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Urban Energy Technical Note

Renewable Energy Projects

Renewable Energy Sources (RES) are playing an increasingly important role in the generation of electricity (RES-E) as well as in the provision of other forms of end-use energy. About 50% of the total new capacity of electricity generation installed in 2010 came from RES (IEA 2011). Despite what has been said, the global trend clearly indicates a breakthrough for energy generated from renewables. There is a large and as yet untapped potential for utilising RES, especially in developing countries. Renewable Energies can play an important role in increasing access to energy and in combating energy poverty in urban areas.

RES and RES-E projects are always "tailor made" projects in the sense that they are always site specific. They depend on the available source of renewable energy, and are also specific to the required end-use energy. This is a particularly important consideration in the urban context. Projects can vary greatly in size (i.e. power output), in energy conversion technology, in the type of end-use energy generated (i.e. electricity, and/or heat or mechanical energy) and other outputs for example fertiliser, in the case of biogas plants. The generated electricity can be utilized in connection to the national power grid or in island operation without grid connection. Energy can be produced and sold to customers, thus generating income, or can be used for self-consumption.

The development of RES projects of all sizes is a complex exercise, requiring thorough consideration of a multitude of factors especially the expected average energy yield as well as possible variations in energy outputs. An accurate estimate of costs and other non-cost requirements, and also the question of cost recovery are important considerations when planning an RES project.

This Technical Note (TN) focuses on RES-E and other ways of utilising RES, especially in urban areas. A systematic approach comprising 8 steps to project development is presented with particular regard to small scale applications, ranging from 100 W up to around 20 kW. It includes technologies such as Solar Photo Voltaic (for electricity generation), Solar Water Heating (SWH), small wind turbines and biogas generation.

The building stock in cities can increasingly produce energy for self-consumption, thus moving from "consumption" to "pro-sumption".

Fig. 01: **Electrification levels in East Africa (percentage of population with access, 2012)**

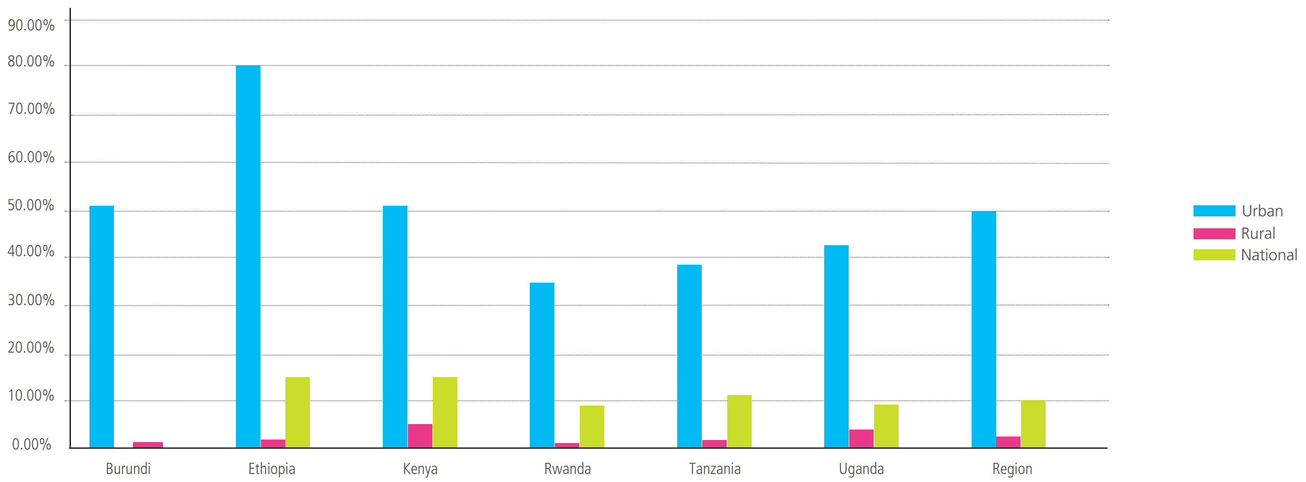
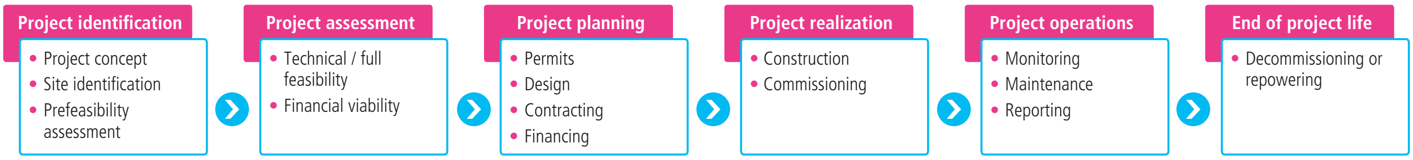


Fig. 02: **Project cycle overview for RES and RES-E projects**



Step 1: Determining the Renewable Energy potential

The first and perhaps most basic requirement for a renewable energy project is the availability of RES. This can be wind, sunlight, small rivers, or biodegradable solid or liquid waste.

The use of solar PV elements for producing electricity will depend on the amount of sunlight available in particular the hours of direct as opposed to indirect sunlight (when the sky is cloudy) per day. The average intensity of solar radiation is also important. It is highest at the equator and diminishes towards the North and South Poles. Many countries are currently developing solar maps based on satellite measurements, which indicate the average site-specific solar potential.

The potential for converting wind energy (kinetic wind energy) into electricity or mechanical energy for water pumps varies widely reatly from site to site. Wind maps comprising meteorological data are available, but the actual site specific potential can only be determined through measurements. The bigger the capacity to be installed, and thus the investment, the more important it is for measurements to be taken on site. For small wind turbines, it might be sufficient to check "if the wind is blowing in the back yard" during the year. The risk is that a turbine will be installed only to stand still most of the time because there is no wind.

The potential for hydro power obviously depends on the presence of running water, i.e. a river. Also important here is the kinetic energy that the river carries, which depends on the volume of water and its speed. Sloping terrain offers additional potential, as water accelerates when flowing downhill. The most important consideration is, however, the seasonal flow rate. Obviously, if the river dries out, no power can be produced.

Biogas can be produced from a variety of bio-degradable organic substrates. In principle, liquid and solid waste can be converted into biogas. However, the yield varies according to the waste type. The substrates need to fulfil certain requirements in terms of liquid and solid matter content. The continuous availability of suitable solid and liquid waste, as well as a sufficient amount of water are prerequisites for biogas generation.

An important variable is the capacity factor (in %), that is the ratio of the average energy yield actually achieved to the (theoretical) maximum yield possible. The capacity factor of solar systems for example is typically between 20-25%, which is due to the fact that they only operate in daylight (50% of the time) and are subject to the solar-path, which only reaches its peak during mid-day. Also, in most places, the sky is frequently cloudy.

Step 2: Site Selection

The primary criterion for site selection for RES and RES-E projects is good or very good renewable energy potential at the site with regard to the anticipated technology (compare with Step 1).

It is possible to go and search for sites that can be converted into renewable energy power plants. Commercial and private sector initiatives especially operate in this way. Sites include not only green fields and brown fields, but also roof spaces on buildings (for solar and wind). Rivers are regularly checked for potential use in hydropower projects.

There are also cases when a site is fixed. This is especially relevant for home systems or RES on-site applications at public or private institutions. The renewable energy potential is assessed on site, and in this case it is only reasonable to realise an RES project where sufficient renewable energy potential has been determined. To highlight this point again: RES projects are tailor-made and site specific. Ad hoc solutions without consideration of the site make little sense.

Other site specific factors also need to be considered, including the availability and ownership of land, the proximity to an existing power grid (national or mini-grid) and any site-specific aspects that may constitute a "no-go" issue.

Fig. 03: **Electricity sector regulatory overview (2011)**

Country	Policy reform	Regulatory body	New Electricity Act	Unbundling	IPPs	Independent T&D operators
Burundi	Yes	Pending	Yes	No	No	No
Ethiopia	Yes	Yes	Yes	No	Not yet	No
Kenya	Yes	Yes	Yes	Yes	Yes	Not yet
Rwanda	Yes	Yes	Pending	Yes	Yes	Pending
Tanzania	Yes	Yes	Yes	No	Yes	Yes
Uganda	Yes	Yes	Pending	Yes	Yes	T=No, D=Yes

Step 3: Technical Feasibility

The technical feasibility of a renewable energy project depends on the proven viability of the energy yield determined by on-site measurements. This is true for all RES, but to a lesser extent, as previously mentioned, for solar energy use. Based on the potential, the various technological options can be considered and the concept developed. This does not mean that all technically feasible options will be implemented however, as the next step will show.

An important aspect of the technical feasibility of RES-E projects is an assessment of the grid connection, i.e. an assessment of the technical feasibility of connecting to the national power grid or a mini-grid for the purpose of selling power or of simple net-metering (the meter running back and forth depending on the amount of electricity produced versus the level of self-consumption). If a grid connection is not technically feasible, the RES-E system needs to be operated as an island system. In most cases, connection to the grid only makes sense for systems with a bigger capacity, as well as with a sufficiently high capacity factor

The technical feasibility, together with the results from the aforementioned steps, can be summarised in a technical pre-feasibility report.

Step 4: Regulatory considerations

Most RES and RES-E projects are subject to a country's legislation and regulations, and hence to a greater or lesser extent are determined by them. This legislative and regulative framework includes, for instance, a country's National Energy Policy, decisions and provisions made by the Energy Regulatory Body, as well as the Electricity and Energy Act (if it exists). Independent Power Producers (IPP) are not allowed to operate in every country. Transmission and distribution of electricity is also regulated and can be either in the hands of the state or is privatised.

For most RES and RES-E projects, relevant provisions in the legal and regulatory framework need to be identified, understood and followed, before the implementation of a project can be considered. The legal and regulatory framework also determines the window of feasibility of a project.

Step 5: Economic Feasibility

After the renewable energy potential, the technically feasible options and the legal and regulatory obligations and opportunities have been determined, the next step can be taken, which is the clarification of the economic feasibility, i.e. what makes sense from a business point of view?

The economic feasibility is determined by a set of factors. For bigger projects each factor typically translates into a fully-fledged study. For smaller projects the conscious consideration of the factors and the stated intention to mitigate negative side effects may be sufficient. The most important elements for determining the economic feasibility of an RES or RES-E project are:

- Economic assessment,
- Financial analysis,
- Clarification and costs of land-ownership,
- Environmental and social impact assessment,
- Risk analysis,

Sensitivity analysis (what is the relative impact on the project of a change in key conditions).

Fig. 04: **East African Feed-in-Tariff overview**

Country	Technology types	Project and overall capacity caps	Basis of tariff	Mini-grid tariff available?	Projects operational under the FIT?
Burundi	n/a	n/a	n/a	n/a	n/a
Ethiopia	All	Yes	Unclear	No	No
Kenya	All	Yes	Cost + return	Yes, for solar only	Yes
Rwanda	Hydro only for now	Yes	Cost + return	No	No
Tanzania	All	Yes	Avoided cost	Yes	Yes?
Uganda	All	Yes	Cost + return	No	Yes?




Step 6: Project design

Once the economic feasibility has been determined, the project design and layout can begin. At this point decisions are made on the specific technological options, the work plan and time frame for construction and commissioning, the financial model and financial plan, and the business model. The project development reaches the point when the project materialises as a concrete plan.

Step 7: Risk Assessment

Despite all assessments, most RES and RES-E projects face risks, i.e. factors influencing the success of the project that lay beyond the sphere of direct influence of the project. Most important from the view point of project developers and financiers is political stability with regard to the energy policy of a country. This includes the support for non-state participation in the energy sector/energy production. Unannounced and significant regulatory changes can impact the window of feasibility of a project.

Another factor is the clarity, certainty and status of land titles or land-use rights, as well as way leave rights. Tax incentives and Feed-in-Tariffs (FiT) can be subject to change. Inasmuch as they are a sensitive part of the financial model of a project, they may push the project into economic un-feasibility.

Timeframes set for the implementation of any energy project are sensitive, and changes can have a significant

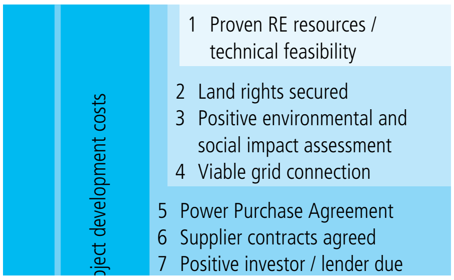
Fig. 05: **Different types of risks**

RE resource risks	Deteriorating resource quality
Technology risks	Poor quality equipment
Market risks	Changes in electricity prices, mini-grid becomes main grid connected
Regulatory risks	Approval delays, land law amendments
Governance risks	Favouritism
Organizational risks	RE project development team fatigue
Construction risks	Damage to major component, failure of contractor to abide by terms of an agreement
Financing risks	Debt interest rates increase

expensive than originally assumed. The bigger and the more complex an RES and RES-E project, the more likely such risks will become.

Finally, there are foreign exchange risks. They are commonly known and will not be further explained here.
In addition, governance in a country constitutes a risk, in particular if corruption is prevalent. Risks related to corruption, from a project development point of view, can hardly be mitigated. Not only are due processes not followed, but paying a bribe or offering a favour to public officials means committing a crime and puts any project at risk of prosecution.

Fig. 06: **Steps taking to bankability and financial closure**



Step 8: Achieving bankability

Banking means risk mitigation, bankability means mitigated risk. Many RES and RES-E projects are considerable investments. In cases when the financing of a project is based on a loan (even a concessional loan, based on more favourable terms than in a normal case in the market) a due diligence will become necessary, i.e. the credit worthiness of the lender based on the proposed project will have to be determined. Bankable in that sense means a project has reached maturity, that related uncertainties have been clarified, plans have been developed and risks are mitigated. At that point banks/investors are willing to provide financing for a project.

The following diagram illustrates possible steps taken to reach bankability and financial closure for an RES and RES-E project. Key external parties/stakeholders include:

- Energy off-takers,
- Investors / lenders,
- Local residents,
- Supplier and contractors