operation of such advanced plant is giving deep knowledge about such kind of systems and possible business model in remote area;
- Advanced technology, fully monitored and managed remotely with local Community for O&M support;
- The Metering & Billing system allows to enhance Hybrid performance, providing a pre-paid service based on real consumption data, it also sensitizes population in terms of electricity consumptions; collected money is used by the Community to partially cover maintenance costs;
- Microgrid stability has been assessed through dedicated monitoring campaigns, demonstrating that installed generators guarantee a power quality level similar to that accepted in the usual Public Distribution networks and also transients due to connections/disconnections, load variation, etc. are quickly and effectively managed by the BESS control.



PV's and vertical axis WTG



Power flows for a typical day of operation



Monthly kWh consumption per client

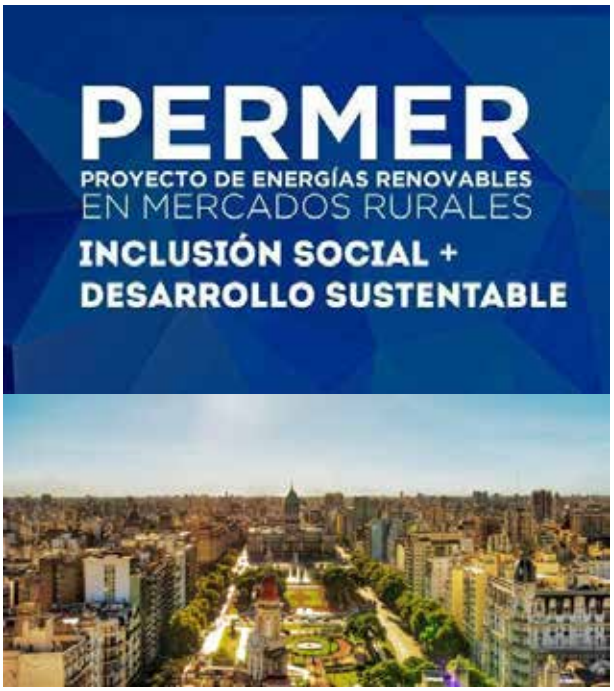
Enel Green Power South Africa – Projects under development

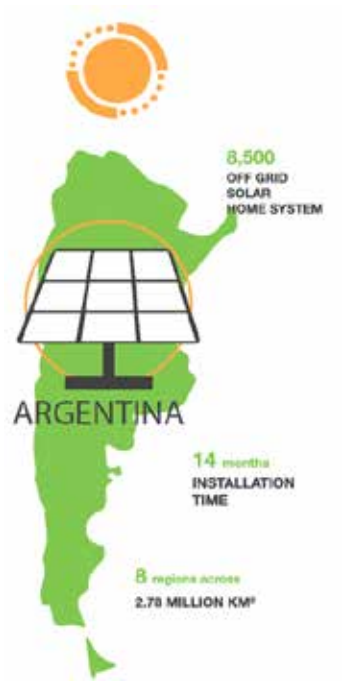
- EGP is committed to supporting corporates in capturing business value and tackling climate change while marching corporate energy needs.
- Sharing our global expertise, we are keen and able to offering our project development capabilities by supplying private sector business with reliable renewable solutions.
- Focusing on large energy intensive customers such as mines as well as commercial and industrial customers such as automotive, food & beverage, etc. EGP is well positioned to negotiate and conclude such long-term private PPA's.
- We are currently in the final stages of negotiating ground breaking on-site captive power project for a private off-taker
- The Polycrystalline photovoltaic solar PV facility will be located within the Gauteng province and expected to generate approximately over 70GWh/year of electricity.





ENERRAY: Plug the Sun
Argentina - the PERMER project





ENERRAY: Plug the Sun
Argentina - the PERMER project

RURAL ELECTRIFICATION IN ARGENTINA

Plug the Sun has been recently awarded with an important **Off Grid tender** in Argentina, included in the renewable energy program **PERMER** issued by the **Ministerio de Energía y Minería** on September 2016. The offer, submitted on 30th November 2016, turned out to be the most competitive both under technical and financial point of view leading to the award notification on 17th January 2017

PERMER "PERMER LPN 03/2016" is the third edition of national projects aiming to extend the electrical access to the largest part of the Argentinian territory.

THE WORLD BANK Ministerio de Energía y Minería Presidencia de la Nación

The **International Bank for Reconstruction and Development**, a World's Bank institution, is granting a 200 MUSD* loan to the República de Argentina in order to guarantee and manage the overall project.

The project includes the supply, installation and maintenance of **8,500 off grid SHS (Solar Home Systems)** that will be located across 8 regions (SALTA, TUCUMAN, CORRIENTES, RIO NEGRO, SAN JUAN Y SANTA CRUZ, NEUQUE, CHACO).

The SHS kits have peak powers ranging between **200 to 300 Wp** equipped with storage system depending on the installation batch and the required delivery of power into DC or AC current.

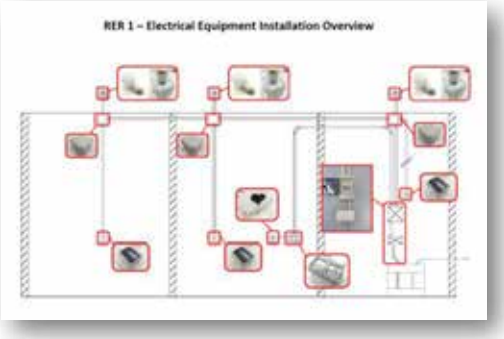
ENERRAY: Plug the Sun
The Peru case

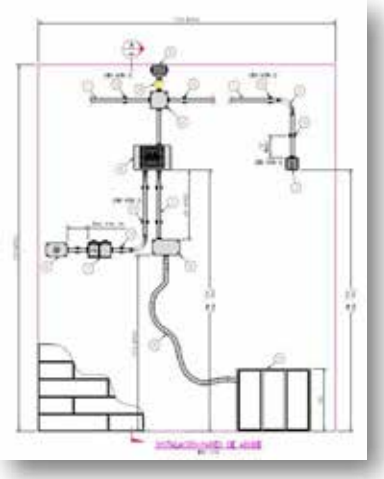




ENERRAY: Plug the Sun
The Peru case

RURAL ELECTRIFICATION IN PERU





Plug the Sun provided a technical solution to this problem thanks to the **DC ENERGY BOX system**, which provides **free, green and fast energy, avoiding expensive infrastructures**.

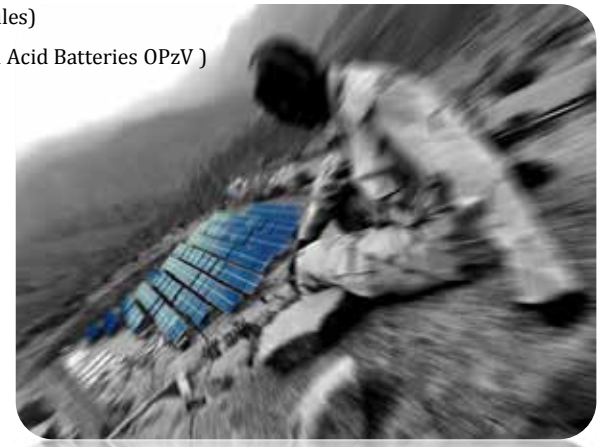
ENERTRONICA
Eritrea, Embatkalla

PROJECT LOCATION: Embatkalla is a very small village, 70 km far away from the capital of Eritrea, Asmara. The village, at an altitude of 1600 m, is connected to a very low efficiency national grid that is available few hours a day. The project is implemented in a land plot of ERCOE facility (Public Administration).

SYSTEM CHARACTERISTICS:

- Solar PV: 250 kWp (Polycrystalline modules)
- Storage: 800 kWh (2250 Ah @C10 - Lead Acid Batteries OPzV)





ENERTRONICA
Eritrea, Embatkalla

AIM OF THE PROJECT:

1. Supply a continuous, reliable and regulated power supply to the facilities, when the site is used for its institutional purposes
2. Supply electricity to the National grid, when conditions are such to guarantee a generated energy surplus
3. Supply Energy in any condition:
    - National Grid availability or National Grid unavailability
    - 24hours/day
    - Grant minimum 2 days autonomy in the case of National Grid Unavailability and out of service of the PV Generator



RESULTS:

➢System construction completed in April 2017; in full operation since May 2017;

➢Advanced technology, fully monitored-based with local Community for O&M support;

ENERTRONICA
Eritrea – 73 sites

PROJECT LOCATION:
All over the state of Eritrea – 73 different places from the border with Djibouti to the border with Sudan and Ethiopia



AIM OF THE PROJECT:
Enertronica is involved on the installation and construction of about 100 innovative PV systems with energy storage based on acid-lead batteries. Such systems will supply facilities, offices, farms and clinics property of the Minister of Agriculture all over the state of Eritrea. Projects are commissioned directly by the Eritrean Government and financed by the European Union (EDF Program).



ENERTRONICA
Eritrea – 73 sites

SYSTEM CHARACTERISTICS:

- Solar PV: 1,7 MWp (Polycrystalline modules)
- Storage: About 10 MWh (600 to 3500 Ah @C10 - Lead Acid Batteries OPzV)
- 100 Shelter solutions (49 of them are based on roof mounted structure for shelter)

RESULTS:

- Shelter solution lesson-learned / Analysis
  - Decreasing of the Thermal Transmittance (U-Value)
  - Increasing of the batteries and Converters life-span, due to the less energy required to condition
  - Modular architecture
  - Each shelter can be moved in any moment from the concrete basement
  - Double door system: the shelter have both the original doors and a second aluminum infix
  - Possibility to do a preliminary check/test.





Politecnico di Milano
Tanzania, Ngarenanyuki

How to make social development and research join

- The hybrid microgrid is in **Ngarenanyuki, Tanzania**, a secondary **school**, involving about **200 people** living in the school and **400 students**. Starting from 2014, the microgrid has been upgraded and today it is also connected to the Tanesco public grid.
- The main power source is a **run-off-river** plant (also used for local farmers) based on a 3.2 kW Banki turbine, balanced by a 4 kW **dump load**. The school installed two back-up systems: a pack of 8 x 100Ah/12V **Chloride Oxide batteries** which can be charged by the micro hydro turbine through a 2.4 kW charger and a a 5 kW **diesel generator**, used when the hydro plant is not in operation and the battery pack are unloaded or for special reasons (i.e. school celebrations, etc.).
- Starting from that situation, the E4G project combined the power systems already available with new installations of **PV panels** (3 kWp) and **lead-acid batteries** (30 × 200 Ah/12V lead-acid battery bank) connected by a **bi-directional Interface Converter** (5 kW) with specific control units and **EMS**.



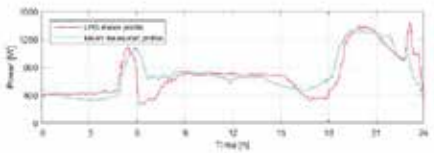


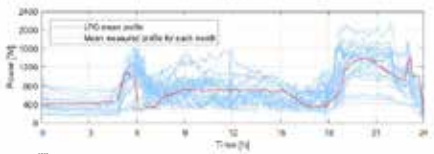
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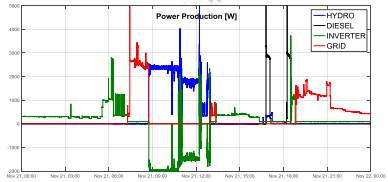
Politecnico di Milano
Tanzania, Ngarenanyuki

- Provide the school with the needed electricity
- Carry out research activities:
  - Load forecasting and generation optimization
  - Frequency and voltage control
  - Battery optimal control
  - Requirements of Grid Codes to make it possible to connect microgrids to public distribution systems









SAET
Hybrid microgrid prototype

In the context of continuous development of new solutions for the incoming needs of the electric market, SAET developed a prototype of a hybrid microgrid solution for electrification of rural areas suitable to provide access to primary needs like lighting and power for food preservation and other basic services.

Based on a standard 20' ISO container to allow easy transportation and installation, the system is characterized by following features:

_ 10kW PV power (installed both on rooftop and on the ground)

_ 20 kWh battery storage (both lithium and sodium chloride technology available)

_ smart EMS fully developed by SAET for microgrid supervision and control

_ on grid & off grid operation

_ arrangement for the integration of wind generator and can be easily scaled to properly match customer needs.





SAET
Hybrid microgrid prototype

SAET hybrid prototype supported the G7 Energy Ministerial Side Event: *"Africa 2030: empowering the continent through innovation, green tech solutions and capacity building"* organized by Enel Foundation, RES4Africa and the Africa-EU Energy Partnership (AEEP), that took place in Rome in April 2017.

It will also be the basis for the development of RES4AFRICA ***Micro-Grid Academy (MGA)*** project, which foresees the implementation of a leading training platform in Eastern Africa to train young professionals on access to energy and sustainable energy solutions.



Installation of SAET prototype during G7 Energy Ministerial Side Event



Geothermal power opportunities in the Rift Valley

This paper has been prepared by:

in collaboration with:

Ruggero Bertani, EGP – Matteo Cavadini, EGP – Mike Everett, ERM

Abstract

The geothermal potential of the Rift valley in Africa is huge, even in its development can be considered at early stage, with the notable exception of Kenya. In this country an impressive exploration, drilling and construction effort has been carried out in the last few years and it is expected to grow even more. Kenya is becoming a geothermal leader not only in Africa, but at world level. It should be mentioned the rather unique application (for Africa) of direct heat utilization, with the large greenhouses complex of Oserian Flowers, where geothermal heat and CO2 is used for growing roses for the world market. The commitment of several world leaders for geothermal activities in Kenya is growing, with many foreign investors which will help to sustain the country geothermal growth rate. The second important country of the Rift area is Ethiopia, with a development still at an early stage, and the potential role of international cooperation should be highlighted as key factor for a step forward to geothermal exploration and drilling.

Introduction

Development of geothermal resources in Kenya started in 1950's. The current installed capacity stands at 573 MWe (WGC2015 official data – additional capacity has been added in recent years and several plants are under construction/commissioning, so the situation is rather fluid) which is only a small fraction of the total estimated potential of

about 10,000 MWe. All the high temperature resources are located within the Kenya Rift Valley, associated with Quaternary volcanoes. Olkaria geothermal field is the largest productive area with five power plants, owned by Kenya Electricity Generating Company (KenGen) and Orpower4.

In addition to electricity application, 10 t is being utilized to heat greenhouses and fumigate soils at the Oserian flower farm, with also 4 MWe installed for local use.
Power generation at the Eburru geothermal field stands at 2.5 MWe from a pilot plant.
There is an impressive boost in development of geothermal resources in Kenya, with 280 MWe commissioned in September and October 2014. Drilling for the additional 560 MWe is ongoing. The Geothermal Development Company (GDC) is currently undertaking production drilling at the Menengai geothermal field.

In Ethiopia, the geothermal electricity is very marginal, being only from the 7.3 from the Aluto-Langano Geothermal Pilot Power Plant. The country generation capacity is 814 MW (90% hydro-generation). The most explored geothermal field is the Aluto-Langano geothermal field followed by Tendaho. These two fields are ready for an easy and fast advancement to the development stage for execution of power projects in the next five to ten years.

Geological background for Kenya and Ethiopia

The East African Rift system is part of the large Afro Arabian Rift system, going from the Red Sea to Mozambique (**Figure 1**). As the rift leaves the Ethiopian segment it bifurcates into the eastern and western branches (**Figure 2**). These branches embrace Tanzania. The most interesting place is in the eastern branch, which comprises the main Ethiopian Rift and Kenya Rifts: it is old and volcanically active.

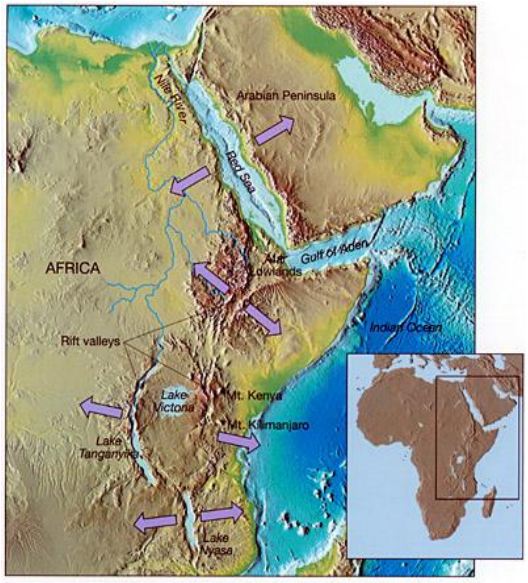


Fig. 1 - General view of the East African Rift System

Its development has been generated by lithospheric extension and upwelling of the underlying asthenosphere, followed by collapse, resulting in large volumes of magma generation and development of volcanoes. Further brittle extension of the crust resulted in down-faulting and formation of the graben. This extensional drift is quantified as 2-3 mm/year in the Main Ethiopian Rift, and less than 2 mm/year in the Kenya Rift and southwards.

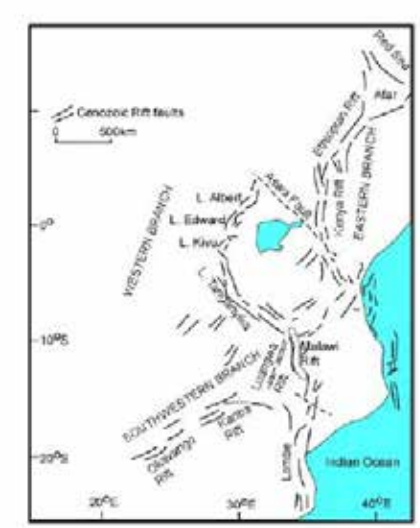


Fig. 2 - Structural map showing the East African Rift System

Of course along the rift axis of the eastern branch there are numerous volcanoes, with presence of shallow hot bodies (magma chambers).

The geothermal activity in the East African Rift occurs accordingly to the standard manifestations: hot springs, fumaroles, hot and altered grounds, and it is closely associated with Quaternary volcanoes in the axis of the rifts, is related to the shallow hot magma bodies under the massifs. In the zones where the crust has been thinned due to extension, high heat flux is measured. The beginning of the rifting activity has been estimated about 30 million years ago, with the uplift in the Lake Turkana area and then migrated southward about 14 million years ago. The important formation of the graben structure in Kenya started about 5 million years ago, followed by eruptions forming flood lavas about 2 to 1 million years ago. During the last 2 million years ago, volcanic activities became more intense, creating the current very active geological system of the rift valley.

Principal geothermal fields in Kenya

The geothermal exploration in Kenya started in the 1950's with surface surveys, leading to the drilling at Olkaria, Eburru and Menengai geothermal fields (**Figure 3**).

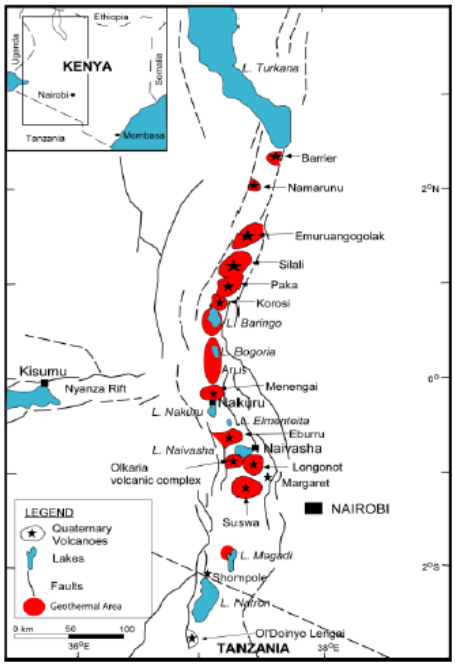


Fig. 3 - Simplified geological map of Kenya showing locations of the geothermal fields and prospects

Olkaria

This field is associated with the volcanic complex on the axis of the rift. The landscape is also dotted with volcanic centers, with fault systems dominantly in: NW-SE, N-S and NE-SW. It is quite a large system, called "The Greater Olkaria geothermal field" and it has been divided into seven sectors: East, West, North-West, North-East, Central, South-East, and Domes. The field has an estimated capacity more than 1,500 MWe and direct utilization of hundreds of MWt. The Olkaria I power plant owned by Kenya Electricity Generating Company Ltd (KenGen) has three units of 15 MWe each, commissioned in 1981, 1983 and 1985. In 2014 two new units for 140 MWe were installed as well as a 70 MWe

wellhead generator. The 3x35 MWe Olkaria II power plant was commissioned in 2003 and 2010. Drilling is ongoing for increasing the field. Olkaria III field is operated by Orpower 4, a subsidiary of Ormat International. The fully private project developed in stages since the first 8 MWe plant in 2000. Today, it has reached the current installed capacity of 110 MWe, all ORC binary plants turbines Olkaria IV, also known as Olkaria Domes, has a drilled capacity of 350 MWe, and 2x70 MWe was completed and commissioning in 2014. An additional 140 MWe are under construction.

Eburru

Eburru geothermal field is located to the north of Olkaria. Six exploration wells were drilled between 1989 and 1991, identifying high temperature geothermal system at >250°C. A 2.5 MWe condensing pilot plant was commissioned in 2012.

Menengai

Menegai is a Quaternary caldera volcano located within the axis of the central segment of the Kenya Rift. The exploration drilling has identified reservoir temperatures of up to 400°C at 2 km depth: this could be the hottest geothermal system in Kenya. A 105 MWe power plants is under construction by 3 companies, for 35 MW each.

Other areas

Suswa is the southernmost of a series of Quaternary caldera volcanoes in the Kenya rift. The inferred reservoir temperatures is >300°C based on geothermometry. Exploratory drilling is ongoing, and it has been licensed to GDC

Longonot is a large caldera volcano adjacent to Olkaria Geothermal field. The geochemical survey revealed that a high temperature geothermal system >250°C exists under the volcano. The prospect was leased to African Rift Geothermal Limited (AGIL).

Lake Baringo is in the northern part of the Kenyan Rift. Geothermometry indicates reservoir temperatures of 120-200°C. GDC plans to drill exploration wells.

Korosi volcano is located in the neighbors of Lake Baringo; gas geothermometry indicates reservoir temperatures of more than 250°C. Exploration drilling in the prospect is planned by GDC.

Paka is a relatively small shield volcano. With surface geothermal quite activity (fumaroles at >97°C). Geothermometry indicate the reservoir system to be at more than 250°C. GDC plans exploration drilling.

Other potential geothermal prospects are *Lake Magadi, Emuruangogolak, Namarunu, Barrier volcanic complex, Lake Bogoria and Arus.* Detailed studies of these prospects are planned by GDC.

Greenhouses application in Kenya

In the Olkaria Central field, operated by Oserian Development Company (ODC), there are two 2.0 MWe ORC and back pressure plants, commissioned in 2004 and 2006 to provide electricity for private use of the greenhouse system. The ODC activity is in the "cut flower" (mainly roses) export, utilising geothermal heat for greenhouse needs. Plate heat exchangers are used to heat fresh water, for general heating and soils sterilization. Moreover, separated CO2 is used to enrich the levels in the greenhouse (**Figure 4**). The utilisation of cheap geothermal electricity and heat, as well as the abundance of CO2 has resulted in drastic reduction in operating costs in the flower farm.



Fig. 4 - Snapshots from Oserian Greenhouse

Principal geothermal fields in Ethiopia

The country potential of Ethiopia is extremely positive, despite its delayed development. It has been evaluated that about 20 areas have potential for high enthalpy resource development, suitable for electricity, and a much larger number could be developed for direct uses: horticulture, animal breeding, aquaculture, agro-industry, health and recreation, mineral water bottling, mineral extraction, space cooling and heating, etc. (**Figure 5**). The exploration work has been carried out by the Geological Survey of Ethiopia (GSE), with an intense support from technical cooperation programs: UNDP, the European Development Fund, the development cooperation program of the Italian Ministry of Foreign Affairs, IDA, IAEA, the German Geological Survey (BGR) and the specialized geothermal science and technology training programs in Japan, Italy, New Zealand, Iceland , Kenya (in cooperation with United Nations University- contributed in training and development.

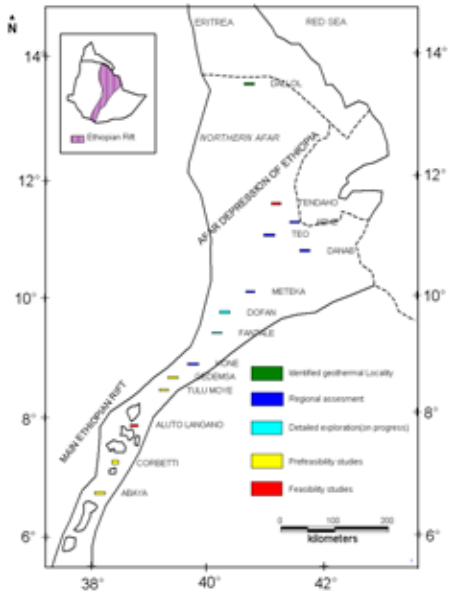


Fig. 5 - Location Map of the Ethiopian Rift and Geothermal Prospect Areas

Aluto-Langano

In the area it has been discovered an underground fluid at high temperature (> 300 °C) along a fault zone oriented in the NNE-SSW direction. A 7.3 MWe pilot geothermal plant was installed in 1999 utilizing the production from the exploration wells. Now the plant is partially rehabilitated and put back into operation of about 3 MWe.

Tendaho

Geothermal exploration was carried out in the Tendaho area (with economic and technical support from Italy) between 1979 and 1980. Three deep (about 2100m) and three shallow exploratory wells (about 500 m) were drilled between 1993 and 1998, with a temperature of over 250ºC. Techno-economic study indicated that the potential from the shallow wells could supply a pilot plant of about 5 MWe, and from the deep system it is estimated about 20 MWe. The Ethiopian government plans to extend the country's main 230KV transmission line to Semera, which is within ten km of the exploration area.

Other areas

The *Abaya* prospect exhibits a widespread thermal activity mainly characterized by hot springs, fumaroles and altered ground, with temperatures around 96 °C. Its potential geothermal reservoir has an inferred temperature of 260°C. The *Corbetti* geothermal prospect area is located about 250 km south of Addis Ababa. It is a volcano system within 12 km wide caldera, characterized by widespread thermal activity such as fumaroles and steam vents. Studies indicate the presence of potential geothermal reservoirs with temperatures exceeding 250°C. The area of *Tulu Moye* is characterised by recent volcanism and it is highly affected by hydrothermal activity with the main hydrothermal manifestation being weak fumaroles, active steaming (60-80°C) and altered ground. The existence of potential geothermal reservoirs with temperature of about 200°C is highly probable. The *Dofan* geothermal prospect is characterised by a complex volcanic edifice, with presence of several hydrothermal manifestations (fumaroles and hot springs). The *Fantale* geothermal prospect is characterised by recent summit caldera collapse and widespread fumaroles activity, the data evaluation of the area suggests that it is potentially prospective for future detail geothermal resource investigations.

Perspective of future developments in the Rift Valley

The East African Rift Valley shows great potential for geothermal power development, alleviating the over-reliance of countries in this region on hydropower, and offering an alternative source of renewable energy into the energy mix. Major geothermal zones globally are depicted in *Figure 1*, indicating the geothermal power potential of the Rift Valley in countries such as Kenya, Ethiopia and Tanzania. This section explores the potential geothermal generation capacity in Kenya and Ethiopia.

Geothermal production and potential in Kenya

As of March 2015, Kenya had an installed generation capacity of 2,295 MW, with hydropower accounting for a considerable proportion of the supply (United States Agency for International Development, 2015). From 2004 to 2014, peak power demand in Kenya grew from 867 MW to 1,468 MW, a growth rate of approximately 8% per year. Power demand projections up to 2030, as provided in Kenya's Vision 2030, are provided in **Figure 2**.

The Ministry of Energy and Petroleum states that energy has been singled out as one of the key enablers of Vision 2030, as expensive energy hinders the competitiveness of Kenya by raising the cost of doing business (Ministry of Energy and Petroleum, 2014). The development of renewable energy

therefore (geothermal, solar, wind and ocean energy, biomass, biofuels, biogas and municipal waste) is extremely important in order to meet the country's growing demand for electricity. The Ministry maintains that renewable energy can supply not only Kenya's current needs but that of future generations in a sustainable way if effectively harnessed. The reliance that Kenya has traditionally placed on hydropower and the seasonal variability of river flows has resulted in reduced supply of hydropower, prompting the country to assess alternative sources of energy production to meet increased demand. The Updated Least Cost Power Development Plan (2013 to 2033) of the Energy Regulation Commission (2013) states that this program will be dominated by geothermal, coal, natural gas, nuclear and wind, with "*geothermal resources being the choice for the future generating capacity in Kenya*". This Plan indicates that geothermal capacity should be increased from the "current" (in 2012) 209 MW to 7,264 in 2033, contributing 27% of the total energy required by the system. This energy mix, and the role of geothermal in the energy mix and demand forecast up to 2033, is provided in **Figure 3.**

The geothermal potential of Kenya and the locations of the geothermal fields are provided in **Figure 4**. Current levels represent a fraction of potential geothermal energy production in Kenya and the government is supporting fast-track projects across the country. The Kenya Electricity Generating Company Limited (KenGen) continues to expand and develop the Olkaria geothermal field with the potential of meeting its full operational capacity of 280 MW. The Eburru geothermal field located to the north of Olkaria is estimated to contribute an additional 60 MWe.

Advanced exploration by Akiira Geothermal Limited will potentially advance the Olkaria field by a further 90 . Additional geothermal exploration is currently occurring in the neighbouring Longonot concession by African Rift Geothermal Limited (AGIL), with drilling ongoing for development of 70 MWe.

The Geothermal Development Company (GDC) has recently successfully discharged two more wells at the Menengai Geothermal Project, which will add to the 137 MW of steam already available for the first phase of the Menengai Geothermal Project development.

Conclusion

Utilisation of geothermal energy in Kenya is improving dramatically and the future outlook is extremely positive, with strong penetration of private sector and foreign investors. The expected short term development is forecasting 2,765 MWe generation by year 2020, with developments not only in expanding generation at Olkaria and Menengai, but also through developments of new areas at Lake Baringo and Suswa. Also for direct utilization growth is expected with GDC projects, focused not only on electricity generation but also direct use.

Geothermal production and potential in Ethiopia

The Government of Ethiopia has stated that it is imperative to provide the economy with the necessary energy inputs at affordable prices. This will encourage economic development and help the country attain the objectives of the Economic Reform Program adopted by the government. With special emphases on renewable energy, the government has introduced Feed-in-Tariffs to promote installation of renewable power generation facilities. Despite Ethiopia being

home to the longest stretch of the Rift Valley, the country has been unable to match Kenya's installed geothermal power capacity (approximately 630 MW) (see **Figure 3**).

The Aluto Langano Geothermal Project was the first of its kind in Ethiopia, where a 7.3 MWe pilot geothermal plant was installed in 1999 utilising the production from the exploration wells. It did not operate for many years, but has now been put back into production, generating approximately 3 MW currently. In May 2017, the Ministry of Water, Irrigation and Electricity announced that the World Bank would provide financial assistance of $126 million with the aim of developing the Aluto Langano Geothermal Project to produce up to 70 MW. Reykjavik Geothermal (RG) has finalized the acquisition of the geothermal exploration licences for concessions in Abaya, Corbetti and Tulu Moye.

Conclusion

Utilisation of geothermal energy in Ethiopia is still limited, despite its very large potential. The long term electricity development Master Plan is stressing the important role that geothermal can play in the country, concluding that exploration should define proven geothermal energy resources in other areas of Ethiopia, as highlighted in the present paper.

The selection and prioritisation of these prospects would be considered based on technical and economic criteria: locations in close proximity to the existing grid, and high population density. It would be necessary a further Development and Expansion of Aluto-Langano Geothermal field.

Regulatory and economical framework

The key regulatory drivers and requirements affecting geothermal development in Kenya and Ethiopia are described in this section.

KENYA

A. Kenya Energy Policy, 2014

The Energy Policy sets out the national policies and strategies for the energy sector that are aligned with the Constitution of Kenya and the Kenya's Vision 2030 (see below). The Kenya Electricity Supply Industry (ESI) is one of the sub-sectors in the energy sector over which the Ministry of Energy and Petroleum exercises oversight on behalf of the Government of Kenya. Under the Energy Act of 2006, the Ministry is responsible for formulation and articulation of policies through which it provides an enabling environment to all operators and other stakeholders in the energy sector. Key stakeholders in the ESI are as follows:

- **Kenya Power**

Kenya Power is responsible for transmission, distribution and retail supply of electrical energy to end users. Kenya Power purchases power in bulk from the KenGen and the Independent Power Projects (IPPs) through bilateral contracts or Power Purchase Agreements (PPAs) approved by the Energy Regulatory Commission (ERC).

- **The Energy Regulatory Commission**

At the heart of the regulatory system is Kenya's independent Energy Regulatory Commission (ERC). The ERC was established under the Energy Act, 2006, and has as some of its primary objectives and functions:

- The regulation of electrical energy, petroleum and related products,

renewable energy and other forms of energy;
- To protect the interests of consumers, investors and other stakeholder interests; and
- Monitor, ensure implementation of, and the observance of the principles of fair competition in the energy sector, in coordination with other statutory authorities.

The generation, transmission, distribution, supply, import and export of electricity can only be carried out by parties in possession of a licence or a permit issued by the ERC.

➢ **The Ministry of Energy and Petroleum**

The Ministry of Energy and Petroleum has the fundamental role and purpose of providing and sustaining quality services, which are geared to satisfy the needs and expectations of its customers. Its aim is to facilitate provision of clean, sustainable, affordable, reliable, and secure energy services for national development while protecting the environment.

➢ **The Geothermal Development Company**

The GDC is a 100% state-owned company formed by the government as a Special Purpose Vehicle to fast track the development of geothermal resources in the country. The creation of GDC was based on the government's policy on energy - Sessional paper No. 4 of 2004, and the Energy Act No. 12 of 2006 - which unbundled the key players in the electricity sector to ensure efficiency.

➢ **The Kenya Electricity Transmission Company**

Kenya Electricity Transmission Company Limited (KETRACO) was incorporated on 2 December 2008 and registered under the Companies Act, Cap 486 pursuant to Sessional Paper No. 4 of 2004 on Energy.

The company was 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.

KETRACO's mandate is to design, construct, operate and maintain new high voltage electricity transmission infrastructure that will form the backbone of the National Transmission Grid.

B. Vision 2030

Kenya Vision 2030 is the country's development blueprint covering the period 2008-2030. It aims to transform Kenya into a newly industrialised, "middle income country providing a high quality life to all its citizens by the year 2030". This policy recognises that infrastructure, and in particular a reliable power supply, is vital in sparking economic growth.

C. The Kenya National Climate Change Response Strategy

The vision of the strategy is for a prosperous and climate change resilient Kenya. The mission is to strengthen and focus nationwide actions towards climate change adaption and greenhouse gas emission mitigation. The following measures are proposed in order to counter potential threats to the energy sector in Kenya:

- accelerate the development of geothermal energy;
- accelerate the development of green energy including wind, solar and renewable biomass; and
- energy efficiency.

D. Scaling-Up Renewable Energy Program (SREP) Investment Plan for Kenya

The objective of the SREP program is to demonstrate, through pilot operations the economic, social and environmental viability of a low-carbon development pathway to increasing energy access using renewable energy. Specific energy legislation in Kenya applicable to geothermal development:

E. The Energy Act, 2006

The Energy Act, amongst other issues, deals with all matters relating to all forms of energy including the generation, transmission, distribution, supply and use of electrical energy as well as the legal basis for establishing the systems associated with these purposes. The Energy Act, 2006, also established the Energy Regulatory Commission whose mandate is to regulate all functions and players in the energy sector.

F. The Geothermal Resources Act, 1982

The legal basis of Kenya's Geothermal Policy is stated in the Geothermal Resources Act of 1982. The Act was written to control the exploitation and use of geothermal resources, to vest the resources in the Government of Kenya and to provide for connected purposes.

The Act also establishes a series of steps which a geothermal developer must follow. The Minister (hereinafter the Cabinet Secretary) for Energy must first authorise all resource exploitation and a geothermal resources licence be obtained from the Cabinet Secretary to enable the developer to drill, extract, and utilise the resource. If electricity is to be produced, the developer must obtain a licence under the Electric Power Act, or if commercial by-products are reclaimed, the geothermal resources licence must include a lease consistent with the Mining Act.

The Geothermal Resources Regulation, 1990, launched a model licence which establishes the basis for negotiating the arrangements for obtaining the rights to the geothermal resources licence. The model licence establishes a schedule for payment for land rental and royalty for the sale of steam or electricity. It provides for the forfeiture of the licence in the event of either unauthorised inactivity on the part of the developer for breach of the geothermal laws, regulations or licence.

The following are the relevant provisions of the Geothermal Resources Act:

- *Authority for Geothermal Resources*

Ownership of all geothermal resources under any land is vested with the Government of Kenya. The Cabinet Secretary for Energy is responsible for declaring any area a geothermal resources area. The Act prohibits any unauthorised use of the geothermal resources and in order to extract and use geothermal resources, one has to be granted authority or licence. Authority to search for geothermal resources is also granted by the Cabinet Secretary for Energy.

- *Geothermal Resources Licence*

The Geothermal Resources Licence may be granted over part or the whole of a geothermal resources area. The licence application must be on the approved form and accompanied by the prescribed fee. The licence granted will be for a term not exceeding 30 years (or as the Cabinet Secretary for Energy may determine). The licence confers upon the licensee the right to enter upon the land (being the subject of the licence) to drill and extract geothermal

resources and includes the right to drill and construct all necessary boreholes, erect the necessary infrastructure for operations, utilise the geothermal resources, and subject to the Water Act, reclaim and utilise any water. The licensee also has the right to take and use or apply the geothermal resources for any purpose specified in the licence.

- *Power of licence in respect of the generation of electricity*

The holder of a licence under the Electric Power Act (CAP 314) may for the purposes of generating, transmitting or supplying electrical power:

- Extract, take, use and apply geothermal resources on or under any land which is the subject of the licence; and/or
- Erect, construct, provide and use such works and appliances as may be necessary for the purpose of generating electricity and in connection with the transmission, use, supply and sale of electricity.

ETIOPHIA

A. National Energy Policy

The National Energy Policy is an integral part of an overall development policy of the State /Government of Ethiopia. The policy aims to facilitate the sustainable development of energy resources for economical supply to consumers. It seeks to achieve the accelerated development of indigenous and modern energy resources as well as to provide support and incentives for the participation of the private sector and community, particularly women, in the development of energy.

The National Energy Policy is intended to enhance and foster Agricultural Development Led Industrialization (ADLI), envisaging the structural transformation of the economy through export-led growth that feeds into an interdependent agricultural and industrial development. One of the general key objectives of the policy is to ensure that the development and utilisation of energy is benign to the environment. In the policy, the government undertakes among others to:

- Greatly expand and strengthen agro-forestry programs;
- Introduce energy conservation and energy saving measures in all sectors;
- Ensure the compatibility of energy resources development and utilisation with ecologically and environmentally-sound practices; and
- Ensure community participation, especially the participation of women, in all aspects of energy resources development and encourage the participation of the private sector in the development of the energy sector.

Among the policy priorities are: to provide the private sector with necessary support and incentives to participate in the development of the country's energy resources; and to pay close attention to ecological and environmental issues during the development of energy projects. As part of modern energy resources development, Ethiopia's geothermal and coal resources will be developed on the basis of their economic profitability.

B. Ethiopia’s Climate-Resilient Green Economy Strategy

This strategy was developed through a joint initiative led by the Prime Minister’s Office, the Environmental Protection Authority, and the Ethiopian Development Research Institute. The objective of the strategy is to identify green economy opportunities that could help Ethiopia reach its ambitious growth targets (which are stipulated in the Growth and Transformation Plan) while

keeping greenhouse gas emissions low. The strategy (The Green Economy Strategy) is currently being implemented and will require a boost in Ethiopia's Agricultural productivity, strengthening the industrial base and fostering export growth.

Electric power generation has been identified as one of the most critical components to capture growth and economic development and a condition for building a green economy in other sectors. Under the electric power sector, geothermal has been identified as one of the potential generation means that can significantly de-carbonise the regional energy profile as well as contribute to Ethiopia's capital stock formation, a critical enabler of industrial and urban growth and a key priority for the growth and transformation programme through rural electrification.

C. Investment Proclamation No. 280/2002

The Investment Proclamation no. 280/2002 encourages and promotes investment necessary so as to accelerate the economic development of the country and to improve the living standards of its peoples. It also describes, that in addition to that of domestic investors, it is deemed essential to widen the scope of participation of foreign investors and to facilitate conditions thereof with a view to enhancing the country's activities (FDRE, 2002).

Specific energy legislation in Ethiopia applicable to geothermal development:

- *Mining Operations Proclamation No.678/2010*

This Proclamation vests all mineral resources on the government of FDRE and provides for security of tenure for all investors in respect of exploration and mining operations. One of its objectives clearly stated in Article 4(5) is to ensure that the country's mineral resources are developed in an orderly and sustainable manner. According to Article 7, no person may be allowed to undertake mining operations without a valid licence. Different licence types are required for different stages in the mineral development processes. These include: reconnaissance licence, retention licence, exploration licence and mining (small/large scale) licence.

- *Energy Proclamation No. 810/2013*

This Proclamation came into force on 27 January 2014 and underscores the importance of expansion of electricity services as essential to enhancing Ethiopia's economic and social development and the need to regulate electricity and energy efficiency and conservation. In Article 3, it establishes the Ethiopian Energy Authority to promote the development of efficient, reliable, high quality and economical electricity services.

Article 10 of the Proclamation obligates any licensee to carry out his activities in compliance with among other, the relevant environmental protection laws, and safety, quality and performance standards determined by the Ethiopian Energy Authority.

In Articles 16-17, the Proclamation allows a licensee to expropriate land under private holding for any generation, transmission, distribution and sale of energy. In undertaking the expropriation, the relevant laws must be followed and the licensee is responsible for compensation of any damages caused to properties of a landholder.

- *Electricity Proclamation No. 86/1997*

Ethiopia also has Electricity Proclamation No. 86/1997 which requires a licence for generating electricity.

Conclusion

Both in Kenya and Ethiopia, and to a larger extent the whole East Africa Rift area, the geothermal resource can play a key role in the development of countries' energy plans with production of reliable and green electricity.

Nevertheless, taking into consideration the high complexity for the realization of geothermal projects, from the early stage development to the construction, operation and maintenance of such facilities, the involvement of large international industry players with proven geothermal know-how is key to fully exploit such resource in an efficient way.

Moreover, the development of new geothermal projects, and the sector as a whole, can be accelerated through the implementation of open, transparent, and competitive-based mechanisms aligned to international standards that could attract global players willing to invest in the geothermal sector in an effective and timely manner way.

Managing environmental & social risks to achieve bankability for renewable energy projects in Africa

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In collaboration with:

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Abstract

Interest in and support for renewable energy projects to address the energy supply gap in Africa continues to grow. Opportunities for investors within this space are plenty but come with unique challenges that require careful evaluation of ESG risks early in the project lifecycle. A key component to a successful project is making sure that is it 'bankable' from an ESG perspective, making it attractive to lenders and investors. The focus of this paper is specifically on how to address ESG risks to ensure that renewable energy projects in Africa are 'bankable' from the start of the project through to the construction and operation of the project.

Introduction

With energy demands continuing to increase across Africa, interest in power projects, particularly renewables, remains high with international developers and investors. Despite Environmental, Social and Governance (ESG) risks being addressed much earlier on in the project life-cycle than ever before, ESG risks often delay and, in some cases, derail financing of projects. To successfully navigate this process and secure funds, it is essential that projects demonstrate from an ESG perspective that they are 'bankable'.

A project is considered 'bankable' when its ESG risks are well understood and when effective measures and structures are in place to mitigate and/or manage these risks to an acceptable level for financiers.

The Environmental and Social Impact Assessment (ESIA) is typically the first step developers take in demonstrating how they have identified and will be managing ESG risks. However, it is at this stage that many projects fail because of the assumption that the ESIA needed by regulators to secure a permit through the national process will be largely sufficient to meet lender needs. Apart from this, in many cases the ESIA is initiated too late in the site selection or design process, often its importance is not fully understood (it might be considered as a mere formal requirement) and thus it is less effective in addressing ESG risks appropriately.

This position paper explores what 'bankable' is from an ESG risk perspective, shows that these risks are also associated with the renewable energy sector in Africa, and discusses some proactive approaches to addressing ESG risks in a way that allows a project to be 'bankable' and compete against the many other power projects in Africa for financing.

Bankable projects

A project is considered bankable if lenders are willing to finance it. In the language of environmental and social consultants, the bankability of a project is not only determined by its technical and financial features but also from its environmental and social performance. Nowadays, it is getting more and more common that when applying for financing from international financing institutions, export credit agencies and commercial banks, companies are required to undergo an environmental and social due diligence in parallel to or following the assessment of other aspects (for example, of economic, financial or legal nature). The purpose of the due diligence is to identify and evaluate potential environmental and social impacts generated by the project and its complance againts applicable international and national laws and standards. The main international standards that usually apply for projects developed in Africa are:

- International Finance Corporation (IFC) Performance Standards on Environmental and Social Sustainability (2012);
- Equator Principles (2013);
- European Bank for Reconstruction and Development (EBRD) Performance Requirements (2014);
- European Investment Bank (EIB) Environmental and Social Standards (2014); and
- African Development Bank (AfDB) Operational Safeguards (2014).

The purpose of the due diligence is to prevent project developers and financial institutions from being exposed to the following three types of risks arising from their client's potential environmental and social issues:

- credit risk: when a client is unable to repay loan on account of environmental and social issues;
- liability risk: when a financial institution faces legal complications, fees, and/or fines in rectifying environmental and social damage by virtue of taking possession of collateral;
- reputational risk: when the negative aspects of a project harm a financial institution's image — in the media, with the public, with the business and financial communities, and even with its own staff.

The correct implementation of these standards together with best practices have shown that this can assist project developers and financiers in reducing liability and reputational risks as well as economic risks caused by work stoppages resulting from social problems or environmental accidents.

Are ESG risks real for renewable energy projects?

Environmental and social impacts and risks are generally recognized as being relevant to the extractive industry as well as for the development of infrastructure, with only minor relevance to renewable energy developments. Initial perceptions are often that renewables have a significant positive environmental impact through the reduction of greenhouse gas emissions and thus there is no requirement to 'manage' environmental and social risks. This perception is misplaced as all renewable energy developments have some negative impacts that need to be mitigated, while several of the benefits can be enhanced. These impacts are experienced locally through the construction and operation of the power plant and associated infrastructure, and impact both ecological and social aspects of the surrounding local environment. Ignoring these impacts, or potential risks, can have dire consequences for the project.

Research in the extractive industry undertaken by ERM (see Figures 1 and 2), clearly shows that environmental and social risks can directly impact the implementation of a project meaning they have the potential to cause delays, subsequent project overspending and potential reputational risks to developers. Is this the case for the renewable energy sector in Africa?

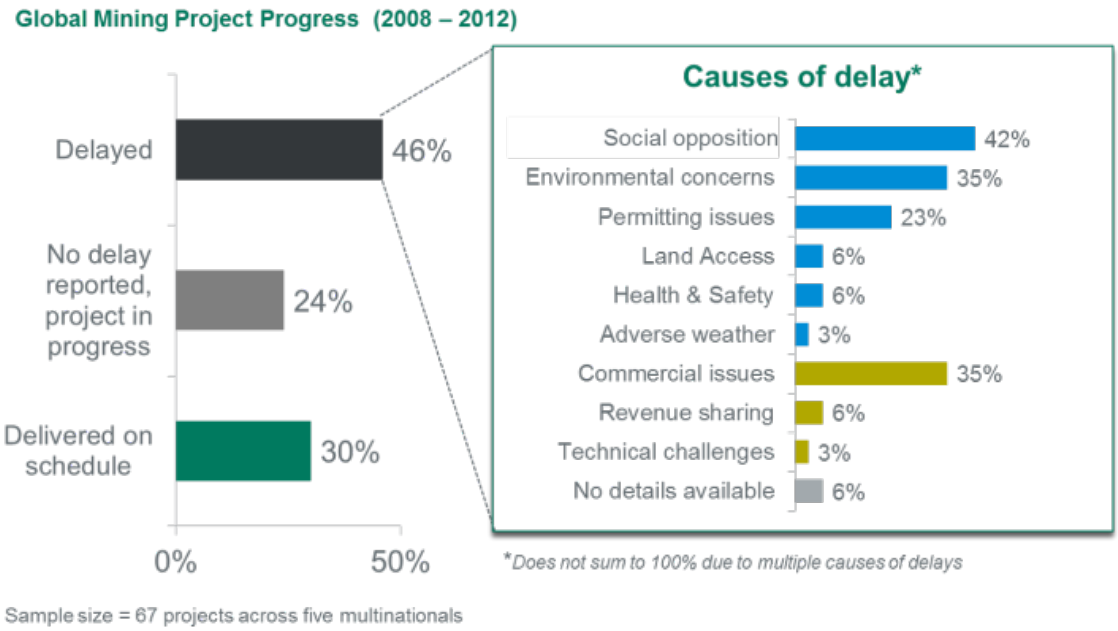


Fig. 1 - Global mining project progress 2008 - 2012, ERM

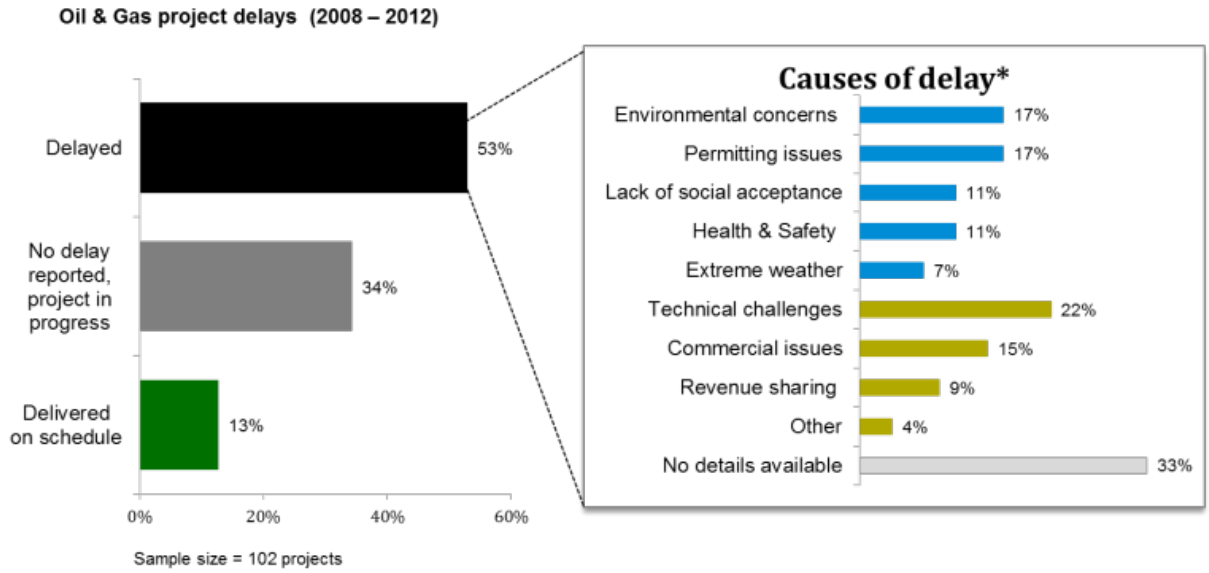


Fig. 2 - Oil and gas project delays 2008 – 2012, ERM

To answer this question, one only needs to consider two major renewable energy projects in East Africa that have been profoundly impacted by environmental and social risks. The first is the Kinangop Wind Project, which was ultimately abandoned on 25 February 2016. KWP Ltd and its shareholders announced that the project would not be completed due to civil disturbances over a 21-month period in the local area of the project resulting in delays that led to a depletion of funds, as well as court cases and community hostilities. Another renewable project in East Africa, this

Power type	Most common high risk ESG issues
Thermal	• Air quality • Physical and/or economic resettlement for land owners and land users • Project induced labour influx • Noise
Wind	• Biodiversity (in particular birds and bats) • Noise and visual • Physical and/or economic resettlement for land owners and land users
Solar PV	• Physical and/or economic resettlement for land owners and land users • Waste management (disposal of waste panels)
Hydro	• Physical and/or economic resettlement for land owners and land users • Project induced labour influx • Biodiversity (from the dam and inundation area) • Environmental flow and fisheries
Associated infrastruc-ture	• Physical and/or economic resettlement for land owners and land users • Biodiversity

one deemed a success, has not been immune to similar challenges. Whilst the Lake Turkana Wind Power Project is expected to inject 310MW from its 365 turbines into the national grid, the project has been held back for 6 months now by a controversy surrounding the completion of a 400KV, 428 km line from its fields at Loyangalani to Suswa.

These are just two recent examples where social risks have either totally stopped the project or resulted in significant delays. There are other examples where ecological issues have been the primary risk. For a renewable energy project to be considered bankable, ESG risks will need to be carefully identified and proactively managed throughout the project life-cycle.

The importance of acting early

Acting early is the key to success when it comes to managing ESG risks and impacts in order to secure international finance for projects and ensure their smooth implementation. There are a number of actions project developers should take from an ESG perspective to make financing as easy and fast as possible, including:

Perform early screening of potential high-risk E&S issues. This could be in the form of a 'red flags assessment' or an early-stage due diligence. The table below illustrates the most common high-risk ESG issues for various power projects (note: this is not an exhaustive list, as different projects will have different sensitivities). It is important to integrate the consideration of potential environmental and social impacts into early site selection and design decisions so that impacts can be avoided or minimized where feasible. International best practice should be applied where applicable at the design phase (e.g. compliance with the World Bank EHS Guidelines). It is also important to note that international finance standards require developers to demonstrate in the ESIA how environmental and social considerations

have been included in the alternatives selection process (e.g. routing, siting, and technology selection).

Engage early with potential lenders and government stakeholders. This dialogue helps avoid unwanted surprises and is important to reassure lending institutions throughout the process that ESG risks are being robustly managed. This can also be an opportunity to discuss and agree on realistic mitigation measures where meeting specific international standards may not be that straight forward. Liaising with governmental stakeholders early is advised to discuss key differences between national requirements and lender requirements and to agree on an approach to bridge these gaps. There are a number of areas that often show key differences between these requirements, including the extent and nature of stakeholder engagement and compensation measures when dealing with physical or economic resettlement.

Identify and engage early with key stakeholders. Stakeholder engagement is a key aspect for all bankable projects. Beyond the fact that it is a requirement of all international standards and often of some national environmental legislation, its actual implementation from the early phase of project development allows the project to gain the social license to operate and prevent the outbreak of protests. The identification of project stakeholders should start ideally at the beginning of the project design phase and, specifically for renewable energy projects, before the identification of the site. Project stakeholders are various individuals, groups or communities who:

- will be affected or are likely to be affected, positively or negatively, and directly or indirectly by the project ('Project Affected Parties'), particularly those directly and adversely affected by project activities, including those who are disadvantaged or vulnerable; or
- may have an interest in the project and/or the ability to influence its outcomes, either positively or negatively ('other influential/interested groups').

Project proponents should identify the different stakeholder groups to outline a continuous public information, consultation and communication strategy. This strategy is generally known as Stakeholder Engagement Strategy or Plan (depending on the project development phase). At first, proponents should undertake a detailed stakeholder identification analysis that specifies and enumerates which groups are most affected by the project, how, and to what degree. The proponent will map the key components, as follows:

- project activities, both on site and the surrounding area, that may result in local environmental or social impacts;
- impact zones (e.g. labor standards and employment, land use and acquisition, soil/air/water pollution, etc.) for each component; and
- directly affected, indirectly affected, and vulnerable groups in the impacted zones.

Following the preliminary stakeholder mapping, based on field surveys and desktop study, the proponent should verify this analysis through direct consultation with stakeholders or credible and trustworthy representatives. The project's stakeholder engagement strategy should be based on meaningful and culturally appropriate interaction and good faith dialogue with

interested parties. It should be commensurate with project impacts and development phase.

When starting stakeholder engagement at the early stages of project development, developers have the possibility, among others, to reach an agreement for a suitable location which minimizes social impacts and maximizes benefits, and to disclose correct and reliable information on the project which can prevent the spreading of false beliefs and expectations (in particular regarding employment). Engaging early will help the project to develop trustful relationship with local communities and authorities and identify, from the very beginning, local needs that could be addressed through a sustainable community investment strategy.

Identifying from the very beginning opportunities that can create additional value to affected communities. Bankability is achieved more rapidly when a careful assessment of the local and business context is performed in the earliest stage of the project. This allows a deeper understanding of the local communities that the business will be operating in and, subsequently, an effective management of ESG risks and opportunities. The screening of opportunities that can create additional value to the local community pushes the company to be proactive and meaningfully engage with local stakeholders as international standards require. This approach reduces the risk of poor ESG performance and of subsequent delay in achieving bankability status. For this reason, a number of project proponents have developed in recent years a thorough and strategic approach to the management of ESG risks, by developing a cross-functional coordination at the company level and by focusing corporate policies on external aspects such as local hiring/procurement policies and community investment programs.

For renewable energy projects, the local hiring aspect is an issue that must be handled carefully to meet local expectations and possibly maximize the contribution of available local workforce. This is particularly important for renewable energy projects, as the number of available jobs in the construction and operation phases is lower than envisioned by local communities and generally largely based on skilled workers. In this regard, investment in capacity building or *ad hoc* community investment programs can successfully contribute to maximize local opportunities and, ultimately, contribute to a positive reputation at local and national level. A successful ESG management strategy focused on local and business context should be developed around achieving the following targets:

- target local people categories that might contribute in the most effective way to building the project's 'social license to operate';
- build capacities at local level that are recognized as beneficial in the project context (either with direct and indirect impacts); and
- depending on project size and characteristics, consider a variety of capacity-building options to ensure diversification of the local workforce and supply chain.

The importance of social issues

People are seldom straightforward and this means that measuring social impacts is often

complex, making the full understanding and management of social risks prior to financial close a real challenge. This is exacerbated by the fact that social impacts are often excluded from consideration in many of the national ESIA processes in Africa. As a result, unless a project proactively incorporates international finance requirements early in the process, as previously advocated, significant additional work on the assessment of social impacts is often needed to supplement a national ESIA. To further raise the stakes, as illustrated in the table above, social issues can often present some of the highest ESG risks to a project (e.g. physical and economic resettlement, and community conflict associated with physical environmental changes to air quality, noise emissions and water supply). Social issues can make or break a development; on one hand, they can stop a project dead in its tracks, and on the other hand, good social management can de-risk a project and generate value in the eyes of potential investors.

Below are several ways in which project developers can de-risk projects for social issues and avoid related delays in financing:

Work to build trust with local communities at the outset. Good stakeholder engagement should start early, as explained in the former sections. Once trust with stakeholders is lost, it is difficult to regain. It should be noted that social impact assessments need to include the community's consideration of perceived impacts, since these can often pose a very real social risk to projects. The only way to identify these risks is by engaging stakeholders early in the impact assessment process.

It is essential to understand any potential impacts on people's livelihoods since these can pose a high ESG risk and will require a significant amount of management. If land take is required for the development, the following should be considered:

- who are the current land owners and how will they be impacted?
- is land ownership clearly documented? Note that in many parts of Africa this may not be the case (e.g. community/tribal ownership of land).
- are there any other users of the land who are dependent on the land to support their livelihoods? Note that this can include informal or even illegal use of the land.
- any compensation will need to be in line with international finance standards (e.g. IFC's Performance Standard 5), so it is important to understand how the national compensation process may differ. Note that there may be a requirement to 'top-up' national compensation.
- if the land has been allocated to the project by the government, this does not automatically mean that any government-led resettlement meets international requirements.

Determine if the project has the potential to affect any indigenous peoples. If this is a possibility, the stakeholder engagement process, and indeed the social impact assessment, will trigger additional requirements under the IFC's Performance Standards (IFC Performance Standard 7) and will introduce an added layer of complexity. Potential impacts on indigenous peoples also pose an increased reputational risk and NGOs are likely to focus their attention on the

project. Engaging with indigenous peoples requires a deep understanding of their culture and livelihoods and must be led by appropriately qualified individuals that are known and trusted by the affected communities.

Don't underestimate the capacity or influence of local NGOs. NGOs have access to project information, permits and licenses and can be adept at identifying non-compliance. They can place considerable pressure on project developers, thereby increasing the risk of reputational damage. Additionally, with the increased role of social media in society, international NGOs often back local NGOs as part of targeted campaigns. This means that small, local NGOs often receive guidance and resources from larger, international NGOs. Additionally, potential local ESG issues are more likely to be communicated to an international audience, thereby increasing the reputational risks both for a developer and their financiers.

Appoint the right Community Liaison Officer (CLO). This is a key decision in helping to manage local project risks effectively. A local individual with knowledge of international standards/protocols and hands-on experience in stakeholder engagement is ideal for this role.

Ensure that a robust Environmental Social Management System (ESMS) will be in place for construction and operation. From a social perspective, it is essential that this system also includes procedures and resources to manage social impacts, any labor working condition issues and community grievances on an on-going basis for the life of the project.

The importance of full project commitment to implementing ESG mitigation and enhancement measures

Experience has shown that in order to manage ESG risks throughout the project life-cycle, a company needs to commit to the appropriate level of human resources to implement the necessary risk mitigation measures during both the construction and operational phases of the project. Showing this commitment prior to the start of construction has become more important to project lenders and financiers, as they require proof of qualified staff and appropriate organizational management systems to ensure implementation.

Two common situations have been observed in bankable projects, especially in small to medium scale projects, such as renewable energy projects:

- a full set of environmental and social documents is prepared in compliance with international standards (usually with the support of external experts) but they remain a mere formal exercise without actual implementation. Site procedures and practice remain those generally applied by the developer on all sites and no personnel with specific environmental and social skills are deployed; and
- project developers appoint specialists within their staff responsible for the due diligence/compliance monitoring phase (specifically as company interface with lenders) as an additional task in addition to their normal workload without giving them the right tools, support and

authority to set up a project-specific environmental and social management system.

An effective environmental and social management system aimed at mitigating environmental and social risks should be endorsed by the project's management team and become an integral part of the company procedures and day-to-day business operations. This implies that a dedicated organizational structure with adequate skills, resources, agreed upon strategy as well as a good monitoring system is necessary to ensure good environmental and social implementation and performance.

Related infrastructure

The installation of supporting infrastructure needed for a power development is something that is often overlooked when conducting a national ESIA. Common examples include transmission lines, substations, access roads and pipelines. If these are essential to the project and would not exist without the project, they are considered 'associated facilities' and need to be considered as part of the scope for the international ESIA, even if they are not directly funded by the project.

Conclusion

Using the appropriate mechanisms to integrate ESG risks into the project life-cycle will allow project developers to help de-risk their projects, making them 'bankable' from an ESG perspective. This will increase the likelihood of securing international financing and receiving the funds more quickly. From previous forums that address power in Africa, it is evident that there is plenty of money for investment; however, there are not enough 'bankable' projects. With so many power projects in Africa competing to secure financing, managing ESG risks properly can make the difference between a successful development and one that never gets off the ground.

Role of regional interconnection in fostering RE Integration in Eastern Africa Power Pool

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Abstract

The Eastern Africa Power Pool (EAPP) was established in 2005 in order to exploit the benefits of regional cooperation regarding the development of power systems of Eastern African countries. Strengthening the grids, extending cross-border interconnections and increasing electricity trade flows between neighbouring countries could have significant positive effects on the overall welfare of power systems but so far the results still lag behind ambition in the EAPP region. This paper shows possible pathways for the EAPP electricity system until 2030 and illustrates the benefits of regional integration of EAPP members' power systems in the light of economic efficiency, system welfare and new ambitions about the development of RES to reduce the carbon footprint of power systems. The fostering of regional interconnections will allow to maximize national potentials of RES and to integrate larger RES capacity into the systems, while ensuring its robustness and an efficient management of intermittency.

Introduction

Established in 2005, the Eastern Africa Power Pool (EAPP) is the specialised electric power institution of the Common Market for Eastern and Southern Africa (COMESA). The two institutions work to foster regional economic integration of African countries, also through the integration of national power systems. Twelve countries are actually members of the EAPP: Burundi, DRC, Egypt, Ethiopia, Kenya, Libya, Rwanda, Sudan, Tanzania, Uganda, Djibouti and South-Sudan.

EAPP's mission is to create a "unified regional electricity market [...] to secure power and optimize the usage of energy resources in the region".

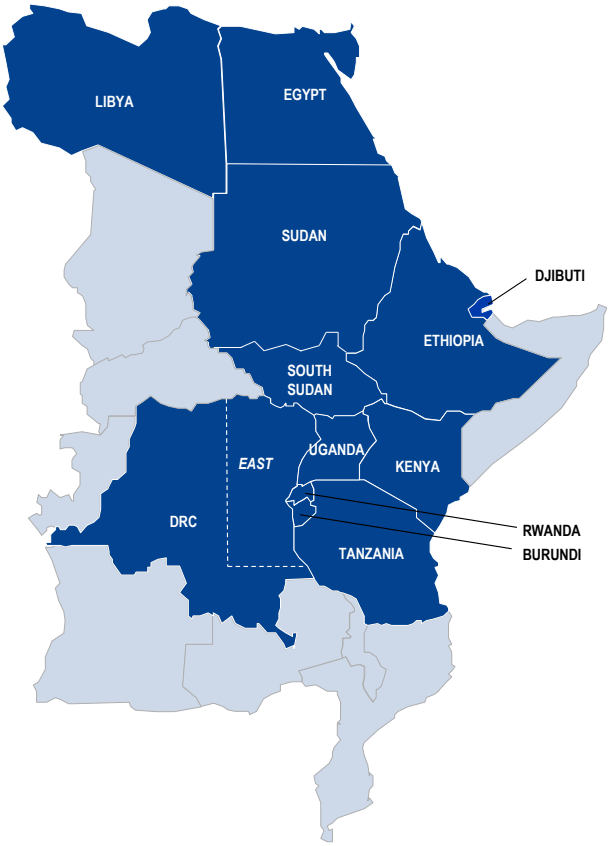


Fig. 1 – The EAPP area

Its main objectives could be resumed as follow:

- To promote regional planning of investments in generation, transmission and distribution assets within the region;
- To increase interconnections and power exchanges between member countries;
- To create a supportive environment for financing of power energy investments in the region.

The EAPP energy landscape

Despite the fact that EAPP governance framework is in place since 2005, electricity systems in Eastern Africa remain largely underdeveloped. Most of the EAPP members face the challenge of relatively low electrification rates, i.e. according to IEA around 80% of East African population lives with no access to electricity. Electrification rates at national level are rarely above 40% and there is a significant discrepancy between urban and rural areas (see Table 1). In 5 out of 10 EAPP countries, only 10% or less of the rural population has the privilege of access to power. This circumstance is typically compensated by a strong use of solid biomass for cooking and heating: in 2015, biomass contributed with 110 Mtoe to total final consumption in the EAPP region representing a 59% share, while electricity only contributed with 17 Mtoe, covering 9% of total final consumption. In rural areas, biomass use is even higher, especially woody biomass. As population levels rise, the region's biomass consumption could double every 20-25 years, according to REN 21.

Country	Population without electricity (M of people)	National electrification rate	Urban electrification rate	Rural electrification rate
Burundi	10	5%	28%	2%
DRC	62	18%	42%	0%
Egypt	1	99%	100%	99%
Ethiopia	73	25%	85%	10%
Kenya	36	20%	60%	7%
Libya	0	100%	100%	99%
Rwanda	8	27%	72%	9%
Sudan	24	40%	67%	26%
Tanzania	36	30%	57%	18%
Uganda	31	19%	52%	12%

Tab. 1 – Electricity access in EAPP countries in 2014 (Source: IEA, World Energy Outlook, 2016)

Power generation is inadequate to satisfy the current power demand in the region. As a result, shortages and load shedding are frequent and affect the economic activity and the global social welfare of the EAPP countries. The power demand of the EAPP region has increased on average by 7.5% per year between 2000 and 2016. For forthcoming years, there is an expectation of a **strongly growing electricity demand, driven by the widespread of electricity access, urbanization, population growth and GDP increase**. Satisfying such a massive demand increase will require large investments in new generation capacities, including the deployment of renewables, and in the development of electricity grid infrastructures. The power generation mixes of EAPP members are not diversified, relying very often on one or two technologies for more than 90% of the installed capacity (see **Figure 3**). Nevertheless, EAPP members can rely on abundant local energy sources to expand electricity generation in a competitive way. While fossil energy sources are available only in few countries (i.e. oil and natural gas in Egypt and Sudan, coal in Tanzania), the renewable energy potential is particularly abundant within the all-region.

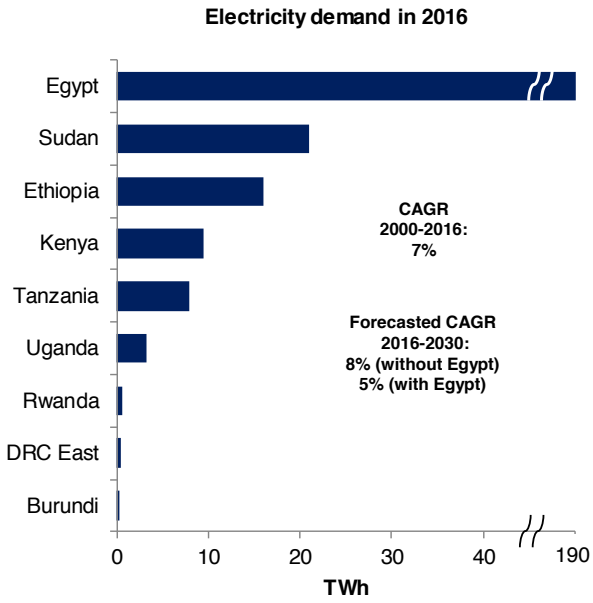


Fig. 2 – The EAPP members' power demands, 2016(Sources: see Methodological note)

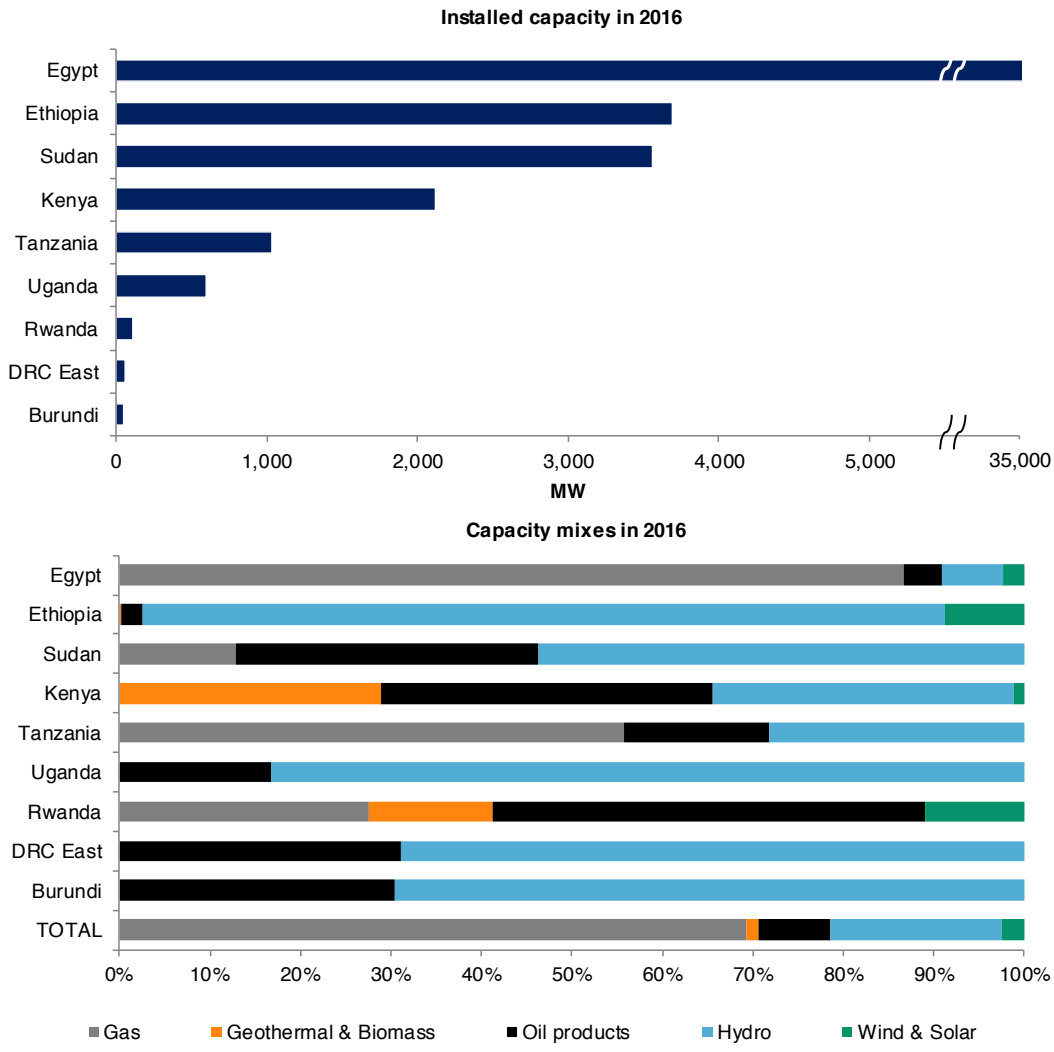


Fig. 3 – The EAPP members' installed capacity in 2016, MW total and by fuels (%) (Source: see Methodological note)

The hydropower potential is around 45 GW in Ethiopia as well as in DRC and up to 3 GW in Uganda. Kenyan geothermal potential is estimated between 8-12 GW and all the Rift Valley, which includes also Ethiopia and Tanzania, is rich in geothermal resources. Biomass potential is also very strong, from peat to agriculture residues and waste, and widespread in all the countries and it represents a valuable solution for power generation. Finally, all EAPP members present perfect conditions for the development of wind energy and solar energy, notably PV. Solar Europe estimates a solar potential of 1.1 TW in the EAPP region. Egypt, DRC, Tanzania, Ethiopia and Sudan also feature a significant wind power generation potential.

While hydropower, geothermal and biomass power plants are common in the region, and might be considered as mature technologies, grid-connected wind and solar power are still not very common. Maximisation of intermittent renewable energy resources will require proper integration strategies, as the implementation of innovative technologies and market reforms as well as the

enhancement of power networks and interconnections. Increasing power systems integration and trade, through the creation of a regional power market, can enhance energy security, bring economies of scale in investment, facilitate financing, enable greater renewable energy penetration and allow synergistic sharing of complementary resources.

The observation of EAPP countries' power sectors shows that National Governments have preferred stand-alone approaches in order to ensure the security of power systems until today. Despite the existence of the EAPP framework, only few countries are effectively interconnected and the existing interconnectors have very limited transmission capacity. As a result, market integration and power exchanges remain very low within all the EAPP region. Changing this approach will have significant positive impacts in the light of the future energy systems evolution.

Region to/from	Region from/to	Existing	Committed
Drc	Burundi	16	
Drc	Rwanda	100	
Egypt	Sudan		200
Ethiopia	Kenya		2.000
Kenya	Tanzania		220
Rwanda	Burundi	12	100
Rwanda	Tanzania		27
Sudan	Ethiopia	200	
Tanzania	Burundi		27
Uganda	Kenya	145	
Uganda	Rwanda	5	250
Uganda	Tanzania	70	

Tab. 2 – Existing Interconnector and main committed new projects, MW (Source: EAPP Master Plan 2014)

Regional system planning as solution for optimal integration of renewables in electricty systems

The vast potential of renewable energy in the EAPP countries represents a key opportunity for the future development of power systems within the region. However, proper integration strategies are required to make efficient use of these valuable renewable energy resources. Examples of such strategies are (1) the implementation of innovative technological solutions such as storage, demand response and micro-grids, (2) an appropriate market design (RES market integration, ancillary services), and (3) an upgrade of the physical infrastructure (grid enhancement, interconnections). The enhancement of cross-border interconnections is an efficient option for a more organic development of RES and it would allow the countries to maximise their potential and to reduce RES related risks, such as intermittency. Regional integration would then coexist with other solutions, contributing to create the "hybrid power system" necessary to efficiently address the power system development challenge in the region.

Grid development as technical solution for the efficient integration of RES into power systems

Bulk deployment of wind and solar PV requires redesigning the grid rules in order to accommodate and integrate the energy produced without constraints. The intermittency of wind and solar generation could endanger the stability of small electricity systems where online flexible generation is missing. Therefore, biomass and other technologies could be relevant in order to support the system, compensating the

intermittent nature of wind and solar PV and increasing the ability to dispatch energy.

Some of this renewable energy potential could first be exploited at local level in the form of micro grids. In fact, this is already happening in some EAPP countries thanks to government policies, rapidly declining global prices for solar PV and innovative business models. One example is the Powercorner initiative, launched in 2016 by the French multi-national energy company ENGIE in Tanzania. Their first project involved electrifying a rural village of 800 inhabitants by deploying a hybrid containerised mini-grid consisting of 16 kW of PV panels, 45 kWh of Lithium-ion batteries and a back-up genset. The technical solution includes a low-voltage AC distribution network and access to energy efficient appliances (TVs, fridges, freezers etc.). Clients pay a deposit upfront (connection fee) and ENGIE installs a smart meter for charging the consumption on a pre-paid basis. Payments are handled via mobile money, i.e. cell phones. By the end of 2017, eight Powercorner projects will be deployed in Tanzania alone, each ranging between 20 and 40 kW of PV capacity. By 2018, the initiative will be launched in two more EAPP countries.

Such initiatives help to kick-start the electrification process but they do not generally eliminate the need for larger electricity grids. This is because the most cost-effective RES potential is not always located near consumption centres, especially when it comes to wind and hydro, as can for instance also be observed in Ethiopia. In fact, the experience in Europe shows that investments in new RES capacity are accompanied by investments in new grid infrastructure that is used to connect power plants and for integrate markets. As required by the European Commission, the European Network of Transmission System Operators for Electricity (ENTSO-E) publish a Ten Years Network Development Plan (TYNDP), every two years, with a focus on the future scenarios (demand + generation) and providing a list of infrastructure needs. The TYNDP 2016 scenarios include a relevant growth of renewable electricity sources, supplying 45% to 60% of the total annual demand. As reported in the last plan, most transmission investment needs (€150 billion investments of pan-European significance) are linked to RES-integration developments, planned in order to connect RES to the grid or to relieve network congestion.

The TYNDP example demonstrates that grid development is necessary to enable RES deployment and could solve several further issues related to electricity supply and quality of the service. New grid reinforcements are planned in order to answer to different purposes, typically for mutual support in case of scarcity situations, thereby ensuring the reliability of electricity supply. Their role in improving social welfare has received growing attention due to several black out registered over the last 20 years. As illustrated in the TYNDP 2016 report, market integration also fostered by grid reinforcements reduces bulk power prices by 1.5 to 5 €/MWh (depending on fuel and CO2 cost assumptions per scenario).

To solve investment needs, TSOs have proposed tailor-made grid reinforcement solutions adapted to every specific situation. As a result, a large range of available technologies has been implemented. For 15% of the cases, the upgrade of existing overhead lines can prove sufficient to achieve the required capacity increase with a limited impact on the related areas. Increased grid transfer capability does not always match with increased network length thanks to

restructuring; and when the network length increases, it is by 40% underground or subsea.

This experience indicates that in order to fully exploit the benefits of RES in the EAPP region, a thorough grid planning at national and transnational level would be beneficial.

Regulatory aspects for successful regional integration

Electricity systems are radically changing, thanks to the new rising technologies from the production sector through to consumption. The cost reduction of solar and wind power facilities is shifting the trajectories of the forecast towards an even more distributed generation. The EU is leading the international communities in the aim to pursue diversification of the supply of services in the coming years by increasing user numbers with direct involvement of all parties. The new regulatory proposals (introduced by the 2014 Climate and Energy Policy Framework, by the 2016 "Clean Energy For All Europeans" policy package) will create business opportunities for innovative companies able to diversify and offer consumers even more services.

According to the EC proposals, in future energy markets should reward flexible generation, demand and storage at equal footprint. Additionally, market rules must be adapted in order to make renewable producers participate both in the energy and services markets (procured from primary, secondary, tertiary and balancing reserve). This will facilitate innovation and digitalisation and will make European businesses responsible for providing greater energy efficiency and low-emission technologies. The increasing complexity of networks implies a higher need of coordination among different grid users to better identify threats to secure system operations and to adjust measures to mitigate these risks. The European Commission is supporting initiatives organised by transmission system operators at regional level, with the scope of strengthening their cooperation in assisting their task of maintaining the operational security of the electricity system. The areas of collaboration cover several initiatives: sharing existing tools, methods, and procedures, operating services alternately or cooperatively and jointly optimising services and tools for TSOs as well as developing new ones.

To enable the full integration of new distributed users in the market, the 2016 "Clean Energy For All Europeans" legislative package indicates that countries and network operators must make an effort to develop robust transmission and distribution infrastructures and a well-interconnected European network. The Commissioners state that whilst Europe has the most secure electricity network in the world, significant investments will be required up to 2030 to strengthen transmission and distribution.

A strong coordination between TSO and DSO is necessary, with reference to the planning of grid development, in order to face local congestion on the medium and low voltage grids, as well as to face the need of voltage control. Thus, they should contribute to the formation of an integrated European energy market. They enable the energy transition and empower prosumers' contribution by ensuring transparency, confidentiality and neutrality in data management, no matter which data governance is established. TSOs and DSOs should contribute to the social welfare maximisation with a fair cost and benefit allocation.

DIMENSION	PUBLIC SECTOR	PRIVATE INVESTORS
Feasibility	Assess revenues, operating costs and investments and compare different project implementation scenarios and schemes	Assess revenues, operating costs and investments and decide whether and how to implement the project
Financial viability	Assess financial performance of the project over its life and calculate *whether and to what extent the project needs public support*	Assess whether dividends paid over project's life are in line with own hurdle rate of return for investment
Bankability	Assess if the projected cash flows are adequate to finance the projected debt services and calculate *whether and to what extent the project needs public support in order to be bankable*	Assess if the projected cash flows are adequate to cover the projected debt services and the project is bankable

Tab. 3 – Public and privates investors financial approaches to infrastructure investments

Financial aspects of cross-border interconnections projects

The financial viability and bankability of the interconnection projects are based on different principles depending on the investor characteristics: public sector versus private investors (**see Table 3**).

Sometimes a project may appear economically feasible to a company but not be structured or scheduled optimally for bank financing. Indeed, banks are most interested in cash flow during loan repayment period not overall project economics and their main interest is to ensure that the project offers:

- sufficient collateral
- predictable and adequate future project cash-flows, i.e.:
  - enough revenue to pay off loans
  - enough financial benefits to attract private finance
- high probability of success within given market

In general, "bankability" reflects constraints/opportunities of both the project scope and the environment in which it is implemented. In this context the Free Cash Flow on Operation is the key indicator for lenders.

More specifically, to finance transmission infrastructures two models are available:

- Project financing, where financing is made by an independent company (either owned by the utilities or participated by third parties)
  - When adopting "project financing", the main issue to be addressed is the relative cost of capital and the likelihood of raising funds for the project
  - This financing scheme would impact the cross-border energy transactions through a specific tariff for the use of the interconnector (entry-exit system).
- Split investment, where each company would finance its own part of the network. Under this scheme each company would include its own part of the investment in the network tariff. Key issues to be addressed are:
  - How to allocate the investment?
  - How to split congestion revenues?

In the Split Investment approach usually the recommended choice is to determine the revenue stream for each party with a cost-plus approach, known also as a "rate-of-return (RoR)" regulation.

RoR is used to determine a stream of revenues that allows recovering the investment. Each year the utility is allowed to recover part of its capital expenditures (CAPEX) and its operating expenditures (OPEX). Revenues are then defined as the sum of OPEX, charges, amortization and capital remuneration. Capital remuneration (gross of its yearly amortization) is obtained by multiplying the asset value by a defined interest rate

Independently from the financing scheme, another key issue is the optimal definition of the Project Gearing (Debt/Equity Ratio). In general for the Project Gearing the remarks summarised in the **Figure 4** apply.

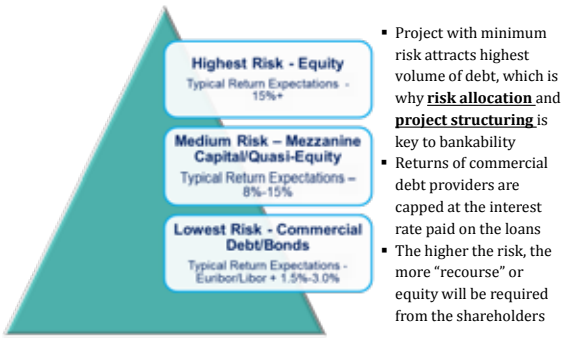


Fig. 4 – Project gearing best practice for infrastructure investments

The benefit of an integrated EAPP

To illustrate the potential benefits of enhancing regional integration between the EAPP members, we have developed a high-level quantitative analysis based on an electricity market model aimed at simulating the behaviour of the EAPP system in the year 2030 (more details in the Methodological note). Three scenarios have been developed in order to illustrate different possible paths for EAPP members to satisfy the future demand increase. The scenarios aim at showing the potential benefit of interconnections in the integration of intermittent renewable sources within the EAPP area:

- The "**Grey scenario**" illustrates a case in which future demand will be satisfied primarily through to investments in thermal generation capacity (with a 6% penetration of intermittent renewables over regional demand), and only already committed interconnectors will be built in the region;
- The **"Green scenario"** considers the same interconnection capacity of the Grey scenario, but envisages more investments in intermittent renewables (18% wind and solar in 2030); and
- The **"Green Integration scenario"** includes additional interconnection investments (plus 5.3 GW with respect to Grey and Green scenario).

Key characteristics of the scenarios are summarized in **Table 4** while details on generation mix are shown in **Figure 5.**

	Grey	Green	Green Integration
Power Demand in 2030	525 TWh 185 TWh (w/o Egypt)	525 TWh 185 TWh (w/o Egypt)	525 TWh 185 TWh (w/o Egypt)
Intermittent RES penetration (% on demand)	~6%	~18%	~19%
Interconnection capacity	3.4 GW	3.4 GW	8.7 GW

Tab. 4 – Key scenario characteristics

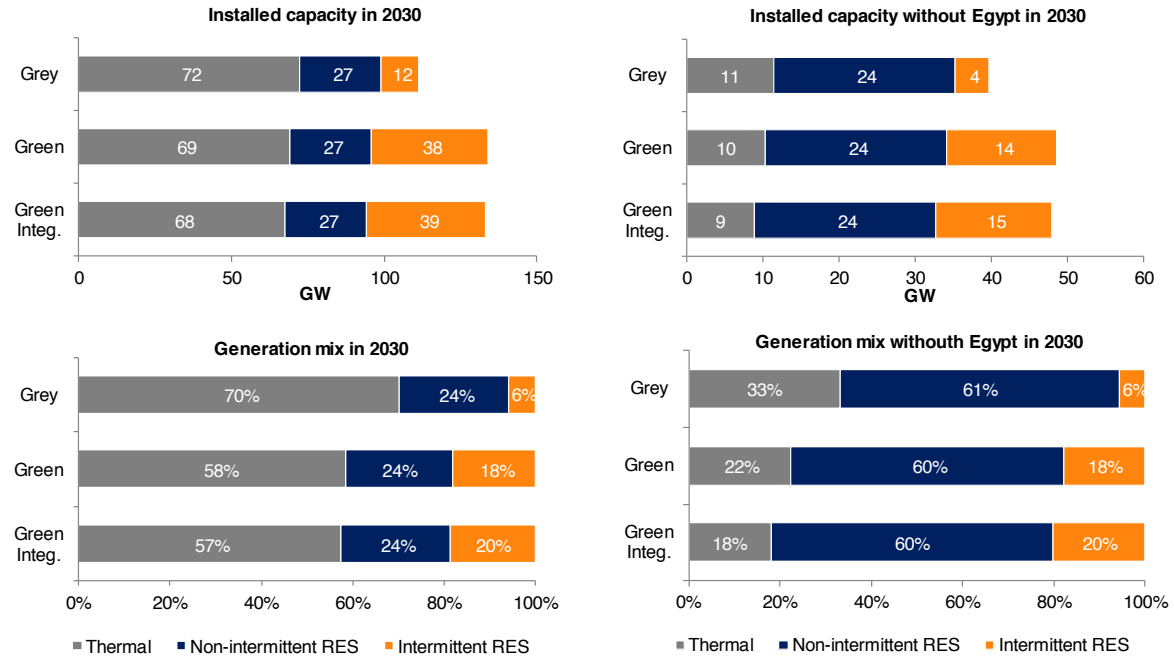
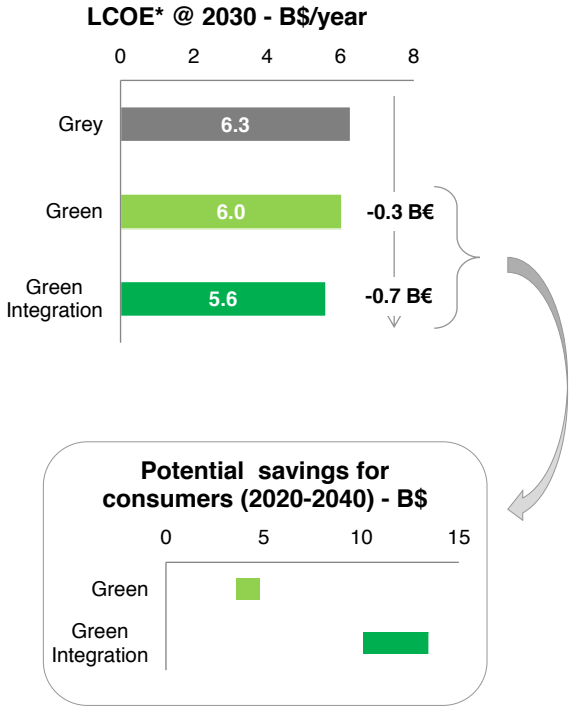


Fig. 5 – Installed capacity and generation mixes in the three scenario

Go green. Our analysis shows that in green scenarios the levelized cost of energy is lower due to the long term cost advantage of wind and solar generation. In the Green scenario this allows for an advantage of about 0.3 B$/year, which reduces the cost of meeting the increasing demand by a range of around 4-5 B$ in the Green in the long term.

Use interconnections. The advantages of the going green are amplified by interconnections. In the Green Integration scenario, the presence of interconnection on one hand reduces the need for more expansive thermal generation (which is necessary in the Green scenario to ensure system security), and, on the other hand, allows to transfer across countries excess renewable generation fully exploiting their potentials (with a significant reduction of curtailments). The reduction in the levelized cost of energy rises to 0.8 B$/year, providing a potential cumulative long term saving (for consumers) ranging from 12 to 17 B$.



*contribution of hydro and geothermal excluded (equal in all scenario)

Fig. 6 – The advantage of renewables (EAPP w/o Egypt)

Despite overall energy costs decrease, upfront investment costs (2017-2030, see **Figure 7**) increase by 7 B$ because the development of additional intermittent renewable capacity only partially replaces thermal capacity which remains compulsory to ensure enough flexibility in the system. This negative impact can be alleviated substantially if an increased development of interconnection is pursued as this solution provides lower energy costs without additional investment costs. In fact, the additional investments for the interconnections are compensated by the possibility to reduce investments in thermal generation as the system is able to better exploit the complementarity of the generation mix of the different countries through import/export of energy and flexibility.

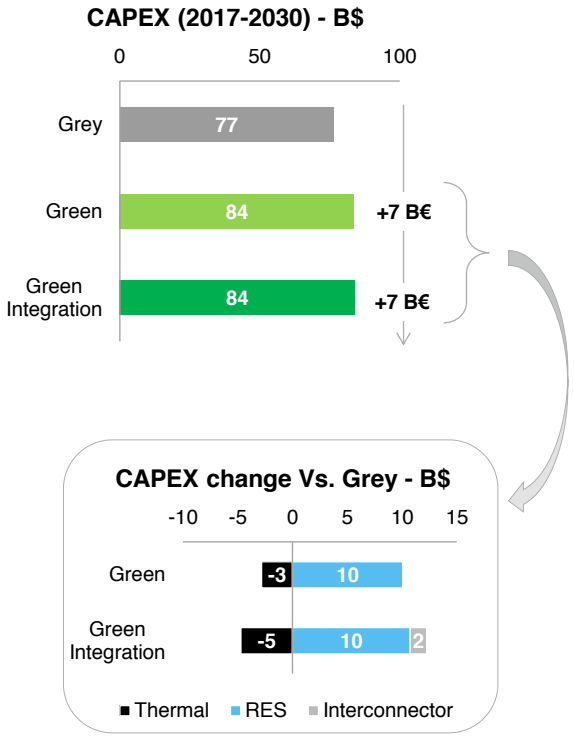


Fig. 7 – Integration is a must (EAPP w/o Egypt)

Lastly, a greener solution would significantly reduce the environmental cost of the electricity sector. In fact, the Green and Green Integration scenarios provide for a reduction of 30%-40% of the carbon intensity of the power system (**Figure 8**).

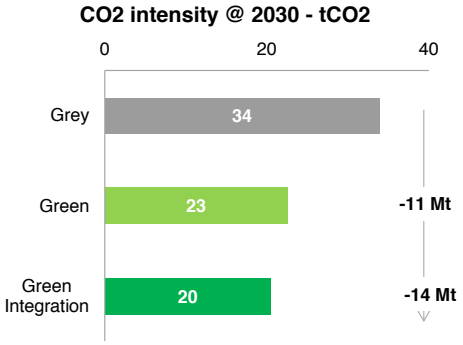


Fig. 8 – CO_2 Intensity (EAPP w/o Egypt)

Successful exemples of cross-border integration

As mentioned above, the geographical area covered by the EAPP is endowed with outstanding renewable energy sources. One of the most promising and largely still unspoiled form of renewable energy is represented by the hydro resources, namely associated to the Nile river. The hydropower potential of the Nile Basin is estimated to be 145,000 MW. This potential for hydropower would allow providing 65 percent of the region's electricity demand. The remaining demand could be supplied exploiting the availability of a wide range of renewable energy resources including solar, wind and geothermal.

In this context, Ethiopia is already playing a key role to boost hydropower generation not only to supply the steadily growing internal demand, but also to trade reliable renewable power with the neighbouring systems, particularly Kenya and Sudan. Some successful stories are recalled here below.

Ethiopia-Kenya integration

Between Ethiopia and Kenya a 2,000 MW 500 kV HVDC link is currently in an advanced stage of construction and its commissioning is foreseen by 2019 (see **Figure 9**). The total value of the project is approximately $1,260 million, mainly financed by the World Bank, the African Development Bank and the French Development Agency. A long-term (25 years) power purchase agreement (PPA) of 400 MW with Kenya has already been signed with capacity factor of 85% corresponding to about 3,000 GWh/yr. In general, this interconnector will allow covering possible shortfalls of energy supply in Kenya, a power system which is largely based on RES generation. Indeed, despite a wide availability of local RES, the power system of Kenya may be at risk of inadequate power supply due to a combination of geothermal inflexibility, intermittency of wind and PV generation and occurrence of very dry years in the country. Hence, the HVDC link with Ethiopia will help solve these constraints.



Main characteristics of the Ethiopia – Kenya interconnector

- Technology: HVDC – LCC bipolar. Overhead transmission line. Ground electrodes for mono-polar emergency operation
- Length: 1045 km
- Size: 2000 MW
- Voltage level: ±500 kV
- Substations:
  - Sodo (Ethiopia)
  - Suswa (Kenya)

Fig. 9 – Routing and main characteristics of the Ethiopia-Kenya HVDC Interconnector

In general, this interconnection can be used in the coming years to trade power further southward with Uganda and Tanzania through the following interconnecting lines:

- Existing:
  - 2x132 kV lines Kenya-Uganda with NTC equal to 145 MW in both directions. About 30 MW of this NTC is in PPA for export toward Rwanda;
  - 132 kV line Kenya-Tanzania with NTC equal to 220 MW in both directions.
- Planned interconnections:
  - 2x400 kV lines Tanzania-Kenya with NTC equal to 1,300 MW in both directions;
  - 2x400 kV lines Uganda-Kenya with NTC equal to 300 MW in both directions.

Thus, the Sodo (Ethiopia) - Suswa (Kenya) interconnector will represent an electric highway fostering the creation of a regional electricity market from Ethiopia southwards.

Ethiopia-Sudan integration

A successful example of integrated generation-interconnection projects is represented by the interconnections between Ethiopia and Sudan.

In this case a stepwise approach has been undertaken consisting of the construction firstly of a small size interconnection (100 MW), and later on a large size interconnection (3,000 MW). The construction and operation of the first interconnection line allowed to address and solve the whole spectrum of problems, technical, environmental, economic and financial, though at a small scale. Further, it allowed appraising the real benefits arisen from the exploitation of this first interconnector. The main characteristics of this first Ethiopia-Sudan interconnector are depicted in **Figure 10**.



Main characteristics of the first Ethiopia – Sudan interconnector

- Technology: AC - Overhead transmission line – double circuit
- Length: 197 km
- Size: 100 MW
  - The transfer capacity has been later doubled to 200 MW once internal network bottlenecks were removed
- Voltage level: 230 kV
- Substations:
  - Matemma (Ethiopia)
  - Gadaref (Sudan)

Fig. 10 – Routing and main characteristics of the first Ethiopia-Sudan Interconnector

Since the commissioning of this interconnector in December 2013 a number of tangible benefits can be highlighted, namely:

- Enhanced access to electricity. Approximately a total of 1.4 million households in Ethiopia and Sudan have been able to have access to electricity at an affordable price
- Better integration of reserve capacity. Ethiopia could export its surplus of hydro generation and Sudan could spare fossil fuels importing carbon free energy, hence reducing the GHG emissions of the country
- Improvements in reliability and security of supply in both countries. The improvement of security of supply has consequently given benefits at social level particularly for the local small-medium enterprises
- Generation of economic benefits from energy trading. Ethiopia has raised its capacity to generate revenue from exporting power, to about $ 8.8 million annually. In turn Sudan has gained from lower tariffs of $ 0.05/kWh for imported electricity as compared to $ 0.096/kWh from power generated domestically
- Complementarity between the predominantly hydropower in Ethiopia and the thermal based generation in Sudan. Though the energy is mainly flowing from Ethiopia to Sudan, this latter ensures security of supply in Ethiopia in periods of low rainfalls.
- Environmental benefits associated to lower GHG emissions thanks to hydropower in Ethiopia.

In addition to the above benefits, this first cross-border infrastructure allowed to enhance collaboration between Ethiopian and Sudanese technical specialists in the respective governments and utilities.

Finally, the investment cost of this interconnection has been $ 55.8 million. The relatively small scale of this project allowed to solve quite easily the financing issues. The funding of the project has been almost equally shared between the two parties and the World Bank has been the main lender.

This "small case" project represented the basis for the development of a wider regional power market and related transmission infrastructures.

In the wake of the success of the first Ethiopia-Sudan interconnector, in 2015 the governments of the two countries decided to move forward to examining a much bigger interconnection (3,000 MW) boosting substantially the energy interchanges between the two countries. The feasibility study was awarded to CESI, who completed the activities in January 2017. The new interconnector is called "Blue Nile Energy Corridor" and its main characteristics are summarised in **Figure 11**. The drivers towards an enhanced integration between Sudan and Ethiopia are manifold, in summary:

Ethiopia

- Enormous hydro potential available
- Large power generation increase foreseen in the mid-term:

- 6 GW new installed hydro power in Grand Renaissance Dam

Sudan

- High demand growth foreseen in Sudan: mainly due to the improvement of electrification of several isolated areas (+13.7% average annual growth in 2020-2030)

The main objective is to increase the reliability of power supply in the two Countries by taking advantage of the hydro-thermal complementarity of the two systems, and the variability of the peak demand.

The "Blue Nile Energy Corridor" represents an outstanding example of combined generation and interconnection project, since the economic justification of the project is closely related to the construction of the Grand Renaissance Dam.



Main characteristics of the Blue Nile Energy Corridor

- Technology: AC - Overhead transmission line – double circuit with intermediate substation in Sudan – line series compensated
- Length: 590 km
- Size: 3,000 MW
- Voltage level: 500 kV
- Substations:
  - Grand Renaissance (Ethiopia)
  - New Jebel Aulia (Sudan)
- Intermediate substation:
  - New Rabak (Sudan)

Fig. 11 – Routing and main characteristics of the Blue Nile energy corridor

Though a number of issues have already been addressed and solved when building and operating the first Ethiopia-Sudan interconnector, the implementation of a much bigger project calls for the overcome of daunting challenges, particularly related to:

- Economic justifications of the project, the estimated investment cost of which is $ 450 million
- Environmental and social impact on the territory
- Solutions to finance the project.

As for the economic justifications of the project, an accurate simulation of the expected power and energy exchanges between the two countries and related benefits were assessed applying different market models, such as:

- Coordinated thermal generation only
- Integrated hydro-thermal generation (coordinate scenario)
- Market coordination based on bilateral agreements
- Regional coordination considering neighbouring countries (possibility of wheeling part of the Ethiopian hydropower to Egypt).

Considering that the lifetime of the new infrastructure is at least 40 years, the analyses had to cover a sufficiently wide time period. The economic analysis has been carried out considering a time period until 2055. As an example, **Figure 12** shows the expected energy exchanges in both directions until the year 2035 in the so called coordinated scenario. It can be seen that, whereas in the first period of operation until 2030 the energy exchanges are predominantly towards Sudan, later on a bidirectional exchange is expected since Sudan would develop internally a mix of wind and PV generation combined with natural gas fired power plants. In parallel, the internal demand growth in Ethiopia would reduce the power surplus for export. By quantifying the benefits arising from a bilateral and regional market integration and monetising other benefit indicators associated to security of supply and integration of RES generation, a cost-benefit analysis has been carried out showing the full economic viability of this project.

As for the environmental and social impact, since the Blue Nile Energy Corridor is stretched over about 600 km, in parallel to the technical and economic analysis, it turned out to be of utmost importance to define in detail the routing by minimising the interference with other infrastructures and activities, particularly the agricultural areas. Further, direct contacts with the local authorities and municipalities have been undertaken so to find preliminary agreements since the beginning of the project design. This action turned out to be key to avoid delays in the permitting process.

Finally, as soon as the two parties have approved the project based on the positive technical and environmental outcomes and the appealing economic indicators, immediately a new process was started to find how to finance the project. Indeed, in many situations, especially in case of countries with poor affordability and low financial rating, transmission projects, though economically justified, were delayed or even cancelled due to the lack of a solid financial model, which is essential to get the required capital.

In the case of the Blue Nile Energy Corridor, the Split Investment has been selected and for the two parties the best financing model in terms of project leverage (debt/equity ratio) has been computed together with the two key financial indicators: Free Cash Flow on Operation and Free Cash Flow on Equity.

Currently the two parties are in negotiation with potential lenders to start the project implementation once the share of equity capital and bank debt has been secured.

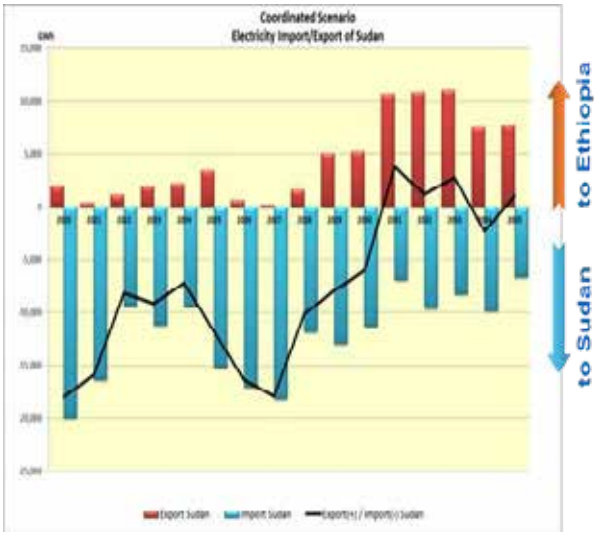


Fig. 12 – Routing and main characteristics of the first Ethiopia-Sudan Interconnector

Best Practices from the rest of the world (Central America- SIEPAC)

A successful example of the role of interconnection to create a regional electricity market is represented by the SIEPAC (Sistema de Interconexión Eléctrica de los Países de América Central - Central American Electrical Interconnection System). The idea of interconnecting the six countries of Central America (Panama, Costa Rica, Honduras, Nicaragua, El Salvador, and Guatemala) dates back to 1987. After a long process the SIEPAC interconnection is now in operation. It consists of a 1,788 km long corridor with a capacity of 300 MW. The transmission lines are at 230 kV double circuit (see **Figure 13**) connecting 16 substations, enabling the power exchanges with the domestic grids. The upfront investment costs attained approximately $ 506 million.

The SIEPAC represents an electricity highway overlapped to the national systems enabling bidirectional power exchanges between all interconnected countries. The basic idea for its construction was the possibility of exploiting the complementarity of already

existing and planned generation resources in the various countries with related price differentials. Hence, differently from many EAPP interconnection projects, the construction of the various SIEPAC building blocks was not associated to the construction of specific power plants. Indeed, each country retained its own autonomy in the generation expansion project, more or less as it happens in Europe.



Fig. 13 – SIEPAC transmission corridor (source EOR)

On the contrary, SIEPAC shows similarities with EAPP being the physical infrastructure enabling the establishment of:

- the Regional Electricity Market (MER)
- the Regional Regulator (CRIE)
- the Regional Operator (EOR).

The approach of SIEPAC for the regional integration was based on a gradual growth of a competitive regional electricity market based on reciprocal and non-discriminatory treatment that contributes to the sustainable development of the region protecting the environment. So the basic principles are: Competition, Gradualness and Reciprocity. This integration process, the achievement of which took more than two decades, was relying on a "Treaty of Regional Electricity Market" signed by governments in 1996 and ratified by national parliaments in 1998.

Thus, two important lessons can be drawn from SIEPAC:

- Engagement of political authorities
- Adoption of gradualness in the integration process.

This two basic conditions have been the basis for the creation of regional markets also in other areas of the world, such as SAPP (the Southern African Power Pool) and, more recently, the ArcoNorte Project aiming at interconnecting Guyana, Suriname and French Guiana with the Brazilian States of Roraima and Amapá. The stepwise integration of Ethiopia and Sudan power systems and markets represents an example coherent with the process followed in Central America.

In particular, the development of the market mechanisms for cross-border energy transactions followed a smooth and gradual process. In the SIEPAC case the first energy exchanges were based on short term transactions arising from regional optimal dispatch. These short term exchanges (spot market) were later integrated by medium and long term contracts. In the case of EAPP, since several interconnection projects are associated to the construction of hydro power plants, the approach for starting the cross-border energy transaction shall be the other way round with respect to SIEPAC: in a first stage, exchanges based on long term contracts with PPA between sellers and purchasers shall be set and only in a later stage short term transactions can start creating progressively a spot market. This very same approach has been suggested also for the ArcoNorte Interconnection project.

After a first phase with limited energy exchanges, the optimisation of the power dispatch at regional level together with bilateral contracts allowed to boost the

energy transactions inside the MER, from around 250 GWh in 2013 to 1,781 GWh in 2016.

In conclusion, the development of the SIEPAC system contains all the ingredients for the power system and market integration in East Africa, namely:

Endorsement of the integration process at the highest political level sealed by the signature of a Treaty

- Set up of regional institutions to coordinate the development of cross-border infrastructures (association of System Operators), harmonise the regulatory framework (association of Regulators), set up of market rules and platforms for energy exchanges (regional Market Operator)
- Adoption of a gradual process in regional integration both for the deployment of "hardware" infrastructures (transmission and generation in case of East Africa) and "software" assets (rules for the regional power market, mutual transfer of know how/knowledge sharing)
- Securing the investments through opening to private and public agents.

Conclusions

The consistent electricity demand growth driven by industrial development and increasing electrification will profoundly change the power system across all EAPP.

In response to such huge changes EAPP members could choose to evolve along different paths which will define future sustainability, affordability and security of the entire system. Significant benefits could be attended by increasing investments in intermittent RES generation assets. In fact, the abundant solar and wind potentials would give the opportunity to EAPP members to reduce energy costs, diversify generation mix and reduce dependence on imported energy sources (fossil fuels).

In the framework of a more intense RES development increasing the interconnection capacity would allow to maximise its benefits, opening to:

- Better exploitation of complementarity between generation mixes and renewable potentials of all EAPP members
- Enhancement of energy cost reduction

Key to interconnection development and the maximization of its benefits is a TSO coordination and regional system planning, including common regulation/market design. Moreover, such coordination allows to better integrate all new technologies arising across the overall power system value chain (i.e distributed generation, storage demand response, etc), and that represent both and opportunity and a challenge for the power systems. A coordinated approach could also allow to better find suitable financial structure, improving bankability of interconnections projects and fostering their development.

Moreover, an increased RES penetration together with an optimization of the overall system significantly reduces the environmental impact of power systems, also creating a social consensus both locally and internationally.

This virtuous path could represent the key for an optimal development of EAPP power system. If different evolutions of EAPP fundamentals and political willingness are always possible, the benefits of integration will continue to stand out compared to stand-alone approaches.

Methodological note to EAPP system modelling

This analysis does not want to represent our view of the optimal solution for future developments of the EAPP power system but is rather an exercise to show the potential long term consequences of the development of the system along different paths.

Therefore results presented here are for illustrative purpose and should be considered as an indicative estimation of such potential consequences

The simulation has been conducted at an hourly level taking into account the interaction of all the relevant technologies and seeking the optimal solution which maximize system welfare.

The model BID3 is an economic dispatch model based around optimisation. The model balances demand and supply on an hourly basis by minimising the variable cost of electricity generation. The result of this optimisation is an hourly dispatch schedule for power plants and interconnectors on the system. In this analysis we have considered three thermal and five renewable categories of power plants. The thermal plants are grouped based on the fuel type: gas, coal and oil derived products. The renewable sources are: reservoir hydro, run-of-river hydro, solar PV, onshore wind and geothermal/biomass

The scenarios have been developed using public available data from national incumbents and/or international organizations to estimate the potential power demand of the EAPP zone to 2030 and other relevant inputs:

- UETCL, "Grid Development plan 2015-2030", Uganda
- United Republic of Tanzania Ministry of Energy and Minerals, "Power System Master plan", Tanzania, 2016
- Ministry of Energy and Petroleum of Kenya, "Development of a Power Generation and Transmission Master Plan", Kenya, 2015
- EAPP, "EAPP regional power system Master Plan", 2014
- Ministère de l'énergie et des mines du Burundi, Direction générale de l'energie et de l'eau, "Élaboration de la Stratégie sectorielle pour le secteur de l'énergie au Burundi", 2011
- Egyptian Electricity Holding Company, "Annual Report 2015-2016", Egypt, 2016
- Republic of Rwanda Ministry of Infrastructure, "Energy sector strategic plan 2013/2014–2017/2018", Rwanda, 2015
- Republic of Sudan Ministry of Water Resources & Electricity, "Sudan Potentials, Opportunities and challenges in Energy field", Sudan, April 2016
- Federal Democratic Republic of Ethiopia Ministry of Water Irrigation and Electricity, "The Ethiopian power sector: a renewable future", Ethiopia, March 2017
- World Bank, "Commodity markets outlook", April 2017

The scenarios have been developed ensuring that they reach similar level of system security levels even if, in terms of flexibility availability, while Green and Green Integration reach enough flexibility, the Grey scenario presents excessive levels.

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

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Abstract[1]

Over the past decade, the debate on access to energy and sustainable energy strategies for developing countries has tended to lean mostly on technology, finance, and policy as key drivers. Thanks to this approach, there has been some progress in expanding global energy access – although the goal of universal access is still far off and is likely to remain so for the next two decades. Scaling up strategies for access to energy requires a different perspective and an innovative approach to capacity building. In line with the ethical imperative of the 2030 Agenda for Sustainable Development of "no one left behind" and its focus on people, the cross-cutting role

[1] The contents of this position paper are a short summary of a more extensive work:
Colombo, E. et al. 2017. "State of Energy Access Report Special Feature: The Power of Human Capital: Multi-Level Capacity Building for Energy Access". Background paper prepared as part of the State of Electricity Access Report of the World Bank (http://documents.worldbank.org/curated/en/104731494940162971/pdf/BRI-P148200-PUBLIC-FINALSEARSFHumanCapitalweb.pdf).

of human capital (individually and collectively, as communities and institutions) becomes crucial both as a catalyst and a booster. Indeed, without the proper human resources, it will be impossible to achieve a transformative change in energy access – one that is efficient, effective, equitable, empowering, and long lasting. That is why human capital is now recognized as a core dimension for any strategy designed to reduce energy poverty at the global and local levels. In this perspective 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 a win-win opportunities for local community and private investors. Indeed while fostering ownership and empowerment it may create the enabling working environment to reduce some of the people-related risk for private investors.

Background and Introduction

A paradigm change is requested if we wish to support the **penetration or Renewable energies within 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) 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 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 renewable energy technologies require new skills for installation, maintenance, and service. The **new and diverse energy markets** require that different players understand their role.

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 and now 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 behavior**; 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: a new asset for the energy supply chain

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 renewable energy**, 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 (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

Despite a common framework suggesting the most relevant action to be done in the field, does not exist, some recommendations might be drawn. From international experience. 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).

These essential elements can then be grouped into **three macro-dimensions** to help discern a rational base for capacity building, each of them (**figure 1**) responding to a crucial component of the sector:

- **Energy access is a long-term process** that needs planning and qualified human resources over a variety of diversified subjects and requiring a multitude of skills.

- **An integrated approach is crucial in the whole life-cycle perspective**, from identification to monitoring and evaluation. Capacity building strategies should also benefit from a multi-stakeholder approach, including local teaching institutions, NGOs, and the private sector.

- To couple diversification with integration, ad-hoc strategies need to highlight different **teaching tools for different learning outcomes.** These strategies should include adequate financing over the long term to ensure ownership and sustainability of energy access initiatives.



Figure 1: Multi-level breakdown for capacity building

Level 1: Diversified targets. If the goal is diversifying targets to benefit from any formal (governmental-based) or informal (community-based organization) learning programs initiatives should also include people working in small enterprises, rural industries, the informal economy, self-employment, unemployed, and irregular or precarious employment. Given the diverse nature of the competencies required, a variety of local, national, and international stakeholders need to be involved. Agenda 2030 also highlights the relevance of local institutions and civil society organizations, as well as international cooperation and partnership, to support national plans and create networking among competent people. By expanding the original subdivision proposed by IRENA, three major categories – individual, organization, and government – and within them, a further breakdown (youth, municipalities, and ministries) – a more ready-to-use taxonomy may be drawn (**table 1**). It is worth underlining that different players could be both targets and beneficiaries for capacity building actions – for example, women trained in certain energy areas can also contribute to spreading technology within their families and local community.

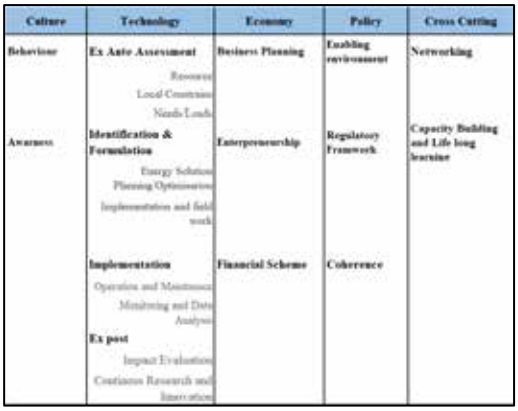
Table 1: Level 1: Diversified targets

Individuals	Organisation	Government
Youth Citizen Educators Technicians Researchers Enterprenours Prosumers Public Officers Civil Society operators	Public bodies (municipalities, local authorities) Private Sectors (SMSs, cooperatives..) Civil society organisations	National entities (ministries, national authorities) Regional level (overarching organisation, networks)

Level 2: Comprehensive approach and life-cycle perspective. People are the catalyst and the global driver of change, and technological solutions need to be designed to meet today's and tomorrow's capacity requirements. A good way to do this is with a life-cycle perspective that links skills with labor needs. By establishing solid bridges between the labor market and vocational training and skills development, capacity building becomes more effective and can contribute to closing the gap between job opportunities and required skills. Moreover, beyond the technological capacities and competences linked to the implementation phase of any energy access project, capacity building encompasses a comprehensive approach, including the country's human, scientific, organizational, and institutional capabilities. The goal is to enhance the ability of a country or a body (or a project consortium) to evaluate and address crucial questions related to the economy, finance, and enabling policies – such as a full understanding of potential environmental and social impacts. Monitoring, evaluation, and accountability are key to significantly increase the availability of high-quality, timely, reliable, and disaggregated data and their ex-post analysis. This facilitates designing appropriate corrective measures and

pursuing knowledge-based local research and innovation to ensure local ownership and thus the long-term sustainability of energy access initiatives. For level 2 a taxonomy with five main categories is proposed: **cultural, technological, economic, political, and a cross-cutting dimension** (**table 2**).

Table 2: Level 2: Comprehensive, life-cycle approach



Culture	Technology	Economy	Policy	Cross Cutting
Behaviour	Ex Ante Assessment	Business Planning	Enabling environment	Networking
Awareness	Identification & Formulation	Enterpreneurship	Regulatory Framework	Capacity Building and Life long learning
	Implementation	Financial Scheme	Coherence	
	Ex post			

Level 3: A mix of strategies and teaching tools. Countries should pursue their strategies based on national priorities on capacity building – and whenever available embedding capacity building components within all the existing projects and enforcing national or regional coordination. It is also crucial to promote individual actions following a decentralized and project-based approach for activities that are part of existing projects at the country level. For access to energy, our level 3 combine traditional or participative education, and learning by doing (**table 3**).

Table 3: Level 3: Mix of strategies and teaching tools

Traditional	Partecipate	Learning by doing
Lecture	Exposure	Assignment
Seminar & Workshop	Assignment	Joint project
Visit	e-collaboration	Technical assistance
e-learning	Project work	Tutoring on the job
Informative campaign	Business Case	Local, regional lesson learnt

These three levels can then be combined to help policymakers come up with a multi-level approach that combines targets, skills, and strategies/teaching tools.

Final Consideration

Achieving universal energy access is a long-term undertaking. 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.

Our approach based on three elements is now a reference also for the World Bank: (i) a mix of target groups, skills, and stakeholders; (ii) a comprehensive life cycle approach, within the energy supply chain; and (iii) a mix of strategies and tools that can be selected for the various targets and the expected skills to be generated or reinforced. This will facilitate the transformative change that is required to scale up access to energy and sustain local ownership, promote economic development, and ensure long-term impact.

Entrepreneurship Education in Ethiopia. Seizing the Opportunities of RES in Africa

This paper has been prepared by:

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Abstract

The article summarizes the goals and activities of UNIDO's Youth and Women Entrepreneurship Promotion Project (YOWEP)". YOWEP is a joint effort of Fondazione Giacomo Brodolini and LUISS Business School funded by AICS, the Italian Agency for Cooperation and Development and by the Austrian Development Cooperation, aimed to supporting entrepreneurship capacity building in Ethiopia. As Ethiopia and Africa will start to leverage on their energy potential, new entrepreneurial opportunities will arise. It is important to help these countries to be ready to seize these opportunities.

Introduction

Entrepreneurship education has the aim of promoting entrepreneurial development and business venture creation, thus contributing to the economic growth of countries. The scope of entrepreneurship education is however much wider than training on how to start a business, as it includes developing an entrepreneurial mindset, a set of skills and attitudes like creativity, self-confidence, initiative, project management, among many others, which can be applied in every organizational setting (European Commission, 2004). No wonder that entrepreneurship education has been included in several government's policy agenda, including African Governments.

In the context of Africa, entrepreneurship education and RES diffusion can be reciprocally advantageous. Entrepreneurial skills are key for developing the RES supply chain. At the same time, RES Solutions

represent the basis for the development of many other off-grid businesses, either traditional (as the agribusiness) or more innovative (as the internet companies).

This article reports the results of a UNIDO project of entrepreneurship education in Ethiopia, funded by AICS, the Italian Agency for Cooperation and Development and by the Austrian Development Cooperation. The project, entitled "Youth and Women Entrepreneurship Promotion Project (YOWEP)" is being carried out by a Consortium composed of Fondazione Giacomo Brodolini and LUISS Business School – a Division of LUISS Guido Carli University.

The project

YOWEP's main goal is to assist the Government of Ethiopia in its efforts to create employment for women and youth through the promotion of investment in the productive sectors of the economy, entrepreneurship development and women's economic empowerment.

The development of micro and small and medium enterprises is a priority for the Government which is reflected in the 5-year Growth and Transformation Plans (GTP I 2010-2015, and GTP II). In order to increase the job opportunities and the creation of new business ventures the project aims to develop entrepreneurial skills in the target group.

Main tasks of the project are:

- Developing training materials (a toolkit) for entrepreneurship development
- Mapping and assessing capacity of the Ethiopian entrepreneurship development institutions to adopt and implement the training packages.
- Training of trainers in order to assist the Ethiopian institutions in delivering the entrepreneurship education program.

Entrepreneurship education in Ethiopia

Even if the economy has experienced a robust growth over the past decade, averaging 10.8% per year in 2003/04—2014/15 compared to the Sub-Saharan Region average of 5.4%, developing and conducting a business in Ethiopia is not an easy task, according to The World Bank yearly report Doing Business (2017): starting a business, dealing with construction permits, getting credit, *getting electricity* are among the most cited challenges for the Country's entrepreneurs. The need for RES, entrepreneurship support policies and education is therefore a key strategic issue in this country.

The Government put entrepreneurship education at the center of its policy agenda. The final goal of GPT I was to transform Ethiopia into a middle-income country by 2025. Among the many policies identified in the Plan to achieve this goal there is the accelerated training of 10,000 trainers who in turn will provide capacity building on entrepreneurship. Similarly, the GTP II recognizes the strategy importance of developing an entrepreneurial culture. In 2013 the Government, in partnership with UNIDO, launched Ethiopia's Entrepreneurship Development Program. The Prime Minister's launch speech highlighted the importance of entrepreneurship education for the Country: "Without the development of entrepreneurial skills by hundreds of thousands of our youth, the kind of equitable distribution of wealth that the government is very keen on achieving cannot be realized. And the

country's industrial development will be stunted without the required entrepreneurship skills and enterprise". Under this Program, a national Entrepreneurships Development Center (EDC) has been established to guide the development of entrepreneurship education in the country. EDC's focus is the Train of Trainers (ToT), especially University Professors that teach entrepreneurship programs, and supporting the development of Entrepreneurship Centers of Excellence in higher education institutions dedicated to entrepreneurship education and business development services.

Notwithstanding these efforts, a recent study (Mudde, Gerba & Chekol, 2015). Found that entrepreneurship education and entrepreneurial activities are at their infant stage at Ethiopian universities. Lack of strategy, organizational capacity, innovative teaching methodologies, student demotivation, low cooperation with businesses are the main problems.

Concerning pedagogical issues, another study (Gerba, 2012) gathered information from 16 public Ethiopian Universities and 76 entrepreneurship instructors. Most of the respondents (92%) had not conducted research in the field of entrepreneurship nor had a special training or specialization in that area (72%). The teaching methods used are class lectures (100%) followed by reading assignments (59%), a business plan preparation project (54%), class discussions (41%), case studies (20%), research project (16%), lectures by prominent entrepreneurs (164%), and site visits to prominent entrepreneurs (8%).

In our project's need assessment phase, these issues emerged very clearly:

- All the university representatives approached confirmed that methodologically most of the entrepreneurship courses in Ethiopia are based on lectures and partly on the development of a fictional business plan. Teachers usually do not engage students through more participative methods, such as laboratories, simulations, case studies, role playing, exercises. A representative of the Ethiopian Youth Federation declared that curricula do not inspire young students to become entrepreneurs.
- Representatives from some Departments, except Management and Industrial Engineering, felt that their entrepreneurship teachers lacked also the experience and the knowledge of the contents too.

University-Industry Collaboration in Ethiopia

Another major issue concerns the collaboration between Universities and the businesses. Universities should play a pivotal role in providing a highly qualified workforce and a stimulus to science and innovation. Alongside their traditional roles of teaching and research, universities need to play a greater role as facilitators of community development and local entrepreneurship by engaging with local businesses and society.

The literature on University-Industry Collaboration (Rajalo and Vadi, 2017; Bruneel, D'Este and Salter, 2010) has identified several benefits of University-Industry Linkages (UIL). Collaboration between universities and industries is critical for skills development (education and training), the generation, acquisition, and adoption of knowledge (innovation and technology transfer), and the promotion of

entrepreneurship (start-ups and spin-offs). Industries collaborate with Universities in order to access well-trained graduates and knowledgeable faculty, access to basic and applied research results, get assistance in continuing education and training and foster Corporate Social Responsibility activities.

In recent years, the Government of Ethiopia has strongly promoted UIL. In particular:

- Ethiopia's First and Second Growth and Transformation Plan (GTP 1: 2010-2015) put university-industry linkages at the center of the strategy to make Ethiopia a middle-income country by 2025.
- The last 2010-2025 national Science and Technology Innovation (STI) policy, developed in 2010 and specifically based on the GTP, focused on realizing these policy objectives: (i) Create a general governance framework for coordinated and integrated STI capacity building; (ii) Establish a framework for technology accumulation and transfer; (iii) Develop adaptive research that is geared towards rapid technology transfer and adaptation; (iv) Develop and commercialize traditional knowledge and technologies; (v) Define the national S&T landscape and to strengthen linkages among the different actors in the national innovation system; (vi) Ensure integrated implementation of STI activities with other socioeconomic development programs and plans and activities; (vii) Support mechanisms to progressively increase private sector participation in financing innovation.
- The Ethiopian Higher Education Proclamation No. 650/2009 Article 25(5) includes UIL as a strategic priority of Ethiopian Universities: "Every public institution shall have the responsibility to forge relations with industries for mutual benefits and on the basis of principled and transparent negotiations and agreements."

A study of four Ethiopian Universities (Ayenew, 2015) reports that UIL is still at an early stage. Internship is the main form of collaboration with industries. Consultancy services, research and trainings are the other forms of interaction between universities and industries, where civil engineering and mechanical engineering departments are the main actors in this area. Lack of laboratory facilities, inadequate infrastructures (like communication, transport, journals, books, etc.), time constraint due to heavy teaching load and lack of strong industry linkage offices are identified as the main barriers for collaboration with industries.

Mudde, Gerba and Cheko (2015) identified these issues in the interactions between Universities and external stakeholders in Ethiopia:

- Lack of readiness from the side of the university to engage external stakeholders, especially the private sector;
- Lack of effective staff incentives mechanisms;
- Lack of interest, awareness and initiative from university management but also within the business community on the opportunities of cooperation;
- Lack of trust on the expertise and knowledge of the university from the business community;
- Reluctance of stakeholders to come to the university when they are invited;
- Reluctance of stakeholders to support students in internship and research work
- Mismatch in perception of pricing of university services: stakeholders expect

low prices because of the community service obligation of the universities.

The needs assessment we performed in the UNIDO Project confirmed this situation:

- U-I linkages often lack a strategic orientation: there might be some contingent partnerships with separate companies or formal agreements with industry associations (chemical, mechanical industries) but there is not a continuing and wide collaboration.
- U-I linkages are mostly targeted towards placing students in internship programs. In some cases, most of the UIL Office time is devoted to this, thus leaving no much time for developing more strategic types of collaborations.
- The involvement of industries in curriculum design is quite rare. University education curricula and training programs are often not aligned with industry needs, creating a mismatch between what firms need and what graduates have learned. Firms themselves show a low interest in skills development within firms, because of their focus on low-technology intensive production activities.
- The involvement of practitioners in classes is very rare in entrepreneurship classes.
- The coordinators of University incubation and Entrepreneurship Centers we met described training and supporting potential entrepreneurs as the main activities but more work needs to be done in connecting start-ups with potential investor companies or industry partners.

Activities and recommendations

Based on the need assessment phase, the project developed materials for an entrepreneurship curriculum which had the following features: broad enough to include all the relevant issue in entrepreneurship education; designed to foster interaction between students and teachers, thorough the analysis of case studies, exercises, simulations, games; structured in modules and submodules, on order to give the trainers the flexibility to adopt selectively the contents.

Another major issue we needed to address, based on the situation assessment, was the pedagogical preparation of instructors. LUISS teachers developed and delivered therefore a 5-day class on entrepreneurship education methodologies. The main goal was to help the trainers to balance theory with practice, traditional lectures with exercises, case studies, simulations, problem-based learning and other engaging activities. Also, a goal of the class was to help trainers to take into consideration not only business and technical skills, but soft skills too (defined as capabilities and behaviors to act entrepreneurship).

Further activities have been considered necessary but could not be included in the project. However, we identified the following activities for a future project:

- Supporting Universities in the organization of entrepreneurship education. Many Universities we met need a strategic and organizational orientation for entrepreneurship education. In other words, they need to become themselves entrepreneurial universities in fostering entrepreneurship education. In particular, there is the need for a different approach in “marketing” the course to students and teachers. Teachers and students need to change their mindset

about the course. The main goal of the entrepreneurship class should not be "to create more entrepreneurs". This short class could not achieve this daunting goal. Rather, the real goal should be to spread an "entrepreneurial mindset" that could be beneficial to igniting in students the passion to become entrepreneurs themselves or to give them the entrepreneurial skills to succeed event if employed in business and public organizations.

- Supporting Universities in the development of linkages with the businesses. Collaboration with industries allows the possibility to involve entrepreneurs and managers as lecturers or testimonials, to create opportunities for internships and employability, to generate additional revenues from company grants, consultancy activities, technology transfer, and even to develop start-ups thanks to partnership with financing institutions. In particular, in the RE sector, new opportunities arise as Ethiopia and Africa will start to leverage on their energy potential.

Conclusions

The project, which will be concluded in the end of 2017, has brought to light some important aspects that need to be considered in fostering capacity building for RES in Sub-Saharan Africa:

- RES may radically change the context of local businesses and universities by providing access to energy sources. RES providers may fill the gap in University-Industry Linkages by engaging entrepreneurship scholars and students in educational programs, technology transfer, development of entrepreneurship centers and incubators. With the new access to RES, new business ventures will be possible. Universities may dramatically improve their results in terms of student employability by leveraging with these new opportunities.
- In order for this to happen, both university scholars and students need to change their mindset. University students, even if represent the most educated pool of human resources in the territory, are neither generally inclined to start an entrepreneurial career nor aware of the usefulness of entrepreneurial skills in their own lives. University scholars feel overwhelmed by the task of teaching entrepreneurship. They need support in order to become entrepreneurial themselves in teaching entrepreneurship.

In both challenges, projects like the one we were involved in can make an impact by creating opportunities and transferring experiences otherwise difficult to develop locally.

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RES and energy storage: new opportunities for emerging markets

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Abstract

Renewable Energy Sources (RES) are a fast and reliable way for providing energy for countries under fast development, and represent a competitive and economically sustainable solution when in presence of abundant natural resource, which is typically the case of such countries. On the other hand, in a context of increasing RES penetration that is becoming more and more common in many countries around the globe, the random and non-predictable electricity production coming from renewables can affect grid management bringing: (i) Unbalance issues; (ii) Increase of power flow on critical section of the grid; (iii) Regulation issues due to lower system inertia and lower regulating capacity compared to traditional generators scenario. Thus new solutions to increase grid safety and reliability as well as a better exploitation of green generators are required. In this context Energy storage -sometime as part of integrated hybrid generation systems - providing the possibility to receive and store electrical energy and release it in a different moment with controllable time delay and power modulation, can help to solve grid congestions thus resulting to be a mandatory asset for grid sustainable and safe development. Moreover, this ability can be even more useful in presence of weak grids in remote areas. In the next paragraphs, an overview of technology, applications and current regulatory frameworks together with the description of some projects already deployed will be presented.

Technology overview

Energy storage is not a single technology, but rather refers to a suite of diverse technologies. Due to the wide range of technologies, it is important to begin by outlining the types of technologies which can be deployed.

- Pumped hydro energy storage (PHS)

Pumped hydro energy storage has dominated energy storage for over a century. The vast majority of current installed energy storage capacity comprises PHS technologies. The operating principle is simple and efficient. PHS stores and generates electricity by moving water between two reservoirs at different elevations. During off-peak periods an electric motor drives a pump or pump turbine, which pumps water from a lower reservoir to a higher storage basin. When electricity is needed, the water is directed downwards through turbines.

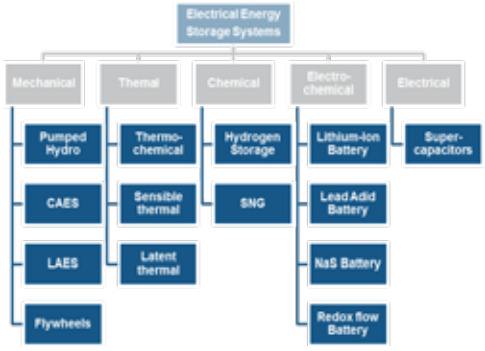


Fig. 1 - Scientific categorization of storage. *Source: PwC, 2015.*

- Compressed air energy storage (CAES)

This technology shares some characteristics with PHS in that it is mature, commercially viable, can provide significant energy storage at relatively low cost, and also has topographical constraints. However, compared to PHS, its contribution to large-scale energy storage is less significant: the only commercial plants are a 321MW plant in Huntorf, Germany, and a 110MW plant located in McIntosh, USA. A new 330 MW project is being developed in Northern Ireland. CAES utilizes off-peak electricity to compress air, usually at high pressures, for storage in geological structures such as mines or aquifers, salt caverns, and aboveground pressure vessels. The compressed air is then released, preheated and used to drive a turbine-generator system, to produce electricity when required.

- Liquid air energy storage (LAES)

Sometimes referred to as Cryogenic Energy Storage (CES), LAES is a promising storage alternative to CAES and PHS, currently at the demonstration stage. It is not prone to geological constraints or public resistance. Air is compressed and cooled in a refrigeration plant, using cheap, off-peak energy, and stored in a relatively large insulated tank or vessel. This liquid air is then converted back to gas, expanded in volume, heated and used to drive a turbine to generate electricity on demand. It can be particularly suited to locations where there is a source of low-grade heat or cooling, such as an industrial process.

- Flywheels

Though flywheels have been in existence for decades, they have only recently gained attention for large-scale stationary energy storage. They store kinetic energy in rotating discs or cylinders, suspended on magnetic bearings. They are suited for applications requiring high power for short periods, and require little maintenance, compared to other storage technologies.

- Batteries

These depend on chemical reactions that occur between the electrodes and generate a

flow of electrons through an electrical circuit. Whilst these electrochemical devices have been used for energy storage since the 19th century, they have mostly found use in small-scale applications, such as mobile power sources, and in the automotive industry.

However, the growth of electric vehicles and the need to integrate renewable power technologies such as solar and wind are driving huge investments in the development of battery technologies.

Currently the leading technologies in service is lithium-ion, but many other possible battery chemistries are in development or in the research phase, and could well supersede these for specific applications. For example, flow batteries store the electrolytes separately from the electrodes, and therefore storage capacity can be increased by increasing the volume of the storage tanks.

Anyway, latest years clearly showed Lithium based technologies gaining majority of market share for Renewable Integration applications and for fast ancillary services for grid support - thus for the majority of Energy Stationary Applications - and this happening thanks both to impressive technological improvements (in terms of lifetime, energy conversion efficiency, and response fastness) and to fast decreasing cost, which have been in the range of 15 - 30% YoY (depending on the application), this last item due to synergies with consumer electronics and most recently to the rise of Electric Vehicles industry.

Batteries from electric vehicles which no longer meet the requirements of this application may well still have a 'second-use' in static applications, as detailed later in a dedicated chapter.

- Superconducting magnetic energy storage (SMES)

SMES stores energy in the magnetic field of a coil. The coil is superconducting in order to reduce the electrical losses, and therefore requires a cryogenic cooling system. The response time is extremely fast, and the technology is suited for short-term power applications such as improving power quality.

- Supercapacitors

Supercapacitors are an established technology which stores much more energy per unit volume or mass than traditional capacitors. The response time is extremely fast. The costs per unit of energy storage capacity are higher than for batteries, though supercapacitors can withstand much higher numbers of charge/discharge cycles. Supercapacitors therefore are suitable for very short-term power applications.

- Hydrogen

Power to Gas (PtG or P2G) uses electricity to create hydrogen by electrolysis. Hydrogen can be stored as gas under pressure or liquid at low temperatures. It can then be used to create electricity in conventional reciprocating engines, gas turbines or in fuel cells, though in many cases it may be better to use the gas for industrial uses, space heating or transport.

- Synthetic Natural Gas (SNG)

Hydrogen can be converted into methane (SNG). The main advantage in the context of energy storage is that the amount of hydrogen that can be tolerated in existing natural gas infrastructure is limited (of the order of 10% depending on technical characteristics of the infrastructure). There is no such restriction on the amount of SNG that can be injected into existing gas infrastructure. Methane, being a larger

molecule, also has lower leakage losses than hydrogen.

- Thermal Energy Storage (TES)

There are three fundamental forms of thermal energy storage:

- Sensible thermal storage - increase or decrease of temperature of a storage medium, such as water, oil, rocks or concrete.
- Latent thermal storage - phase transformation, e.g. molten salt, paraffin, or water/ice;
- Thermochemical storage - a reversible chemical reaction, which is energy demanding in one direction and energy yielding in the reverse direction (sorption and thermochemical), such as silica gel, zeolite, metal hybrids, or zinc.

Thermal storage can be used to produce electricity, by producing steam for a conventional thermal power plant. However the heat can also be used directly in industrial process or for space or water heating; this clearly requires less plant and avoids conversion losses, though the value of heat is substantially lower than the value of electricity.

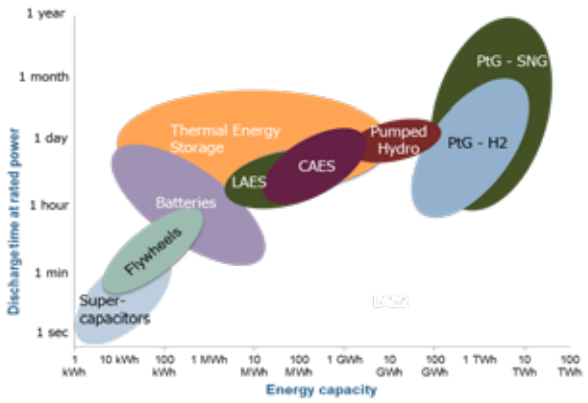


Fig. 2 - Mapping of storage technologies to performance characteristics.

Source: PwC, 2015, following Sterner et al. 2014

Note that thermal storage can also be used to provide 'cold', and this is currently a growing market for energy storage in the form of ice for deferring air-conditioning loads.

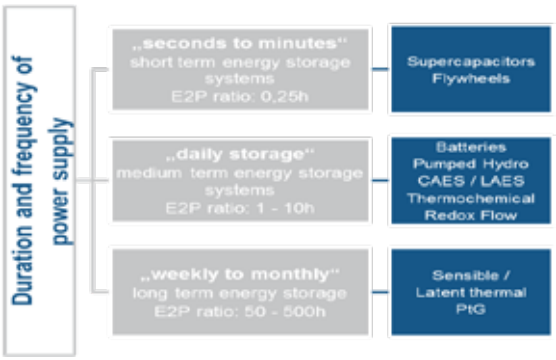


Fig. 3 - Duration and frequency of power supply.

Source: PwC, 2015, following ISEA Aachen, 2012 (*)

The application of energy storage can roughly be placed on a continuum of power and energy. In general, energy applications are defined as those that need a continuous supply of energy over a considerable length of time. In this case, the total energy flow is more important than the magnitude of the charged or discharged power. Typical energy applications include peak shifting, energy arbitrage, etc. In contrast, power applications require fast injection and absorption of energy, but durations for such operation are usually shorter. Power applications include frequency control, and ramp rate control for intermittent renewable generation. Electricity storage applications can usually be viewed as either primarily energy or primarily power applications, and this categorization can be applied to technologies as well, using the E2P ratio, also known as Discharge Time. If the E2P ratio is about 0.5 h

or less, the technology can deliver or absorb significant power over a short time, such as flywheels, supercapacitors or, nowadays, many types of Lithium batteries. If the E2P ration is about 4h or greater, the technology can sustain energy delivery for a much longer period, like certain batteries, especially flow batteries. In addition, two large-scale technologies (pumped hydro and compressed air energy storage) are capable of providing significant levels of both power and energy, however they usually should be categorized as technologies suiting energy applications. Since each storage technology can serve a range of applications, other factors should also be considered for a detailed classification, like round trip efficiency, cycle and shelf life, and other physical limitations.

Battery Cost projection

Cost information and projections for stationary battery packs are less available than comparable information for automotive batteries due to less spread, production and scale economics. There are numerous storage systems available on the market to match domestic 3 kW power plants. Table 1 shown the costs of these systems that, although using different types of batteries, have a storage capacity of about 10 kWh. Costs are quite different comparing systems with same storage energy: nevertheless it is important to specify that it is often not enough to compare the battery convenience by dividing their cost by nominal stocked capacity at full charge (i.e. $ per kWh capacity). Although this method may be useful for comparing batteries of the same type by brand or model, the same estimation can be inaccurate and misleading when comparing batteries with different operating principles or, in the same type, with different chemistry. In order to improve the estimation, a more appropriate valuation method, i.e. Cost of Stored Energy (CoSE), needs to be introduced. It is necessary to divide the battery cost for the total amount of stored energy throughout the battery life. This parameter returns a value much closer to the real cost of energy storage in batteries. The total stored capacity throughout the battery usage period can be calculated by considering the nominal storage capacity, the cyclic battery life and the depth of discharge for each cycle, and the capacity loss upon cycling.

Using this data, CoSE was calculated for the five different commercial systems reported in Table 2 (see appendix). At same price and technology the BYD system is cheaper than the LG system, as the CoSE is lower. Much more widespread are the cost information on automotive batteries, which allows for some cost-cutting considerations as a consequence of market diffusion. In fact, the costs vary not only depending on the type of battery used but also depending on the production volumes. The cost of lithium-ion battery for hybrid auto plug-in was dropped from about $ 1000kWh-1 in 2008 to $ 268kWh-1 in 2015, -73% in seven years, while the goal is to reach a cost of 125 $ kWh-1 by 2022 (an additional - 58% in seven years). Other studies estimate significant cost reductions: CE Delft estimates reductions from $ 600 kWh-1 in 2012 to $ 320 kWh-1 in 2020, up to $ 210 kWh-1 in 2030. On this basis, a lithium-ion of about 324 kWh (i.e. useful for running an electric bus) could cost about $ 100,000 by 2020, with further reductions expected for 2030.

Electric vehicle batteries get second-life with ESS

The electric vehicle (EV) market has blow-up in 2017. EVs sales are growing up rapidly and consequently also the quantities of used batteries. Cost reduction in Li-ion batteries has enabled this revolution. Car companies

and researchers are now studying how to reuse those exhausted batteries after they are used in EV. This is the common environmental criticism of EVs, and an important issue about the destination of these used batteries.

Second-life is the term used for when a retired or used EV battery is converted for use in an energy storage project. This process includes the following stages: retired batteries recovery, performance evaluations, and batteries pack reorganization, second use in energy storage system, and batteries disposal and recycling/reuse.

EU Regulations, require the makers of batteries to finance the costs of collecting, treating and recycling all collected batteries, are already encouraging tie ups between carmakers and recyclers. The fundamental problem is that the cost of recycling a battery is around €1 per kilo, the value of the raw materials that can be reclaimed is only a third of that. Cost of recycling is the current barrier, and rather than be recycled, it is useful to reuse it. The lack of recycling capacity is a real problem and for this reason lot of carmakers thinks the answer lies in reusing rather than recycling EV batteries. These batteries can still have up to 70%-80% of their capacity. Therefore, after broken down, tested and repackaged they are perfect for functions such as energy storage.

The batteries world is constantly innovating, and a second-life EV battery is an economical choice. This increasing Li-ion demand will help to continue to lower energy storage costs. Cost reductions from adjacent markets such as battery powered electronics like EVs and large scale renewable energy growth such as solar and wind are paving the way for increased storage, while regulation around grid stability and renewable adoption has been extremely inviting as well.

There are markets around the used batteries and it is still not clear what benefits from that trade.

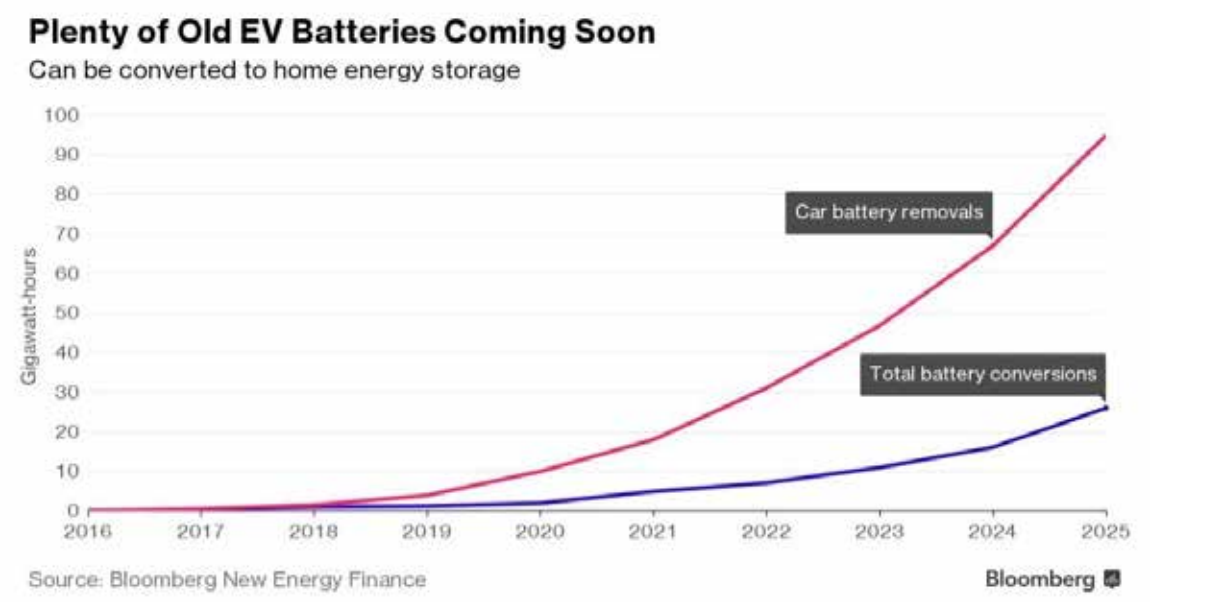


Fig. 3 - BNEF forecast of used battery availability and estimated volumes for a second-life in stationary energy storage 2016–2025 (GWh).
Source: BNEF

Forecast from Bloomberg New Energy Finance (BNEF) estimate volumes around 95 GWh of available used Li-ion EV batteries in 2025 that exceeds the size of the current stationary storage market, and probably 25 GWh will be reused in stationary EES.

All rechargeable batteries have a limited life. Li-ion batteries are common in EVs and its life is about 2000-3000 charge-discharge cycles. Li-ion batteries designed for EVs need high energy density to maximize range while minimizing weight. At the end of its useful life these batteries don't die completely. They just reduce its capacity making them unsuitable for EV usage but they can maybe get a second-life as stationary energy storage systems.

This second-life Li-ion battery is a complex and sometimes expensive process. To reuse them in other applications is not as simple as removing EV batteries and then installing them directly into a stationary system.

Before beginning its second life however each individual battery must be evaluated. To help ensure that EV batteries are safely deployed in their new applications, UL is developing the safety standard UL 1974 that will aims to provide users with confidence that a used EV battery will function effectively in a residential, commercial or utility-scale storage application.

UL is developing the safety standard with input from carmakers, electric utilities and academic institutions. Source

The battery must be manually removed from an EV and the pack disassembled into individual cells. Then, these cells must be tested to determine the battery's state of health, sending batteries without sufficient remaining capacity to be recycled. Even within the batteries suitable for reuse, cells must be sorted by similar remaining capacity, or else the second-life system performance would suffer. These are labour and energy intensive processes, but efforts in both academia and industry are underway to reduce costs. Introducing automation in the process will reduce time and labour costs, as will convince battery manufacturers to use easy design for disassembly.

There are a number of invaluable partnerships on both the supply and demand sides of the process. Fostering relationships early on in the development of energy storage systems (ESS) with original suppliers such as Li-ion battery manufacturers and policymakers is the key to a lean, reliable supply chain.

At the moment, there are some limitations to our current understanding of the second-life battery opportunity because few vehicles have reached the end of their life; there isn't a clear indication of how much remaining capacity can be expected from these batteries after typical use. EV manufacturers by using more standard battery components could help to second-life users, and the design of the original EV battery can also minimize the cost of converting it for stationary storage. Pricing for second-life batteries are already very compelling with prices of €100 - 150 per kWh available and as EVs ramp up increasing numbers will come to the market.

There are different alliances and joint ventures, deals and solutions with large EV automakers advancing second-life usage including Nissan, General Motors, Daimler, BMW, and Renault.

Overview of the EU grid codes to point out best practices for emerging countries

National grid codes are used to define the electrical performance requirements of generating assets, operational and dispatch rules, and the technical requirements for interconnection to the grid. Appropriate grid codes updated can considerably reduce potential adverse impacts of grid-integrated variable RE.

During the last few years generation from renewable energy sources (RESs) has grown considerably in European electrical networks. Transmission system operators are greatly concerned about the impact of RESs on the operational security and efficiency of their networks and more in general of the ENTSO-E interconnected system. Grid codes are to be revised in order to harmonize the rules regarding the connection of RES power plants. A main issue concerns frequency control: frequency is greatly affected by RESs intermittency and its deviations must be limited as much as possible in order to guarantee a suitable level of power quality. To improve frequency stability, in the future, Grid codes could extend frequency control requirements also to RES units, whereas today they are applied only to conventional power plants. Energy storage systems can be a possible solution to increase the flexibility and performance of RES power plants: they allow generators to modulate their power injections without wasting renewable energy. In this paper, the authors studied the suitability of extending frequency control to RES units integrating them with energy storage systems. In particular, the paper focuses on the impact of frequency control on the storage lifetime by analyzing the power charge/discharge in response to real frequency oscillations. Actually, Grid codes set the rules and technical requirements for power system and energy market operation. The different types of grid codes facilitate:

- The operational flexibility;
- Operational stability;
- Security and quality of supply;
- Well-functioning wholesale markets.

In order to counteract this kind of problems, national and international authorities updated their standards and grid codes regarding the connection of active end users to distribution networks, including both distributed generations and Energy Storage System (ESS). Changing and evolving grid codes are necessary for changing and evolving grid supply and demand.

Grid codes traditionally focused on static reactive power control, power factor and dynamic requirements such as low voltage ride through capability. The codes are now evolving into more demanding requirements including dynamic control of reactive power, voltage and frequency at the point of connection, and power quality. To create these new functions, each interconnection code and technical rule must be analyzed for similarities and differences in data requirements, specified curve shapes and default values. Lately, storage industry is always looking for a quick solution but it must take around one year for implementation plus another one for network code changes. The grid requirements and codes are applicable in different area; though most of them were originally developed for generating systems and only a subset of these include specific function for ESS and battery energy storage system (BESS).

Creating grid codes on the consumption side will help improve the storage system development scheme. For countries with

stringent grid codes, electricity storage can ensure that renewable power generators meet the required conditions. In order to counteract this kind of problems, national and international authorities updated their standards and grid codes regarding the connection of active end-users to distribution networks, including both distributed generation and electrical ESS.

Regardless of all the potential positive benefits discussed, ESS still requires careful analysis of the costs and benefits issues. The introduction of ESS as a grid code requirement should be done in order to give freedom of choice to the power plant owners or the grid operators as regards the technology that matches the desired application.

Harmonization of standards, grid codes and testing procedures

The Electricity Directive regulates the unbundling of Transmission System Operators, Distribution System Operators and the functions of electricity generation and supply. As energy storage is not mentioned in the Electricity Directive, the position of energy storage in relation to the unbundling requirements is not clear. As a result, electricity storage is generally regarded as a generation system. The Directive also specifies that a TSO cannot "directly or indirectly exercise control or exercise any right over any undertaking performing any of the functions of generation or supply" of electricity. A grid code serves the mission of defining the physical connection point requirements to be followed by energy production equipment in order to be connected to the grid; in addition a Regulatory framework defines the requirements for permanent connection and the relevant network parameters to be supported, in a way to secure system operation. The introduction of ESS as a grid code requirement should be done in order to give freedom of choice to the power plant owners or the grid operators as regards the technology that matches the desired application. Grid codes and requirements must be aligned with the technical capability of the participating technologies. Care must be taken to ensure that new grid codes do not create barriers for new entrants, and that over specified requirements do not lead to an oversupply of services beyond what is actually required. Developing national and international standards for ESS are now essential and vital for the cost effective generation of this alternative power, and to the growth of grid-scale ESS. By using ESS it's possible to feed power to the grid so that production need not be scaled up and down repeatedly to adjust to changing demand levels. These systems also absorb the over generation from wind and solar power facilities and release that power when needed.

The goal of some organizations, alliances or laboratories is to accelerate harmonization of standards, grid codes and testing procedures to carry out interoperability, scalability, safety, quality, availability, and affordability in energy storage components and systems. ESS must be intelligently plugged into the utility's existing information and operations technology. Without established standards, components and systems will come with proprietary connectors, and the process of plugging them together becomes a laborious task repeated for each new project, which will add to project cost and lead time. Hardware that makes up an ESS: batteries, power converter system (PCS), metering system, and the energy management system (EMS) can be intelligently plugged into each other and the electrical system. One of the

most important processes is standardize communication and connections, which will accelerate interoperability and scalability of ESS. Also, reduce engineering costs, enabling a robust energy storage market, and improve standardization procedures for safety and efficiency. National and international standards and updated grid codes should be developed to reflect and to follow technology improvements and advances in control systems networks.

Regulatory aspects and harmonization of network codes are needed on national and international levels. Standards must help fully deployment of inverter based capabilities to mitigate voltage impacts on distribution systems and provide useful services to support bulk system reliability and performance. Structural and technical harmonization of grid codes are needed to address standards for new emerging technologies like as wind, solar, storage and so on; principally inverter based distributed resources. Cooperation between TSOs/DSOs and international organizations such as (IEC, IEEE, CENELC, ENTSO-E) is necessary and should be supported to improve harmonization of grid codes. In many countries and grid companies, different grid codes have been recently approved with the scope of defining the connection rules for passive and/or active end-users, updating their general grid codes, or developing separate standards documents such as requirements to meet the demands of fast-growing wind, PV power generation and ESS.

While there has been strong progress in EES in California, similar advance has not been observed in Europe represented by the UK, Germany and Italy. Australia, Europe and United States have experienced progressive renewable penetration during the past two decades. Environmental concerns and political regulations, in parallel with available technology, are the main drivers for the change. Transmission power networks are well interconnected, robust and dimensioned with sufficient reactive power margins and spinning reserve to be correctly balanced. In addition, well known operational and market rules exist. All EU Member States and other European countries have their own Energy laws and Network Codes. These are in a constant process of European harmonization. In general, there is no mention of energy storage in European electrical energy legislation or regulations; exceptions are Germany, UK and Italy. In Europe, electricity storage is increasingly recognised as being the vital tool to deliver the low carbon energy system efficiently and the European Commission are in the process of considering amendments to electricity market design.

Some generic principles should guide the future investment framework for storage:

- There is a need for a European legal and regulatory framework regarding general principles for storage;
- Storage should compete on a level playing field with other technologies, and the tariff structures should ensure neutrality of storage;
- Storage devices should not be restricted to a single service, as this would not be economically efficient;
- The TSOs should have access to data for central and distributed storage facilities for system security for all timeframes.

Progress has been made towards grid code harmonization in Europe, which has been a binding EU regulation since May 2016 and is in force under EU law. One of the elements of the Electricity Directive is the initiation of Agency for the Cooperation of Energy Regulators (ACER), which has developed the Framework guidelines on electricity

balancing directed at the TSOs. These guidelines do not specify any technology for balancing the electricity grid and leave the use of energy storage open. Also closer definitions will be needed in local jurisdictions for electricity storage to meet exacting local regulatory requirements.

The European Network of Transmission System Operators for Electricity (ENTSO-E) has published a the European network codes or grid codes for electricity balancing based on ACER's guidelines that includes the possibility for energy storage facilities to become balancing service providers.

There are a number of recent EU codes that already clearly make the distinction between generation and storage. In general, there is no mention of energy storage in European electrical energy legislation or regulations. Exceptions are Germany, UK and Italy.

The most recent versions of European standards report the recommendations for the connection of generating plants, CENELEC TS 50549-1 (LV) and CENELEC TS 50549-2 (MV) distribution networks, whereas CENELEC EN 50438 regulates LV micro generating plants with rated current under 16 A.

In Germany, the grid codes make no special requirements on storage; however it shall meet both the requirements on load and on generation, depending on its operation mode. In this context, reference is made to the technical guidelines of the German Association of Energy and Water Industries (BDEW) and association for electrical, electronic & information technologies VDE on integration of distributed energy resources and electrical energy storage. The BDEW at 2014 has proposed definitions of energy storage:

- An energy storage facility is defined as a facility which receives energy with the objective of storing it electrically, chemically, electrochemically, mechanically or thermally and making it available again for use at a later time.
- An electricity storage facility in the electricity supply system is proposed to be defined as an energy storage facility which receives electrical energy from a general supply grid, temporarily stores it and later feeds the released energy back into a general supply grid.

About market integration, the German renewable energy sources act (EEG) covers storage of RE source and the transmission code explicitly mentions storage as an option for the reserve/balancing power markets without mentioning other applications of electrical energy storage.

European network codes and market design packages may be important for electricity storage in the UK. In the UK, storage is explicitly mentioned in capacity market regulations. The UK National Grid held in 2014 a first capacity market auction which was also open for energy storage facilities Also, a recent service named enhanced frequency response is explicitly aimed at electrical ESS. In Italy, the ESS connected to the grid has to respect the regulation for the connection of a generator to the transmission/distribution grid. Italian grid codes CEI 0-16 (MV) and CEI 0-21 (LV) indicate technical rules for the connection of passive and active end-users to the network. Italy has stipulated that the TSO and DSOs can build and operate batteries under certain conditions. At the moment ESS connected to the grid have to respect the regulation for the connection of a generator to the transmission/distribution grid (Italian decree law 93/11). Italian network regulator

(AEEGSI) passed a decision on provisions related to the integration of ESS for electricity in the national electricity system (574/2014/eel) defining network access rules for energy storage.

However the TSO shall justify, through a cost/benefit analysis, that the ESS is the most efficient way to solve the problem identified (e.g. compared to building a new line). In any case the TSO should not receive remuneration higher than the (measurable) cost of alternative solutions. The installation of RE, particularly wind energy in the United States, has often required reinforcement of the transmission infrastructure. With regard to grid codes, there are some special provisions for renewable developers to comply with Federal Energy Regulatory Commission (FERC).

In USA, the 2017 edition of National Electrical Code (NEC) presents the latest comprehensive regulations for electrical wiring, overcurrent protection, grounding, and installation of equipment. Major additions reflect the continuing growth in renewable power technology; these items include dc loads, ac loads in stand-alone systems and battery storage systems.

In South America, the Middle East and Asia the networks continue to develop at the same time that a large integration of renewables is taking place, driven mainly by available technology, more accessible electricity prices, and investors bringing in successful experiences from other countries. The challenges of integration are:

- Stability issues due to limited margins of reactive power
- Lack of interconnection with neighbouring countries and limited spinning reserve
- Poor power quality levels due to low short-circuit ratios
- Networks generally weaker in the areas away from the main cities

For many power network providers, keeping up with the ever changing and increasingly demanding grid codes is a draw on resources. It takes time to keep up, and to interpret changing or new grid codes, and to then extrapolate how those codes may affect the situation and what may need to change in order to remain compliant. Changing and evolving grid codes are necessary for changing and evolving grid supply and demand.

As described above, Electrical Energy Storage

(EES) is a technology which can increase the reliability and resilience of the electrical grid, especially in the presence of unpredictable energy sources such as wind and solar. In particular, EES based on electrochemical batteries probably will continue to be the case over the next decade due to their versatility, maturity and declining installation costs. A large diffusion of EES, mainly based on electrochemical batteries, is expected to take place in the next future on both MV and LV networks. Recently, the integration of a Battery ESS (BESS) is investigated as an alternative solution instead of modulating the hydraulic power.

Both distributed generation units and ESS are required to contribute to the network stability; at the same time, in order to improve fault ride through capabilities, extended operating ranges have been introduced for voltage and frequency in the interface protection systems of local energy sources.

The ESS exploitation at the end-user level, in coexistence with distributed generations, is

encouraged by a variety of different advantages and opportunities, such as:

- The forecasted decreasing cost of storage systems with a future diffusion involving increased production capacity.
- Economic advantages for active end-users, enabling the optimal self-consumption of locally produced energy, alternatively to incentivizing mechanisms and so on.
- Levelling the distributed generation power production, both in terms of daily peak shaving function (PV generators, wind turbines, etc.).
- Opportunities in the participation of end-users to ancillary services markets
- Local supply of end-users in the case of distribution network outage.
- Contribution in supplying the load peak power, reducing the contractual value of admitted power absorption and consequently a consistent portion of the end-user bill.

The increased penetration of RE requires changes to the standards and grid codes to ensure that power grids remain reliable and robust.

Barriers to effective energy storage exploitation

Several studies have examined the barriers to energy storage in different countries. These barriers lead to cost allocation issues, distorted compensation mechanisms, lack of price signals and bureaucratic issues and delays. The regulation complexity are due to the large number of benefits that ESS provides to electric grid as energy services, ancillary services, transmission infrastructure services, distribution infrastructure services, and customer energy management services. Such a large number of ESS benefits have provided a wide market challenges, regulatory bodies and regulatory barriers.

The impact of regulatory bodies on markets, services, technology and stakeholders varies considerably between countries and/or regions. European Union has a significant regulatory role and many other authorities have an impact on the regulation of energy markets. Standards organizations naturally affect which kind of technology is being utilized.

It must be identified the barriers related to the legislation and standardization of electricity markets and related technologies. Legislation and standardization are discussed together because they are often closely linked. Though, they remain distinct as legislation is set and maintained by governments while standards are issued by standardization bodies, official and unofficial standardization bodies. This forms a quite complex field which requires careful consideration when developing new applications and business cases for ESS solutions. Lately, several barriers to the large scale deployment of ESS solutions have been identified. Regulation concerning the openness of competition between different technologies has been identified as a one of the most critical barriers. Barriers prohibiting market entry for ESS can be divided into three categories, covering the main factors limiting mainstream acceptance of energy storage solutions. The first category includes market barriers, which place limitations on ESS usage and the associated energy trading. The second category consists of technological barriers, which may limit widespread access to ESS solutions. The last category consists of legislative barriers, which are controlled by the current political climate in each target country. The main key

barriers can be categorized into no regulatory and policy clarity on the role of energy storage in long-term planning, the regulatory topics can be divided into the following categories which correspond to the areas where most of the immediate market barriers exist:

Regulatory compensation methods:

- Energy tariff structures,
- Investment support schemes for energy storage;
- Revenue compensation mechanisms for energy storage.

Regulation for marketplaces:

- Wholesale market structures;
- Ancillary markets and products for energy storage.

Regulation for technology:

- Standardization and technical requirements for storage;
- Grid connection legislation for energy storage;
- Smart metering, difficulty of measuring and monetizing the values provided by energy storage in the market.

The main key barriers can be categorized into no regulatory and policy clarity on the role of energy storage in long-term planning (a regulatory barrier), the difficulty of measuring and monetizing the values provided by energy storage in the market (a financial barrier), and a lack of market designs and business models (a market barrier).

Another regulatory barrier is in the classification of energy storage technologies. Different markets have different classification systems, and therefore, different compensation mechanisms. This variety adds a further burden to energy storage providers because they have to make separate business cases for each market. The varying classifications and corresponding differences in price complicate the situation for both energy providers and those operating in the other interconnect. Receiving proper revenue compensation for energy storage providers is problematic, especially in regards to providing ancillary services.

Sometimes, it is difficult to effectively compensate energy storage providers for ancillary services because they are often designed to only provide ancillary services and this is not considered by the national commission. Even for frequency regulation, which has mandatory compensation based on actual services for providers, the current framework could be incomplete at best; or sometimes national commission only mandates that grid system operators meet certain standards in compensation mechanisms and does not dictate specific rules. Therefore, different wholesale power markets have different compensation mechanisms, many of which are far from providing just compensation to providers. Certain technologies are much faster in responding to frequency regulation needs than others. However, in the absence of prices for ancillary services, it is often difficult to evaluate a provider's proposal that includes ESS. Parties cannot look to other wholesale markets to estimate revenue streams.

Scenario in African regions

Focusing on Africa's region all the topics previously discussed have to be correlated with the specific politic and economic contest; actually in such a region the EES market is limited by the barriers listed in the following:

- Limited renewable energy development;

- Limited local technical expertise and underdeveloped grid infrastructure;
- Political and/or economic instability, and access to affordable financing;
- Highly regulated, state-run energy markets;
- Low-cost fossil fuels.

Focusing on South Africa, in recent years a significant effort has been applied for the deployment of energy renewables: PV, wind, and in particular CSP with thermal energy storage. Around 1.6 GW of grid-tied energy storage has to date been installed and 1.4 GW of this storage comes from pumped hydro storage; but South Africa would be expected to be the largest market for energy storage for hybrid systems, because the integration of renewable generation is likely to be the key driver for energy storage. The level of government support is raising to new renewable energy technologies. Some studies have estimated the increase of 25GW of wind and solar capacity by 2025, including some energy storage systems to improve power supply and to reduce the frequent outages in this area. There are ideal applications for nano-grids and micro-grids.

Due to decrease in price of the energy storage systems, this new technology will be included in remote power systems that are expected to provide about 70% of energy services over the next years given the lack of grid connectivity. There are no plans for large scale battery storage coupled with PV in the South African utility market, and neither have any of the several proposed plans or studies for the development of the electricity generation network seriously considered storage as a component. Currently the only coupled storage systems are those associated with CSP plant.

Opportunity for energy storage in Africa

Current Africa's weak power infrastructure and rapidly growing electricity demand create a unique environment for immediate, mass-scale adoption of energy storage across a variety of use cases. In many ways, the African market presents a more compelling business case than even the USA and Europe. In addition to grid support and integration of renewables into the electricity system, current status of Africa's power grids create an opportunity to supply power either cheaper than diesel (when coupled with PV) or to "bring-round-the-clock" electricity to remote, unconnected locations (e.g. mines, rural villages).

Bushveld estimates the addressable market for utility scale energy storage in Africa to be 80-90 gigawatt hours (GWh), or $20-30 billion. Key facts include:

- Electricity demand in Africa will grow at 4.5% p.a., with commercial and industrial customers making up 2/3 of total demand.
- Diesel generators in Africa produce around 16 terawatt hours (TWh) of electricity annually, costing $5 billion for fuel alone (or over $0.31/kWh on average), showing that Africans are willing and able to pay for electricity. Combining solar PV with a VRFB storage system can already yield lower unit costs than diesel, without taking into account further cost reductions expected in the coming 12-24 months.
- Energy experts estimate that South Africa needs 4GW and 24 GWh of energy storage capacity already, on top of the 1.3GW Ingula pumped storage project.

Africa may benefit the most from energy storage, compared to other regions, Africa

offers for energy storage adoption over other regions:

- Excellent solar radiation;
- Around 3 million people that need round-the-clock access;
- Easier project implementation;
- High reliance on costly diesel.
- "Savvy" energy consumers, open to new solutions.

Storage in developed markets

Due to the geographical characteristics as well as the peculiar load-generators distribution (major industrial loads in the north, intensive RES deployment in the south) Italy has been one of the first country in the world to face the issues of RES introduction and to deeply test functions and potentiality of energy storage systems (ESS).

In the next paragraphs, an overview of some of the main ESS projects both on distribution and transmission grid will be performed.

Energy storage for the Italian distribution grid

One of the first Italian ESS project, developed starting from 2012, promoted the improvement of distribution grid in Southern Italy regions with high RES penetration providing the possibility to test Energy Storage Systems in primary substations to:

- reduce the variability of power flow due to wind gusts or the passage of clouds;
- Make the exchange of energy profiles between HV/MV substations and National grid more predictable.

In the picture below, one of the three installations foreseen in the project, the 2MW/1MWh ESS in Campi Salentina (LE) is shown. Three 40 feet container were designed and equipped with proper auxiliaries to house batteries, PCS (inverter), EMS (Energy management system) and MV equipment to connect the storage to 20kV grid.



Fig. 4 - Campi Salentina (LE)

The flexibility of lithium -ion technology was adopted to allow both energy (time shift, peak shaving…) and power (frequency and voltage regulation…) operating conditions. A modular structure based on 8 inverters allows high rate of availability. Proper and safe operating conditions are granted by a dedicated design of HVAC system together with a smart control and supervision system that collecting input from batteries and PCS allows the ESS to perform in a safe and accurate way according to the input coming from grid operator.

Energy storage for the Italian transmission grid

Immediately after the first projects for the distribution grid, the Italian TSO launched, in 2013, a huge program of ESS installations to address both congestions on HV grid (energy intensive projects) and safety of the electrical system (power intensive projects). In the context of power intensive projects, in order to increase the safety of the electrical system of Italian major islands, two storage laboratories (one in Codrongianos HV SS in

Sardinia, one in Ciminna substation in Sicil) were developed where several ESS systems (8 in Sardinia and 6 in Sicily, about 1 MW power each) based on power intensive technologies (lithium, sodium chloride and vanadium) able to ensure fast response time were installed



Figure 5 - Transmission grid installations

The target of the installations was to provide reserve, frequency/power regulation (support to low system inertia coming from traditional generators), voltage regulation and power quality and to work with integrate approach with TSO grid management. In the picture below, an overview of Codrongianos storage lab, together with a detail of lithium battery container and a PCS container is shown. Storage lab experience also provided the possibility to deal with multiple technologies and their combined operation. Multiple skills to manage specific battery characteristics (thermal management for lithium, high temperature operation for sodium chloride, chemical aspects for vanadium redox batteries) resulted to be a milestone of the project. As far as energy intensive projects are concerned, a first step in the reduction of congestions on HV grid portions with high wind penetration required the installation of three huge ESS (about 12 MW/90MWh each) based on sodium sulphate technology (NAS), having the capability to store energy for enough hours to avoid 150kV lines congestion as well as to support primary regulation, voltage regulation and increase tertiary reserve.



Figure 6 – Scampitella installation

In the picture above, a detail of Scampitella SANC (Italian acronyms for non-conventional

energy storage system) is shown. NAS battery modules are inside dedicated buildings, each of them connected to a PCS container. Additional four containers are required for auxiliaries, control system, MV devices. Since once heated up, sodium chloride batteries have to be kept continuously at high temperature (300°) up to the end of life, the required degree of redundancy on auxiliary feeding is 4. Scampitella SANC was connected directly to HV grid by means of a dedicated SS built on purpose. Specific results of transmission grid ESS projects are available on public reports.

Conclusion

The multiple experiences that took place in the last 5 years on both Italian transmission and distribution grid result to be a unique milestone in the deployment of new assets for grid evolution. Capabilities and issues of different storage technologies were tested and are the basis for a further intensive deployment of storage in a context of further renewables spread.

Renewable integration and Off-grid hybrid systems

EGP currently has 4 plants integrating Energy Storage System. These are currently in operation and incorporate different configurations of the proposed solution, including the use hybrid Renewables generation systems.

Catania 1 Storage

Location: Italy

Type: Grid-scale PV Solar+BESS

In operation since 2015



Fig. 7 – Catania1

Catania 1 is a 10MW PV plant, MV connected, operated at 8MW due to DSO transmission line lower capability. The installation of a storage system lets EGP store the energy produced at peak hours and put it on the Grid in the evening hours. The BESS is composed by 2MW/1MWh NaS battery, PCS (Power Conversion System) is a by-directional Inverter, LV/MV transformer with MV switchgear and a control system. The Manufacturer is GE ENERGY.

EGP added to the system an upper-level site controller, defined MASTER SCADA, in order to manage the PV plant and the BESS to act as a single energy production system in respect to the DSO.

Catania1 Storage can perform:

- Primary frequency regulation1a;
- Secondary and tertiary frequency regulation1b (reserve power);
- Power generation production time-shift2a, and;
- peak shaving2a.

Pietragalla Storage

Location: Italy

Type: Grid-scale Wind+BESS

In operation since 2015

Pietragalla is a 18MW WIND plant, HV connected. The BESS is composed by

2MW/2MWh SAMSUNG Lithium battery, PCS is a by-directional Inverter, LV/MV transformer with MV switchgear and a control system. The manufacturer is SAMSUNG SDI.

As in Catania1, EGP added a MASTER SCADA controller in order to manage the WIND plant and the BESS to act as a single energy production system in respect to the TSO.

Pietragalla Storage can perform:

- Primary frequency regulation;
- Secondary and tertiary frequency (reserve power);
- Power generation production time-shift and peak shaving;
- Voltage regulation by absorption/delivery of reactive power.

Further developments EGP is trialing in Pietragalla Storage are:

- Island operation of portions of the network1d (like mini-grid composed by a portion of the grid, the storage and the wind farm);
- Participation in the black start of the power system 1e(same as before, but especially after a blackout);
- Spinning reserve 1f (provide synthetic inertia to contribute into grid frequency stability);
- In addition to standard Grid Services, we want to also develop a function for real-time efficiency calculation for DC/DC and DC/AC conversion.

Ollagüe

Location: Chile

Type: Microgrid

In operation since 2015

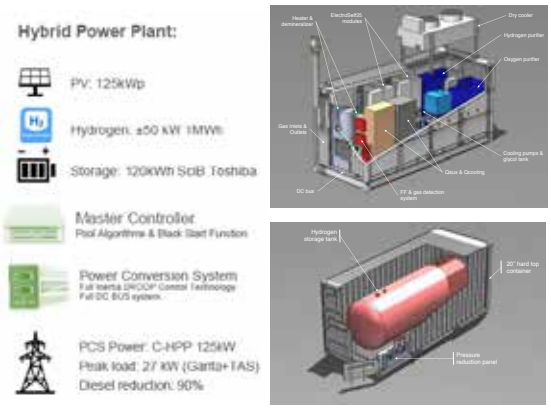


Fig. 8 – Ollagüe

An off-grid hybrid system has been built in the desert of Chile aiming to supply energy to a high altitude village (3700 meters AMSL), limiting as much as possible the usage time of the existing Diesel generator. After the completion of the construction during Q4 2014, the activities of monitoring and field testing are taking place since the beginning of 2015 with plant startup in April 2015.

While ensuring reliable energy supply to the village inhabitants, several possible models are being introduced and tested in the microgrid, starting from the installation of smart meters for the active management of the energy resources. The project presents effective synergies between innovation and sustainability with relevant positive impacts on the local community, meanwhile, enabling a broadening of on the field experience on such advanced plants which are experiencing fast growth, and are targeting emerging markets.

The plant is installed in Ollagüe, a small cut off mine village, 160km from Calama, at the border of Bolivia. Ollague's little more than 200 inhabitants are mainly devoted to their



domestic cattle, and modest catering at the border. The village is not connected to the SING (Systema Interconectado del Norte Grande) and there only existed a micro grid circuit powered by a 250 kW diesel generator, supplying electricity for no more than 16 hours a day (none is provided from 1 am to 8 am). The changes in temperature are extreme, reaching a delta of 22°C in a day time, with minimums of -20°C.

The project is made up of a non-SING-connected hybrid off-grid plant, with PV solar and wind components, battery storage, and a backup diesel generator. Additionally, some thermodynamic cogenerating concentration systems have been connected to the same commune of Ollagüe, providing hot water and electricity to the school.

Cerro Pabellon Hybrid storage system

EGP recently completed the construction of an hybrid storage system (Hydrogen for long duration + fast Lithium Titanate battery for dynamic compensation). System is able to provide 24 hours a day green energy and is completely diesel-free (even for back up, thanks to hydrogen storage), able to seamlessly connect to and disconnect from the grid, and containerized for fast "plug & play" deployment.

Fig. 9 – Cerro Pabellon Hybrid Storage System

As a commercial application of Ollagüe and Cerro Off-grid systems, Enel recently completed the supply of a microgrid with 2 system consisting of 500kW / 1MWh ESS each to FormulaE plus grid monitoring and control devices, in order to improve green energy consumption of the Electric Race vehicles of the series. Moreover, EGP is currently working on other initiatives involving BESS, among which:

BESS near a Wind Farm in North of Europe

Batteries are sized 22MW/33.8 MWh. They are designed to participate to the PCR1a (Primary Control Reserve) market. EGP executed basic engineering for both projects, that are under development and offers from suppliers are under evaluations.

BESS near a Wind Farm in NY State - USA

Batteries are sized 4MW/1 MWh. They are designed to participate to the PCR1a (Primary Control Reserve) New York Independent System Operator's market. EGP executed basic engineering for both projects, that are under development and offers from suppliers are under evaluations.

Retail South Africa (South Africa, retail-residential, in operation since 016):

EGP has developed, installed and operated some residential size hybrid systems which are composed of:

- A photovoltaic system that generate energy;
- A Lithium Battery to store the Energy produced and not directly consumed by the house loads;
- A hybrid inverter able to control both battery and photovoltaic plant;
- A meter that monitors the energy consumption in the house;

Customers (residential size) aims to avoid the load shedding and become more independent from the local Utility and municipalities. The hybrid system can guarantee both these services.

Appendix

Table 1 Comparison of major energy storage technologies by technical characteristics

	Power rating (MW)	Discharge time	Cycles, or lifetime	Self-discharge	Energy density (Wh/l)	Power density (W/l)	Efficiency	Response time
Pumped Hydro	100 – 2500	4 – 16h	30 – 60 years	~ 0	0.2 – 2	0.1 – 0.2	70 – 85%	10 s – min
Compressed Air	10 – 1000	2 – 30h	20 – 40 years	~ 0	2 – 6	0.2 – 0.6	40 – 70%	min
Flywheels	0.001 – 20	sec – min	20000 – 100000	1.3 – 100%	20 – 80	5000	70 – 95%	< sec
Li-ion battery	0.1 – 100	1 min – 8h	1000 – 10000	0.1 – 0.3%	200 – 400	1300 – 10000	85 – 95%	< sec
Lead-acid battery	0.001-100	1 min – 8h	6 – 40 years	0.1 – 0.3%	50 – 80	90 - 700	80 – 90%	< sec
Sodium-sulphur battery	10 – 100	1 min – 8h	2500 – 4500	0.05 – 20%	150 – 300	120 – 160	70 – 90%	< sec
Flow battery	0.1 – 100	hours	12000 – 14000	0.2%	20 – 70	0.5 – 2	60 – 85%	< sec
Superconducting Magnetic	0.1 – 1	ms – sec	100000	10 – 15%	~ 6	~ 2600	80 – 95%	< sec
Supercapacitor	0.01 – 1	ms – min	10000 – 100000	20 – 40%	10 – 20	40000 - 120000	80 – 95%	< sec
Hydrogen	0.01 – 1000	min – week	5 – 30 years	0 – 4%	600 (200bar)	0.2 – 20	25 – 45%	sec - min
Synthetic Natural Gas	50 – 1000	hour – week	30 years	Negligible	1800 (200bar)	0.2 – 2	25 – 50%	sec - min
Molten Salt (latent thermal)	1 – 150	hours	30 years	n/a	70 – 210	n/a	80 – 90%	min

Excludes technologies with limited experience to date from multiple sources.

(*) Sources: Bradbury, K. (2010), "Energy Storage Technology Review"; IEC (2011), "Electrical Energy Storage. A White Paper"; Schlumberger Business Consulting (2013), "Leading the Energy Transition: Electricity Storage." Schlumberger Business Consulting Energy Institute, FactBook Series, World Bank ESMAP Technical Report 006/15 'Bringing variable renewable energy up to scale: Options for grid integration using natural gas and energy storage', and contributions from WEC Energy Storage Knowledge Network participants.

Brand	LG	RedFlow	BYD	Hybrid	Gridedge
Model	Chem Resu 10	Z-cell	B-Box Residential	Home Plus	Quantum
Battery type	Li-ion NMC	Flow Zn/Br	Li-ion LFP	Lead	$Na/NiCl_2$
Energy / kWh	9.8	10 .0	10.24	9.84	9.6
Price /$	8.800	12.600	8.734	11.000	20.000
Cycle life /cycles	3.200	3.650	6.000	2.400	3.500
DoD / %	90	100	96	80	80
Warranty / Wh	30.000	36.500	35.770	14.965	14.000
CoSE/$ kWh^{-1}	0.30	0.35	0.24	0.74	1.43

Table 2 – Characteristics of some commercial storage system for photovoltaic application.

Study on waste to energy business in Kenya and Ethiopia

This paper has been prepared by:

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Abstract

*This paper analyses the existing value chain of **Municipal Solid Waste (MSW) and Agriculture Wastes in Ethiopia and Kenya**. The focus of the analysis is the urban scale for MSW conversion and the industrial scale for agriculture waste conversion, where capacity exists to scale-up industrial relevant Waste to Energy (WtE) projects. These two types of waste represent the **main input for WtE technologies**, which are key components of a sustainable waste management strategy. The paper will show how WtE technologies represent efficient and competitive solutions to manage increasing waste generation and transform wastes in sustainable, climate friendly bioenergy.*

Introduction

Waste management is a key aspect of our modern economic system, strictly linked with production and consumption of goods. Depending on sources and types of materials, **waste streams differ one from another**: from residential to medical waste, from agriculture to construction and demolition wastes. Most of them require **appropriate management strategies** and the implementation of *ad-hoc* policies. Today,

waste management is considered as a fundamental component of the integrated resource management strategy needed to promote sustainable development, including global health, and fight against climate change: landfills and wastewater contribution to global GHG emissions is around 8% of anthropogenic methane emissions (735 Mt CO_2e) and uncontrolled disposal of wastes is one of the major causes of air, land and water pollution with relevant consequences on health. Waste management finds its most appropriate organization model in the **circular economy approach,** which, in addition to a life cycle perspective that could reduce waste along each supply chain, allows to fully valorise the economic value of waste:

- Organizing waste sorting, disposal and recycling to retrieve all secondary materials which may be resold to manufactures;
- Retreating the remaining material to produce high value products for local consumption as heat, electricity, gas or organic fertilizers.

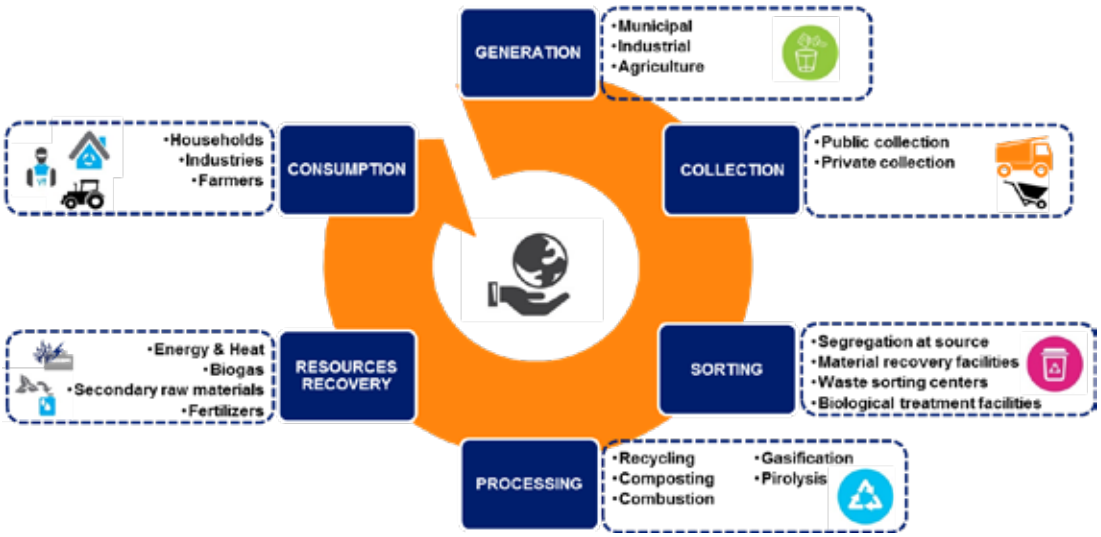


Fig.1 - Sustainable waste management value chain

The relevance of bioenergy for the sustainable development of Africa

Bioenergy has been indicated as a key option to meet the **UN Sustainable Development Goals (SDGs)** and implement the **Paris Agreement on Climate Change** thus contributing to food security (SDG 2), sustainable energy for all (SDG 7), mitigation of climate change (SDG 13) and better land use (SDG 15). Bioenergy represents a **new hope** for Africa and all those regions lagging behind since the early 1960's green revolution. Bioenergy encourages food security and energy access within the world's poorest continent and generally contributing to meet SDGs [2]. Around 70-80% of food insecurity concerns are in rural areas where energy poverty is also concentrated. Modern bioenergy can therefore help improving food security and building synergies throughout the biomass and food supply chain [4]. Bioenergy is crucial for Africa's goal of increasing **energy access**: although its share

to total final energy consumption of Sub-Saharan Africa (SSA) will decrease to 53% by 2040 in the International Energy Agency's (IEA) New Policies Scenarios (NPS), its contribution to power generation will increase with a compounded average annual growth rate of more than 10% [5]. In addition, bioenergy is a key option to keep track of **decarbonisation policies** of African countries. Approximately 90% of African countries have submitted their INDCs meaning a strong commitment towards international policies. Kenya and Ethiopia have ambitious mitigation policies with reduction targets respectively of 30% by 2030 relative to the BAU scenario of 143 $MtCO_2eq$ and 64% by 2030, relative to BAU scenario of 400 $MtCO_2eq$. **Sustainable waste management** systems and bioenergy are indicated as a major driver for climate change mitigation strategies [6]. Finally, bioenergy as a pillar of bioeconomy can help building capacity and infrastructures in Africa to foster advanced biotechnologies such as biorefineries able to transform biomass into marketable products (food, feed, materials, chemicals) and energy (fuels, power, heat) or other industrial biotechnologies.

Opportunities and challenges of solid waste management in East Africa

Waste generation volumes are a **function of population, urbanisation, economic development and level of income**. In most of the emerging countries, characterised by rapid economic and population growths and fast urbanisation, waste generation is growing faster than the capacity of public authorities to manage it. In addition to Municipal Solid Waste (MSW) production, population increases and economic development will generate other kind of wastes associated with agricultural activities. Despite a better understanding of the unmanaged wastes' risks, waste management systems require big investments and well-developed infrastructures. Limited **financial resources**, poor **technical capacities** and underdeveloped **infrastructures** have been the main barriers to the implementation of such strategies in developing countries. WtE is an interesting option to transform waste streams in income streams and useful products, as power and heat. It may be a viable solution to manage the growth of waste generation, while helping fostering electrification and access to modern energy within the region. Several technologies for energy harvesting from wastes have already demonstrated their efficiency: incineration, thermo-chemical and biochemical conversion, landfill gas collection. Each option shall be assessed to find the most profitable in view of local context. Nevertheless, bioenergy is **double-edged weapon** that may turn opportunities into severe threats worsening food security, increasing greenhouse gas emissions, reducing biodiversity and marginalizing more people unless a sustainable bioenergy expansion is not devised. It is therefore important to focus on sustainable biomass supply chains, especially concerning agriculture biomass. They include: i) the boosting of production yields and promotion multi-functional land uses; ii) **the better use of residues and waste from agriculture and forestry value chain**; iii) the use of degraded or marginal land; iv) the reduction of food chain losses [1,2].

Solid waste management in Ethiopia and Kenya

Types of waste streams & management

Ethiopia and Kenya are the two most important emerging economies of the East African region. Ethiopia is the second most

populated state of Africa , with over 102 million inhabitants, and experimented a tremendous GDP growth during the last five years (around 10% per year on average). Kenya is also on its way to accelerate the emergence of its economy, with a stable GDP growth rate of 5.9% per year on average between 2010-2016. Kenya's population is around 48.5 million and has grown by 2.6% per year on average during the last five years. Due to the population growth and economic development, waste generation is increasing and will continue its growth in both countries over the next years. Therefore, waste management is becoming a major concern, especially in urban areas where public authorities (Municipalities and City Councils) are responsible for the delivering of waste management services. Kenya and Ethiopia suffer from limited budgets and insufficient technical capabilities to efficiently respond to the growing waste generation. The available resources are absorbed by the collection and waste disposal services in the main cities and the costs of those services are not covered by the collected fees. The private sector plays a key role in collecting waste door-to-door, especially in urban residential areas, reselling the products to waste-dealers. Hundreds of small and medium enterprises (SMEs) and community-based organizations (CBOs) provide those services, working in parallel with public authorities. Despite the efforts to better regulate and manage those activities, collection and transportation of waste remain poorly organized with limited and rudimentary technical capacities. As a result, collection rates remain low, around 50-60% of generated waste. Open dumpsites and landfills are the most common waste disposal solutions, especially in urban areas. At the same time, hundreds of illegal waste deposits are located inside and outside urban areas. The existing official dumpsites are characterized by limited operation controls on types of collected wastes, and little measures to protect the surrounding environment (as liners, leachate and gas management systems, anti-flooding measures and sound operations). This opens to high risks of polluting nearby aquifers and settlements, and to serious health dangers for local residents and workers: the decaying of organic materials and the uncontrolled burning of wastes are already major causes of intoxication, respiratory problems and other diseases. Sorting of waste is very limited, especially at household level, but partial recovery of recyclables items (plastic, glass, papers, and metals) is done by waste pickers collecting recyclable materials door-by-door or working inside the dumpsites. Waste recycling is organized around licensed waste dealers who buy from large groups of unregistered waste pickers and sell in bulk to large waste recyclers and facilities. Recycling rates however remain very low, around 5-10% of the recoverable materials.



Fig. 2 - Waste management chain

WtE technologies (i.e. incineration, gasification and pyrolysis) provide an efficient solution to reduce the amount of disposed waste in landfills, generating value-added products as electricity and biogas. Kenya and Ethiopia experience a new impetus within the implementation of

bioenergy and new WtE solutions that may have environmental and economic benefits for the country. In 2013, the Government of Kenya established the Directorate of Renewable Energy as one of the four technical directorates of the Ministry of Energy and Petroleum in Kenya. One of the three departments working in the framework of the Directorate of Renewable Energy is 'Bio-Energy Development' whose overall objective is to develop bioenergy including the use of wastes (e.g. agricultural residues, municipal solid wastes) [9]. In addition, both countries have recently adopted new long-term national development strategies, which include clear dispositions and targets to improve waste management systems. Kenya's "National Solid Waste Management Strategy" set minimum requirements for the implementation of waste management strategies by County Governments. Short-medium and long-term targets have been adopted to gradually increase the recovery and disposition rates in the country up to 80% for waste recovery in 2030, including recycling, composting and waste to energy, and 20% of waste landfilled in 2030. Ethiopia, on its side, has made the same with its last "Growth and Transformation Plan" and its "Climate Resilient Green Economy Vision". So far, the use of agricultural wastes for energy use has not been fully developed in Kenya and Ethiopia causing potential economic losses and environmental impacts. The agriculture sector's GHGs emissions recorded in Kenya in 2014 were of 37.1 $MtCO_2eq$ [10], corresponding to more than 60% of the total emissions. Looking at the breakdown of agricultural emissions in **Figure 3**, it is possible to notice the great potential of GHGs reduction from the better management of agricultural wastes (e.g. manure, crop residues) as recently stated in the Kenya's INDC [6]. Beyond GHGs emissions, agricultural wastes can produce air pollution especially when field burning is carried out poisoning of land or water sinks when manure is not properly managed. Similarly, as stated in the country's INDC, Ethiopia undertook the commitment of reducing its GHGs emission of 255 $MtCO_2eq$ from the projected 'Business- as-usual' emissions in 2030, out of which 90 $MtCO_2eq$ are related to the improvement of crop and livestock production practices for greater food security and higher farmer incomes while reducing emissions [6]. A potential reduction of 5 $MtCO_2eq$ from the building sector, including waste management, has been also indicated in the Ethiopia's INDC.

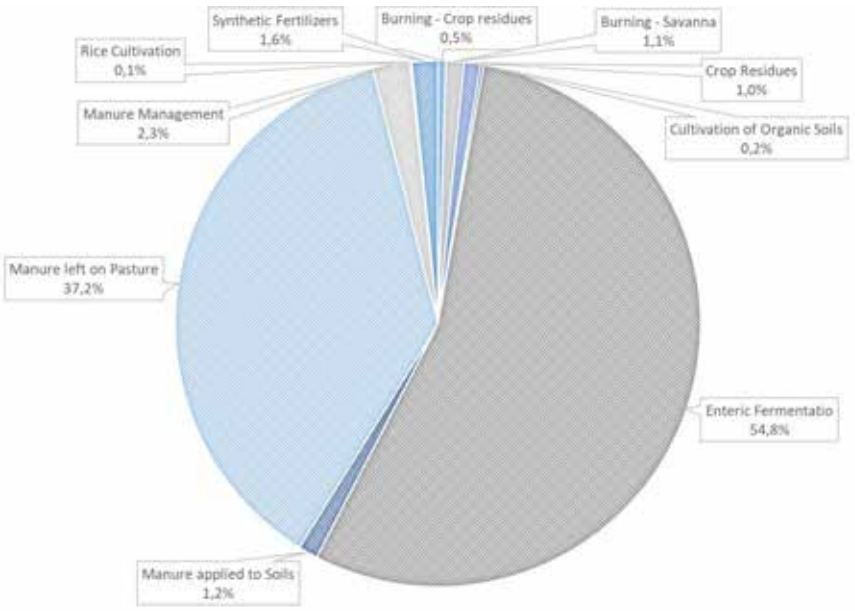


Fig. 3 - Breakdown of GHGs emission sources in the agricultural sector: the case of Kenya [10]

Current status of solid waste management in Kenya and Ethiopia

- **Agriculture waste**

The main subsectors of agriculture in Kenya include horticulture, food crops, industrial crops, livestock and fisheries. Within the food crops subsector, major contributions to the total production are given by maize (3500 kt/y), wheat (400 kt/y), rice (120 kt/y), sorghum (170 kt/y), beans (620 kt/y), roots and tubers like potatoes (1630 kt/y), sweet potatoes (760 kt/y) and cassava (870 kt/y). As long as industrial crops are concerned, the most significant crops, in terms of production and exports, are tea (400 kt/y), coffee (42 kt/y) and sugar cane (6000 kt/y) [10]. Livestock sector contributes to 7% of the GDP and provides for 50% of agricultural labour in Kenya. Both crop farmers and pastoralists keep livestock for food and income generation; various farm enterprises therefore comprise both crops and livestock. The key livestock subsectors are beef (440 kt/y), dairy (4.9 billion litres of milk/y), sheep and goats (100 kt/y), camel (65 kt/y), poultry (26 kt/y) and piggery (16 kt/y) [10]. The production scale of the agricultural activities is predominantly small-scale. Small and medium-scale farms account for about 75% of the total agricultural output, and are characterized by sizes ranging between 0.2 to 3 ha (small-scale) and 3 to 49 ha (medium-scale). The large-scale farming subsector accounts for 30% of the total production. Large-scale farms average about 50 ha for crops and 30,000 ha for livestock ranches. In this framework of an agricultural sector where small-scale producers are dominant, cooperatives play an important role for scaling up economic activities and potentially implementing affordable bioenergy supply chains. Data referred to 2009 show how the number of agricultural cooperatives in Kenya has continuously increased since the beginning of 2000s, reaching the number of 4,477 organizations in 2008, with 1.3 millions of people involved. The cooperatives are mostly assigned the task of managing the marketing of members' products, but

cooperatives linked to certain subsectors, such as coffee and dairy, have also started dealing with processing activities [11]. Smallholders are more reluctant in adopting innovating technologies, due to higher difficulties in credit access (currently found mainly in cooperatives, NGOs and community-based lending institutions); in this regard, the Government of Kenya has committed himself in addressing this issue through the development of appropriate credit packages for small-scale producers [12]. On the contrary, medium and large-sized farms are receptive to technology and practice commercial agriculture by investing on inputs and borrowing credits for farm development. History demonstrated that oscillation of fuel prices can negatively affect the agricultural sector's development. Moreover, in the last decades environmental damages (i.e. reduction of forestry land cover) arose from a wide deployment of forestry products for energy purposes. Other forms of energy provision within farm enterprises are also of interest as they enhance the lowering of production costs and a better utilization of resources. The use of agricultural wastes could therefore spur economic and social development and mitigate environmental damages. Agricultural wastes may support:

- *Heat, power, combined heat and power systems*: including combined generation of heat and power from bagasse, rice straw and husk and other lignocellulose residues through gasification or biomass-fed steam power plants.
- *Sustainable biofuels production*: including bioethanol production from sugarcane, corn, cassava and sorghum and biodiesel from maize residues. Biogas may be also produced from anaerobic digestion of organic wastes at urban and industrial scale including horticulture and manure from feedstock.

The Ministry of Energy and Petroleum of the Republic of Kenya (MoEP) reported [13] a potential of 193 MW of power production from six sugar factories producing of an average 1.8 million tonnes of bagasse per year. However, only the Mumias Sugar Company and the Kwale International Sugar use bagasse for 26 and 18 MW respectively of generated power. The potential for biogas production is between 29-131 MW from Municipal Solid Wastes, sisal and coffee [13] although there could be other options to investigate in the conversion of manure from livestock. Finally, traditional biomass and waste accounts for 68% of the total energy use but with low transition to modern, efficient and clean bioenergy. The maximum (70 litres of ethanol per tonne of cane crushed and all cane used for ethanol production) potential for bioethanol production in Kenya and Ethiopia has been reported to be respectively more than 400 million and 80 million litres per year. Finally, in November 2017, the construction of a sewage treatment plant will start in Kibera aiming at producing 8 MWe of power and 6,000 tonnes per year of methane for cooking purposes [14].

Based on yearly values of main agricultural subsectors production Kenya in 2014 [10], the values concerning organic wastes have been estimated to be making use of differentiated weight fractions of residuals. The same approach has been adopted for the livestock products. Yearly values of manure that could be used to produce biogas have been specified for each type of cattle. According to our estimates, assuming that 10% of solid waste use for energy production (e.g. according to a waste hierarchy with priorities of prevention, re-use, recycling and

finally waste-to-energy), a contribution between 2-5% of Kenya's final energy consumption in 2014 (i.e. 14.7 Mtoe) could be achieved from food crops (e.g. straws, pruning), horticulture (e.g., pruning), industrial crops (e.g., bagasse, straw, pruning). Moreover, around 2.5 billion Nm^3 of biogas could be produced from collecting manure from industrial scale farming (e.g., contributing to 30% of total manure production). This would represent almost a 9% contribution to the final energy consumption of Kenya in 2014. Similarly, for Ethiopia, harvesting energy from solid agriculture residues could share between 3-5% of the country's total final energy consumption. Finally, more than 2 billion Nm^3 of biogas could be produced from collecting manure from industrial scale farming contributing to more than 3% of final energy consumption of Ethiopia in 2014.

- **Municipal solid waste**

Nairobi and Addis-Ababa are two of the biggest and fast-growing cities of SSA. Their current populations are estimated to be respectively of 3.5 and 4 million, growing both at an average rate of about 4% per year. Considering that waste generation levels are a function of population and economic growth, the two cities will have to deal with increasing quantities of solid waste and with the research of innovative, efficient and competitive ways for their disposal. According to the available public data, total MSW generation in Nairobi amount to about 1,095,000 tons per year, around 3,000 tons per day. Households are responsible for almost 70% of the global MSW streams and 30% comes from markets, institutions and industrial areas. Data concerning per capita generation levels vary from 0,6 to 0,8 kg/day. Around 90% of MSW generation is reusable, but only 5% is effectively recycled or composted. The collection rate is between 50% to 60%, representing 1500-1800 tons/day. The city council and the private sector are both involved in delivering collection and transportation services. The Dandora dumpsite, the only official waste disposal site in Nairobi, receives around 820 tons by day. This means that around 2000 t/day are improperly disposed or not disposed in Nairobi.

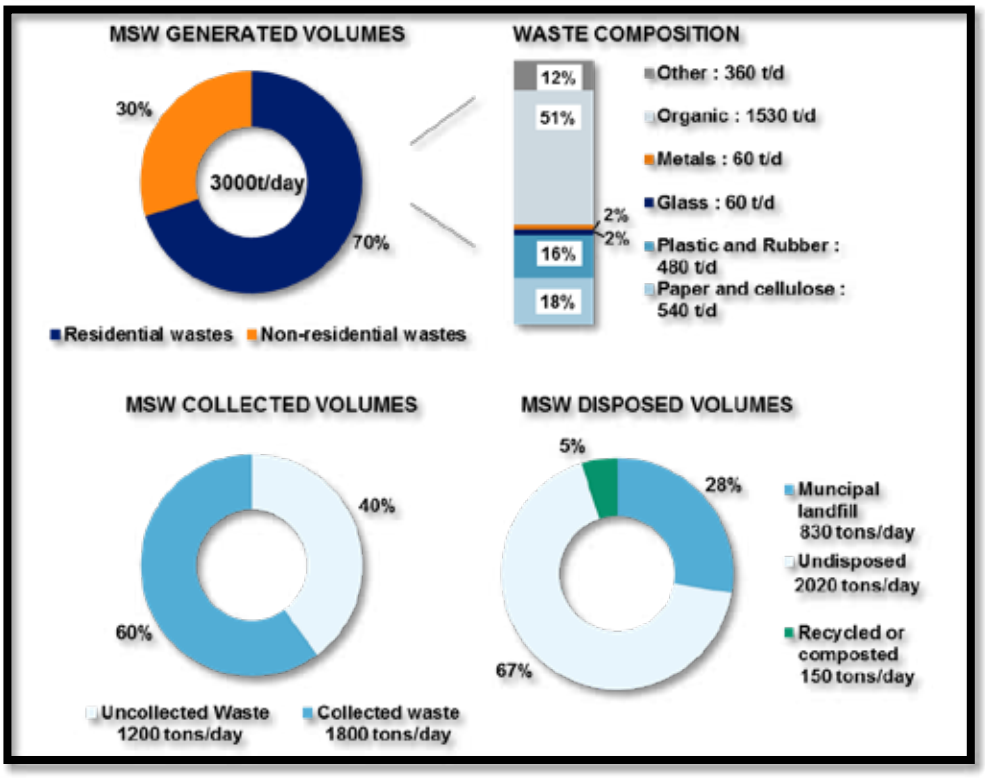


Fig.4 - Nairobi MSW key figures

Public data on MSW generation level in Addis-Ababa estimates per capita generation levels around 0.4 kg per day. Considering Nairobi's current population, daily MSW generation should be about 1,600 t/day, corresponding to a yearly generation of 584,000 tons per year. Residential waste generation represents around 76% of the total. Around 75% of Addis-Ababa generated waste is recyclable or compostable but only 5% is effectively managed in this way. Collection rate in Addis Ababa is around 70%. The private sector is highly implicated in door-to-door collection, receiving a fee from the municipality according to the amount of collected waste. The municipality collects waste volumes from garbage containers and ensures the transport to the Reppi landfill. Around 800 tons of MSW are disposed daily in the Reppi landfill, which is the only municipal waste disposal site in Addis-Ababa and is operational since the late '60s.

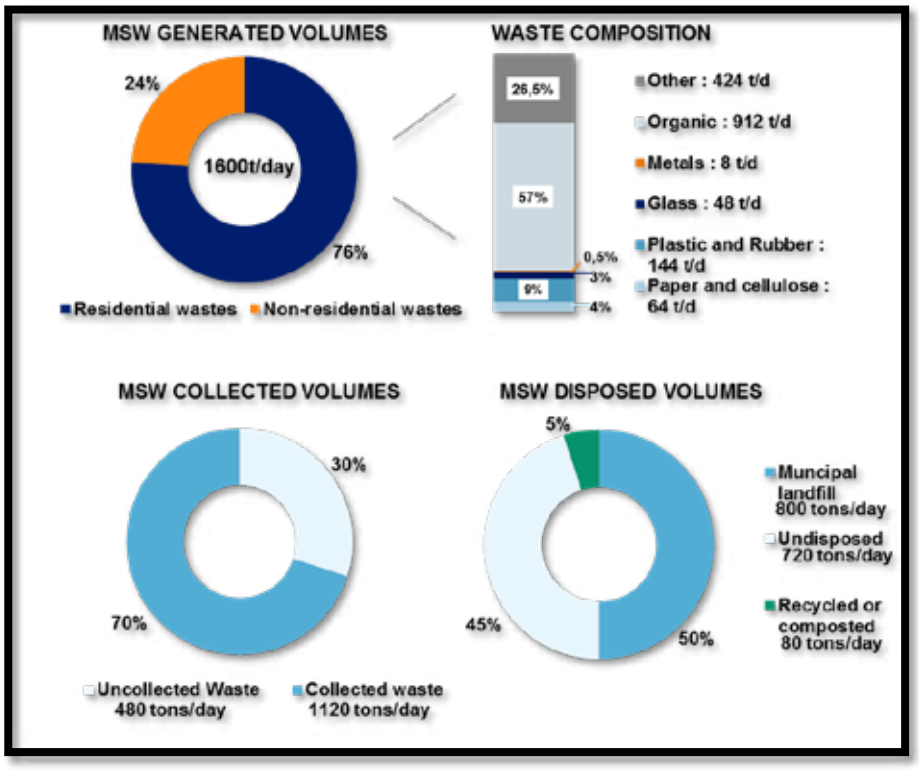


Fig. 5 – Addis Ababa MSW key figures

WtE is an interesting option to increase the efficiency of waste management in Nairobi and Addis Ababa, transforming waste streams in income streams. The treatment of MSW in WtE plants has two significant advantages: a drastic reduction in the mass and volume of waste, up to 70-85% depending on technologies, and the generation of high-value energy. If preliminary treating of waste guarantees better calorific power, incinerators can burn unsorted waste and do not require operations in waste sorting. This allows to drastically reduce the quantities of waste landfilled. The generated electricity and heat can be injected in the cities' power and district-heating networks. The current WtE potential in Addis-Ababa and Nairobi, assuming that all the collected waste will be treated by a WtE facility, is around 784 MWh and 1,260 MWh respectively. Per capita electricity consumptions in Ethiopia and Kenya are respectively around 70 kWh per year and 171kWh per year. This means that around 10,000 households could be powered thanks to the energy produced by WtE plants. Moreover, WtE potentials increase with the growth of collection rates and MSW generation volumes. Currently, the main barriers to investments in WtE technologies are: the lack of public awareness about the value of waste as a marketable commodity and the need to sort and properly store the waste; the dispersion of wastes and the lack of appropriate infrastructures; the capacity to manage complex biomass supply chains for effective WtE pathways. The increase of collection rates, the aggregation of waste volumes from multiple sites and the professionalization of waste supply chain, from transport to sorting and disposal, are key factors to successful investments in WtE

technologies. Commercial viability of WtE solutions must be ensured increasing the effectiveness of waste collection and aggregating waste streams large enough for business development. The first incinerator in SSA is currently being built in Addis-Ababa, nearby the Reppi landfill. The plant will be a first of its kind and will be useful to practically demonstrate the advantages of this kind of technologies and their benefits also for emerging economies.

Waste to energy technology options

- **Landfill gas exploitation**

The control and management of the Landfill gas generated by the anaerobic fermentation of the organic fraction of the mass of solid waste has always been one of the main concerns addressed in the design and operation of a controlled urban solid waste landfill (USW landfill).

What distinguishes a controlled landfill from a "waste deposit" is the organized management of liquid and gaseous emissions. An urban waste landfill is both a problem and an opportunity: whether the latter or the former prevails depends not solely on what is done during the life of the landfill, but also, to a considerable extent, on the activities carried out after the closure of a site. The goal is to enhance the opportunities that a landfill offers, diminishing the side effects of the environmental impact using the best available techniques available.

- **Gasification theories**

A landfill can be described as an accumulation of waste materials, which undergoes a process of degradation, involving a variety of chemical reactions and biological activities; such transformation processes, of a physical, chemical and biological nature, take place simultaneously and continue until all the waste material has been broken down. The main mechanism involved in the breakdown of the waste material is the biological degradation or decomposition of the solid refuse, i.e., the transformation of matter through the action of living microorganisms, e.g., bacteria, producing CH_4 (methane) and CO_2 (carbon dioxide) as well as traces of other substances. This takes place in three separate stages, as shown in the figure below:

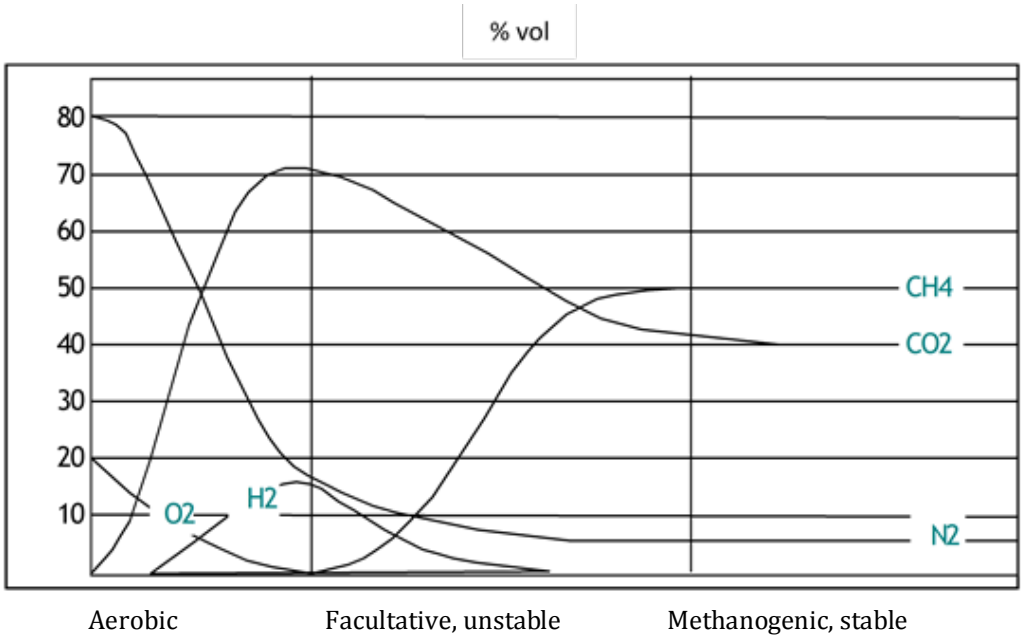


Fig. 6 – Transformation stages

- Stage l: aerobic decomposition. The microorganisms slowly break down the complex organic fraction of the waste using the oxygen entrapped during the deposition in the landfill, until simpler organic compounds, CO2 and H2O, are formed.

- Stage 2: acidogenic anaerobic decomposition. When the oxygen has been exhausted, the so-called facultative bacteria grow and the decompose the waste material further into simpler molecules, such as H_2 (hydrogen), NH_3 (ammonia), CO_2 and organic acids. This is the first phase of anaerobic decomposition.

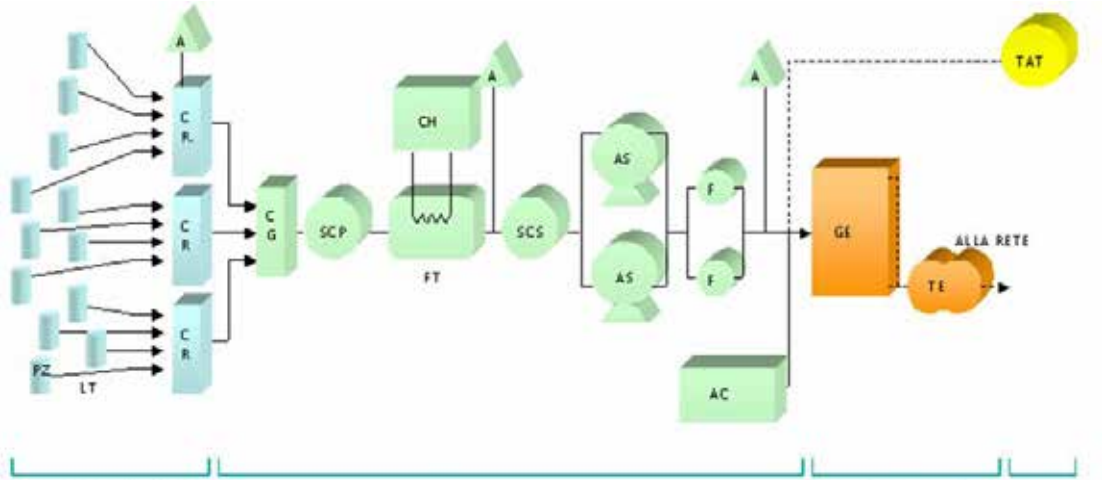
- Stage 3: methanogenic anaerobic decomposition. During the third stage of degradation (second phase of anaerobic decomposition), methanogenic bacteria use the hydrogen and the acids generated during stage 2 to form CH4 and other substances. At this stage, the production of methane increases fast until a virtually constant rate is reached.

The stage of methanogenic anaerobic decomposition is the one of greatest interest for the purposes of Landfill gas energy conversion project, since it has been ascertained that Landfill gas generation starts after three to nine months of refuse deposition and continues for a long period of time, of up to 30-40 years, according to a curve characterized by a peak lasting a few years followed by a progressive decrease, according to an asymptotic curve, until all the organic matter is broken down, or until the complex environmental al conditions suitable far the process cease to exist. It should be noted that the waste decomposition is a complex process, as all the different processes involved may occur simultaneously in adjacent zones of the same landfill and, as a function of the environmental variables of waste accumulation (compression, humidity, temperature, pH, atmospheric conditions, cover, etc.), the phenomena may take place according to different modalities and at different rates.

Plant sections

The project includes Landfill gas uptake, pre-treatment, power generation and flare combustion systems.

In a typical Landfill gas plant, it is possible to recognize the following sections:



COLLECTION SECTION	SUCTION AND TREATMENT SECTION	ENERGY GENERATYNG SECTION AND TORCH
PZ – Well	CG – General Manifold	GE – Engine
LT – Piping	SCP – Primary condensate separator	TAT – Torch
CR –Manifold	FT – Heat exchanger	TE – Transformer
A – Analysis check	CH – Chiller	
	SCS – Secondary condensate separator	
	F – Filter	
	AS – Blower	
	AC – Analysis and control	

Fig. 7 - Plant section

1. Landfill gas uptake and conveying sections, composed of vertical wells, well heads, substations and pipeline to convey the Landfill gas to the following section;
2. Landfill gas suction, treatment, analysis and torch combustion section that includes a series of filters and valves, a cooling station and turbo aspirators to pressurize the Landfill gas and to push it towards the generation sets. The torch is normally set as a back-up during maintenance at the generator or to flare excessive Landfill gas.
3. Electricity generation, transformation and distribution section which produces low voltage power subsequently transformed to high voltage by means of ad hoc equipment and then is transferred to the national distribution network, if available.

If the national power grid is not capillary enough to convey the electricity produced in the landfill, it is possible to burn the landfill gas using the torch
present in the plant; this will avoid the emission in atmosphere of GHG such as methane.

Environmental and social impacts

Socio-economic consequences at local level

The insertion of an initiative aimed to the realization and management of an energy-enhancing plant for biogas is of paramount importance in the social and local context, both because it avoids the emission of pollutants into the atmosphere while also avoiding the danger of explosion and because it favours the local creation of jobs, generating skills that can eventually be evaluated and adopted elsewhere.

The positive impacts at local level are many:

- Environmental benefits for landfill and neighbouring areas;
- Creation of job opportunities;
- Provision of clean energy within surrounding areas;
- Economic benefits for local companies

The planned activities mainly include the continuous engagement of local authorities and the implementation of civil works (i.e. earth moving, basement and excavation, carpentry works, etc.), requested by local companies. Therefore, all the advantages of exploiting this renewable and available energy source should be emphasized. Landfill biogas is a mixture of gas composed mainly of methane and its failure to capture involves, in the first instance, a significant risk of flammability and explosion in concentrated spill areas. The ability to capture and energetically exploit this resource is, as mentioned above, an important environmental and economic opportunity.

Moreover, a further development of the electrical grid can be foreseen. The construction of a landfill gas exploitation plant able to produce electricity can spur Kenyan and Ethiopian authorities to locally enhance the power grid, to convey the energy directly from the plant to the neighbours. The grid's development can locally be a trigger to expand the national network.

Environmental impacts

The plant, in addition to a high economic value, aims at minimizing the environmental impact of biogas dispersion on land surrounding the landfill, which is possible through underground and air spreading.

The dispersion of biogas into the atmosphere contributes to the rising Earth's temperature causing, in turn, severe environmental damage, mainly by its main component: methane. It has, in fact, an impact on the so-called "greenhouse effect" 21 times higher than carbon dioxide (CO_2). To this end, it is to be noted that the combustion of biogas in endothermic engines, while producing carbon dioxide (CO_2), is considered "neutral" to the increase in the amount of total carbon dioxide in the atmosphere as it derives from organisms that had previously absorbed it from the atmosphere itself. These emissions do not therefore contribute to the increase of the phenomenon called "greenhouse effect".

Supporting a sustainable solid waste management in East-Africa

Market analysis, drivers and forecasts within waste management

Forecasts show that Ethiopia and Kenya will continue to experiment stable economic growth in the next years: the World Bank (WB) estimates that GDP growth in Ethiopia and Kenya will be respectively around 8.1% and 5.8% per year on average between 2017 and 2019. Due to high fertility rates registered in both countries, populations are expected to grow around 2-3% per year on average until 2030, with the urban populations representing around 27% and 32% of total populations in Ethiopia and Kenya respectively. As a result, waste generation, including agriculture and urban wastes, is likely to grow even if preservation

policies and increased production efficiency will be set up.

MSW generation will continue to increase in line with GDP and population growths. **Figure 8** shows one possible scenario of MSW generation growth in urban areas, based on the available public data. The figure shows the differential between the volumes generated in 2016, amounting to 0, and the forecasted volumes to 2030. This represents just one among many possible scenarios and does not take into account all possible variables that may influence waste generation levels. However, understanding how MSW will evolve in the next years within the two countries remains a useful tool. Assuming that collection rates in both the main cities of both countries will reach around 90% of MSW generated volumes and that around 40% of the generated waste will be recycled or composted, we estimate the power generation potential of MSW to around 3.2 TWh in Ethiopia and 2.3 TWh in Kenya to 2030.

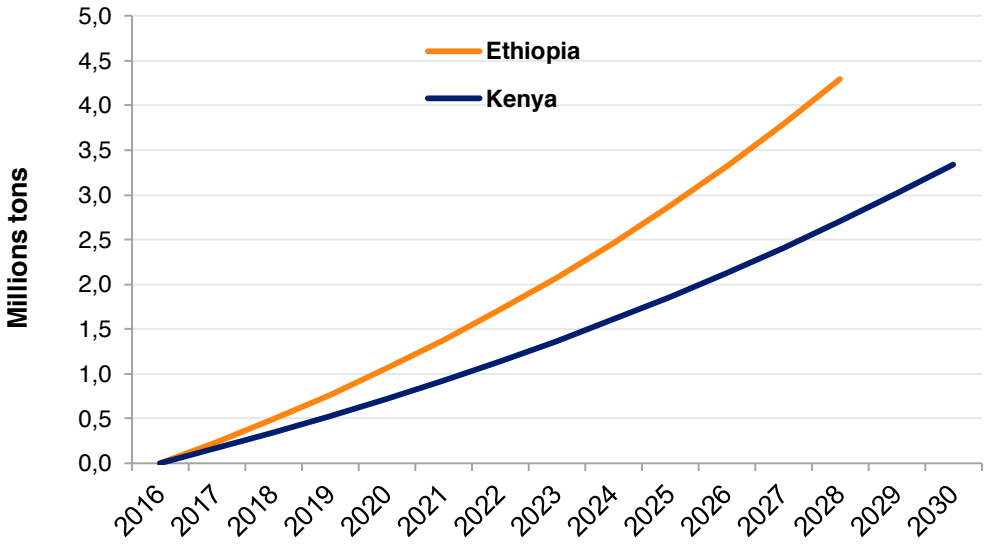


Fig. 8 - Trends of MSW production in Kenya and Ethiopia

Setting up policies for WtE uptake in Kenya and other Eastern Africa countries

Promoting WtE solutions and steering Kenya and other Eastern Africa countries towards a bio-based economy can help reaching both environmental goals and economic growth. On the one hand, WtE initiatives need to build around **existing networks of industries and farmers**, thus reducing costs of setting up new networks and facilitating scale up mechanisms. On the other hand, **governmental measures** need to support the effective adoption of these innovating technologies, their diffusion and future local development. In particular, a clearer and more coherent **policy framework** would help encouraging **research** and development of innovating products, strengthening the communication between **public and private** sectors and enabling new channels of **technology transfer** between them. Policy schemes that could promote and support the diffusion of WtE are required on both sides: supply ("**technology push**") and demand ("**market pull**"). In addition, **crosscutting** measures include all the other policies that

can help building a more solid and functional framework for a bio-economy **(Figure 9)**. As a general recommendation, it is important for policies to have a **stable and long-term** nature so that the private sector has the confidence to invest in risky projects.

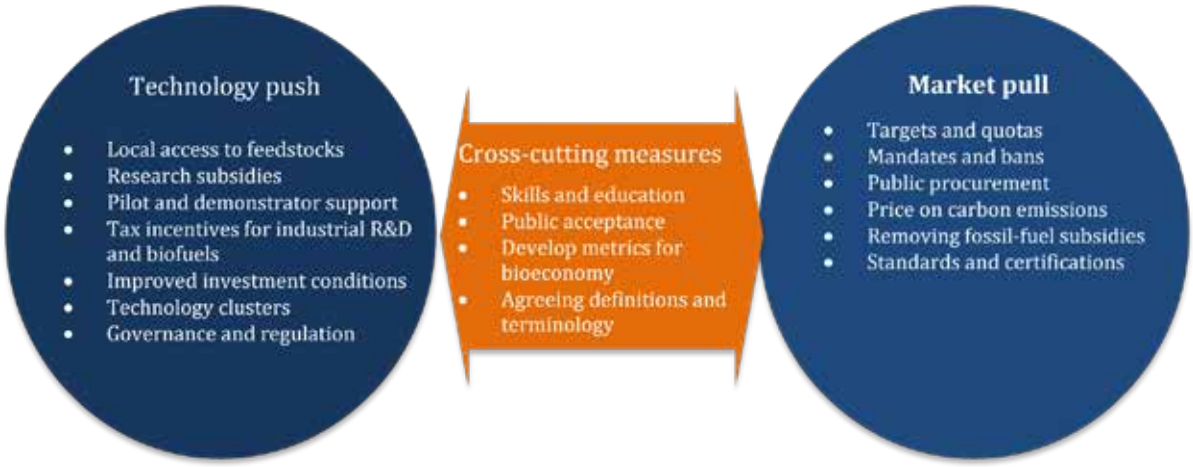


Fig. 9 - Policy inputs for a bio-economy framework, adapted from [1]

On the supply side, **research subsidies and promotion of industrial R&D** would support local development of innovative products. Convergences can be found for instance from the integration of WtE pathways with mini-grid solutions to provide multi-sources renewable based energy configurations. Following the example of most of OECD countries, tax incentives to enterprises could be an effective means of R&D activities promotion. Moreover, a better collaboration between academia and the private sector (e.g. through technology clusters), would allow for a more direct access to products and technologies commercialisation. In this regard, it is worth mentioning Kenya's research infrastructure which can rely on established universities and research institutions. Major efforts should support demonstrative and pilot-scale plants that may also find out effective **business plans** and new **business models**. Helping industries and farmers elaborating sound business plans could help finding convenient source of finance under specifically set credit lines.

Tax incentives may also be applied to biofuels production. Farm-scale production, where fuels are not being sold, could also be exempt from fuel taxes in order to facilitate its economic viability.

Support to **local access to feedstocks** should be treated with particular attention. It is essential that national policies promote the establishment of many **interconnected local production plants** to ensure that residues and wastes from nearby industries, farms and cities (for municipal waste) are fully utilized. Agricultural **cooperatives** could constitute a basis for the selection of the plants location on the territory. In this regard, a further measure with a low cost/benefits ratio could be the development and diffusion of **software-based decision support tools** for the local supply chain.

In order to encourage private investments in the WtE sector, **public-private partnerships**

(PPP) could allow for de-risking private sector investments. Such PPPs are an on-going reality in Europe (e.g. Bio-Based Industries Joint Undertaking, BBI JU) and prevent private investors from shouldering the entire financial burden of the investment. Funds may be found in national agencies such as Kenya National Innovation Agency (KNIA) and used to fund the development, construction and retrofitting of commercial-scale WtE using eligible technologies.

Demand is a major potential source of innovation and includes the areas of **public procurement**, **regulation**, **standards** and **consumer policies**.

In order to foster demand and create a proper market for biofuels, **incorporation of targets** (i.e. targets for the percentage of biofuels to be blended into gasoline and diesels) should be set and pursued. In 2008, 10% blending of ethanol and 2% blending of biodiesel were indicated as reasonable targets for 2015 by the Kenya Ministry of Agriculture, Livestock and Fisheries [3]. It is also recommendable that policies make a distinction between biofuels based on their feedstock and the production methods, in order to guarantee that support will be given to the ones exhibiting higher environmental protection credentials. In this view, biofuels produced from agriculture wastes and residues could bring a valuable benefit with respect to others.

The existence of **standards and certifications** can give more confidence to consumers and credibility to industries promoting WtE technologies and can thus help removing the uncertainties that companies generally face. Other uncertainties that could prevent private sector from investing in WtE technologies could be unfavorable, unclear and poorly-defined feed-in tariffs to sell electricity generated from biogas to national electricity grids. In this regard, previous successful outcomes - as the implementation and development of biomass programme in Mauritius - have showed that the **availability of standard Power Purchase Agreements (PPAs) and pre-determined feed-in tariffs** have played a crucial role for the success of the programme.

Finally, in the field of crosscutting measures, it is worth mentioning the need to build capacities within the field of WtE technologies including the management of biomass supply chains and integration of conversion technologies with local industrial processes. Overall, **delivering modern energy services from biomass in East Africa has strong unexpressed potential that needs to be unleashed to achieve a higher sustainable development in the region**. This inclusive multi-stakeholder process needs to further focus on sustainable biomass supply chains representing the key pillar within a better use of residues and waste from agriculture, industrial and urban value chains.

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