Potential East African Localisation of Small-scale Renewable Energy Manufacture

WWF Short Report

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EXECUTIVE SUMMARY

A recent study conducted by the World Wide Fund for Nature (WWF) South Africa investigated the potential of small-scale renewable energy technologies and mini-grids in East African countries, namely; Uganda; Kenya; Tanzania; and Zambia. The study identifies the need for localisation in the manufacturing phase of renewable energy implementation for electrification, with approximately 70% of the current cost required for imported technologies. This short report investigates the localisation potential of each component that makes up the two most feasible renewable energy technologies in Eastern Africa, namely small-scale solar and wind. As expected, it will be difficult to compete with import markets due to; economies of scale; lack of infrastructure and support from government; lack of resources and materials; and lack of expertise in the countries. However, a few key components were identified, which involve the availability of copper and steel for the manufacture varies components and the high labour requirement needed for wind technology manufacture. The government will need to assist this through incentives, scrapping tax exemptions on imported renewable energy components and establishing local content requirements for companies.

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1: Background

A recent study conducted by WWF South Africa investigated the potential of small-scale renewable energy technologies and mini-grids in East African countries, namely; Uganda; Kenya; Tanzania; and Zambia (WWF, 2018). The need for this study arises from the persisting energy poverty in most African countries, especially in inaccessible rural and urban slum regions, where the development of electrical grid infrastructure is extremely challenging and unlikely in the foreseeable future. (World Bank, 2017). The study partially touches on the issue of localisation regarding small-scale renewable technologies for electrification, with approximately 70% of the cost required for imported technologies (WWF, 2018).

Out of the four primary phases of small-scale renewable energy implementation, namely; manufacture; assembly; installation; and operation and maintenance, the manufacturing phase is the one that is most challenging in terms of increasing localisation. One of the main barriers being economies of scale. East African countries lack infrastructure, funding, support and strategy to grow informal local businesses to the large-scale formal economy, which is necessary to compete with the low cost of import. Another barrier is the undeveloped frameworks, policy and incentives by governments in these countries (WWF, 2018). Currently there is little to no manufacture happening in East African countries in this sector except for a small amount of small-scale wind turbine manufacture in Kenya (WWF, 2018).

This report investigates the potential of localisation in the manufacture of small-scale renewable energy technology in Eastern African countries. Specifically, the study assesses each component of suitable technologies and approximately determines its localisation potential based on certain enablers and barriers.

Some of the biggest industries in these countries are as follows (Hidalgo, 2012):

- **Kenya:** Food (tea, beans, peas, etc.), flowers, oils (petroleum, bituminous, distillates), cotton clothing, cement, steel, medicaments and chemicals (fluorspar, disodium carbonate).
- **Tanzania:** Gold, Food (fish, coffee, tea, etc.), copper, precious metal ores (except silver), tobacco, cotton, oils (petroleum, bituminous, distillates), diamonds, flowers and logs.
- **Zambia:** Copper, cobalt, cotton, tobacco, raw sugar, steel, handbags, flowers, cement, lumber, coffee, nickel and maize.
- **Uganda:** Gold, coffee, tea, raw tobacco, cocoa beans, raw sugar, fish, cement, palm oil, live plants, dried legumes and corn.

2: Technology Breakdown

Renewable energy in Eastern Africa consists of solar photovoltaics (PV), solar thermal, wind, biogas, hydro and geothermal. However, the focus of this study is only on solar PV and wind energy due to the availability of resources, applicability of wide spread use for electrification in these countries and are more likely to be financially feasible on a small-scale basis. Looking at resource data, Eastern Africa has; good solar potential (1400 – 1900 kWh/kWp annual average in all four countries); and low wind potential, with most of Eastern Africa having less than 75 $\mathrm{W/m^2}$ annually averaged wind power density. There are small regions that have good potential for wind energy located in northern Kenya, the coast of Kenya and very small regions in northern Tanzania.

With respect to solar energy, the dominant technology in Eastern Africa by far is pico PV systems (systems from below 1 $\mathrm{W_p}$ up to 10 $\mathrm{W_p}$ in capacity), with about 70% of the world's pico PV and home solar system kits sold in Eastern African countries (WWF, 2018). Pico PV systems are typically constructed from polycrystalline silicone (C-Si) with a rolled glass layer on top and held together using an aluminium frame. The specific components are as follows:

- Silicon (C-Si) cell
- Lamination
- Aluminium frame
- Super-substrate (glass)
- EVA (Ethylene-vinyl acetate)
- Backing sheet
- Wiring (copper ribbon)
- Junction boxes
- Other (packaging, labelling, etc.)

PV technology may require the use of an inverter to convert the DC electricity generated by the panels into AC electricity for connecting the system to a grid or a mini-grid. The components of an inverter are as follows:

- Magnetics and transformers
- Power stage and power electronics
- Enclosure and packaging
- Printed Circuit Board/misc. parts
- Assembly, production and testing

With respect to resource availability, small-scale wind energy does not have as much potential as solar energy in Eastern Africa but it is still relevant and worth considering as overall, it is a simpler technology in terms of manufacture, requiring more labour. Small-scale wind energy consists of systems less than 50 kW in capacity and includes the following components:

- Hub
- Blades
- Pitch mechanism and bearings
- Gearbox
- Generator
- Frame
- Shell and covers
- Electrical connections and interface
- Tower

3: Localisation Potential of Manufacture

Localisation of manufacture depends on the availability of resources in the countries as well as infrastructure, support and financial feasibility of establishing these businesses. This section will evaluate the localisation potential of each component that makes up both PV and wind energy systems. Figure 1 shows the cost distribution of PV manufacture, of which only grid supported residential is applicable.

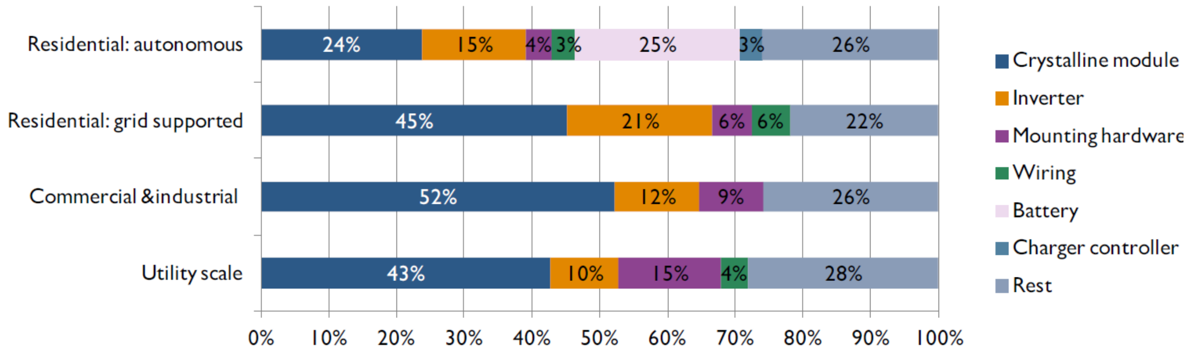

Figure 1: Cost distribution of PV manufacturing (EScience Associates, et al., 2013)

Tables 1 – 4 given below describe the components that make up small-scale solar and wind energy relevant to this study, as well as describing the enablers and barriers to localisation with a final determination of the localisation potential being low, medium or high.

Table 1: Localisation potential of PV panel components (adapted from EScience Associates, et al., 2013)

Silicon (C-Si) cell	
Localization potential:	**Low**
Enablers: • A pay-back period for solar cell manufacturing facility is approximately five years **Barriers:** • Highly competitive industry • Oversupply of capacities • The industry is divided into a technically differentiated, high efficiency cell segments and a bulk cell production segment with average efficiencies, which may be difficult to achieve in Eastern Africa • Most of these companies are forward integrated, which implies that they would supply only to its PV module manufacturing units	

<table>
<tr><td colspan="2">• Highly capital intensive to set up; financial assistance need to be offered to manufacturers to position it on par with manufacturing facilities in other countries, such as direct subsidies, reduced taxes, public guarantees, and interest-reduced loans
• Between 200-500 MW of stable annual demand for a period of five to ten years is required to justify investment in the PV cell manufacturing facility in the country (large scale)</td></tr>
<tr><td colspan="2">Lamination</td></tr>
<tr><td>Localization potential:</td><td>High</td></tr>
<tr><td colspan="2">Enablers:
• Predominately consists of labour costs that can already be localised by sourcing labour from within East Africa</td></tr>
<tr><td colspan="2">Aluminium frame</td></tr>
<tr><td>Localization potential:</td><td>Medium - high</td></tr>
<tr><td colspan="2">Enablers:
• Aluminium frames can be produced locally as per design of PV module manufacturers
• Aluminium could potentially be source from Mozambique, which boarders Zambia and Tanzania
Barriers:
• Aluminium as an input into the production process though it is often imported due to price competitiveness
• Raw aluminium is mostly imported from South Africa, i.e. in Kenya aluminium is approximately sourced 60% from South Africa and 40% from local scrap[1]</td></tr>
<tr><td colspan="2">Super-substrate (glass)</td></tr>
<tr><td>Localization potential:</td><td>Medium</td></tr>
<tr><td colspan="2">Industry profile:
• Global industry
o Globally, solar flat glass manufacturing is about 5% of the flat glass market, but it is expected to increase its share with the growth of the PV and CSP industries
o Glass production for the solar industry has been dominated by low iron pattern glass (rolled glass) for c-Si PV modules; a number of dedicated rolled glass production lines exist globally
o Increasing share of thin film PV technology, together with Concentrated Solar Power technologies, will drive the increase in low iron float glass production; due to the nature of the process and unit volumes required, dedicated float glass production lines are not economically feasible on each continent
• Local industry
o Three core input materials are required for glass production:
1. Sand with low-iron content (silica sand) can be procured locally (i.e. Kenya), but still undergoes the process of removing any excess of iron and drying
2. Dolomite and limestone, which are available locally or procured from neighbouring countries
3. Chemicals required to change the chemical composition of iron in the raw material mix for rolled glass production are imported</td></tr>
</table>

- Float iron glass is usually used only for thin-film, while rolled glass is used for polycrystalline PV panels
- Rolled glass production line is more labour intensive than float glass production line that is highly automated. On average:
  1. A rolled glass production line creates 42 jobs of which 28 are production line operators working in shifts
  2. A float glass production line create about 103 jobs of which about 60 are line operators working in shifts

Enablers:

- Expected increase in local PV module manufacturing capacities in the future and continuous research and development at the local glass manufacturing facilities provide for an opportunity to source glass locally
- High transport costs provide an opportunity for establishing glass manufacturing facility closer to the customer/PV module manufacturers (local)
- Rolled low-iron glass produced locally has received ISO 9050 certification and can achieve TVIS of 94% and TE of over 91%
- Thin film manufacturers are likely to accept a lower grade low-iron float glass for a lower price
- It is feasible for prices of local low-iron glass manufacturers to be on par or similar to European markets

Barriers:

- Local glass manufacturers cannot compete on price basis with imports from Asia, where production of glass is done on a large scale
- Selection of low iron glass is based on economics (lower costs) not marketing
- Not all low iron glass is equivalent of low iron solar glass; optimisation for the visible spectrum does not return the necessary value to justify the increased price in low iron solar price
- High performance coatings are becoming more sought after in addition to ultra-low iron glass
- Low iron raw material resources are limited and expensive
- Limited or no industry synergies exist; solar glass production is a very small part of an average glass manufacturer's business
- Having dedicated lines for solar glass production are only justifiable if sufficient demand is created and economies of scale are achieved; this is more applicable to rolled glass production lines than to float glass production lines
- Glass manufacturing is highly energy intensive (about 35% of total costs) and considering low availability of electricity in East African countries together with global solar glass manufacturing overcapacities, the costs of producing float glass could be significantly higher than the costs of importing them

EVA (Ethylene-vinyl acetate)

Localization potential:	Low

Barriers:

- Needs to be imported
- Supply chain is highly concentrated; thus potential for its localisation is limited but still exists if future demand would unlock economies of scale benefits

Backing sheet	
Localization potential:	Low
Barriers: • Needs to be imported • Supply chain is highly concentrated; thus potential for its localisation is limited	
Wiring (copper ribbon)	
Localization potential:	High
Industry profile: • Copper resources exist, mainly in the Copper Belt region of Northern Zambia and Southern Democratic Republic of Congo • Copper mining already established in the Copper Belt mines **Potential challenges:** • Due to high copper theft incidences, the use of copper ribbon with the wider dissemination of PV technology into medium and small scale could increase the incidence of PV module theft or damage	
Junction boxes	
Localization potential:	Medium
Barriers: • Needs to satisfy IEC standards • New manufacturing facilities with international know-how could be established but would require sustainable demand of about 300MW to make it economically viable	
Other	
Localization potential:	High
Enablers: • Packaging and transportation are easily localised	

[1] (Weramwanja, 2010)

Table 2: Localisation potential of PV inverters components (adapted from EScience Associates, et al., 2013)

Magnetics and transformers	
Localization potential:	High
Enablers: • Has a significant impact on total inverter costs • Steel (approximately 10% of total cost) and copper may be sourced locally	

Barriers: • Requires availability of mill equipment to make magnetics from steel, which may be difficult in East African countries • Large-scale utility projects often require optimal efficiency so international products are given priority to minimise losses	
Power stage and power electronics	
Localization potential:	Low
Barriers: • Quality issues • Noted difficulty establishing local manufacturing of power and semiconductor equipment in a case study of South Africa (mostly imported content), will most likely experience similar challenges	
Enclosure and packaging	
Localization potential:	High
Enablers: • Relatively easy to localise, consisting of a large portion of low level labour • Can be expensive to ship internationally for large-scale production of inverters (size and weight issues) **Barriers:** • Some suppliers prefer preassembled packaging especially for small-scale applications	
Printed Circuit Board/misc. Parts	
Localization potential:	Low - medium
Enablers: • Technically feasible for suppliers to make PCBs locally (66% cost from local labour, electricity, and machining) with imported materials (34% of total costs) **Barriers:** • Local suppliers have to compete with competitive international prices and labour costs (such as the Asian market)	
Assembly, production and testing	
Localization potential:	High
Enablers: • Largely consisting of labour available locally	

Table 3: The subcomponents of wind energy technology and the ratio of total component cost (adapted from Fingersh, et al., 2013)

Component	Manufacturing subcomponents and percentage of total component cost
Hub	• Ductile iron castings, 100%
Blades	• Fiberglass fabric, 60% • Vinyl type adhesives, 23% • Other externally threaded metal fasteners, including studs, 8% • Urethane and other foam products, 9%
Pitch mechanism and bearings	• Bearings, 50% • Drive motors, 20% • Speed reducer (i.e. gearing), 20% • Controller and drive, 10%
Gearbox	• Industrial high-speed drive and gear, 100%
Generator	• Motor and generator manufacturing, 100%
Frame	• Ductile iron castings, 100%
Shell and covers	• Fiberglass fabric, 55% • Vinyl type adhesives, 30% • Assembly labour, 15%
Electrical connections	• Switchgear and apparatus, 25% • Power wire and cable, 60% • Assembly labour, 15%
Electrical interface	• Power and distribution transformers, 40% • Switchgear and apparatus, 15% • Power wire and cable, 35% • Assembly labour, 10%
Tower	• Rolled steel shape manufacturing, 100%

Table 4: Localisation potential of wind energy components

Hub, frame and tower	
Localization potential:	High
Enablers: • Relatively simplistic product to manufacture • Steel may be sourced locally • Labour intensive industry, which may be sourced locally **Barriers:** • Will require large scale production to compete with well-established import markets that have low labour costs such as the Asian market	
Blades, shell and covers	
Localization potential:	Medium - high
Enablers: • Lignocellulosic fibres for fibre-reinforced plastic may be sourced locally from a variety of plants and wood • This manufacture process has a large portion of low level labour involvement, which is easy to source locally **Barriers:** • Economies of scale will require a large scale production to compete with import markets	
Pitch mechanism, gearbox, generator and bearings	
Localization potential:	Medium
Enablers: • Steel, aluminium and copper required for manufacture available in Eastern African countries • A large amount of assembly and labour is required, which is easily sourced locally **Barriers:** • Requires a large number of parts to manufacture motors and generators that will require large scale industries for each subcomponent to compete with import industries	
Electronics and wiring	
Localization potential:	High
Enablers: • Copper and steel resources available locally • Manufacturing process is relatively simple **Barriers:** • Due to high copper theft incidences, the use of copper ribbon with the wider dissemination of PV technology into medium and small scale could increase the incidence of PV module theft or damage	

4: Conclusion

As the market for small-scale renewable energy systems for electrification grows in Eastern Africa, so does the importance of localisation in that sector, as to grow the economy of these countries. Manufacturing plays a major part of this process and is currently very poor in terms of localisation. A big part of this is due to low cost of import. This report began to investigate the areas in which these countries could achieve local manufacturing by looking at each specific component that makes up the related renewable energy technologies, namely small-scale solar PV and wind.

A big barrier to localisation is economy of scale. To compete with the higher efficiency and lower cost of the import market, the local businesses need to progress from informal companies towards the large-scale formal economy. This will be difficult to achieve in countries that lack the infrastructure, funding, support and expertise required. The government will need to assist this through incentives, scrapping tax exemptions on imported renewable energy components and establishing local content requirements for companies.

One of the key manufacturing enablers is the availability of copper from the copper band in Northern Zambia, which could be used to establish the localisation of wiring and electronic component manufacture. Steel is also available for the manufacture of many wind energy components. Although solar has more potential in terms of resource availability, wind technology involves more labour intensive manufacture, which makes localisation easier to achieve. First tier manufacturing is, on the most part, not feasible in these countries and it is more viable to import components for local assembly.

5: References

EScience Associates, Urban-Econ Development Economists & Chris Ahlfeldt, 2013. *Photovoltaic Electricity: The localisation potential of Photovoltaics and a strategy to support the large scale roll-out in South Africa,* Cape Town: SAPVIA; WWF; DTI.

Fingersh, L., Hand, M. & Laxson, A., 2006. *Wind Turbine Design Cost and Scaling Model,* Colorado: NREL.

Hidalgo, C. A., 2012. *DISCOVERING EAST AFRICA'S INDUSTRIAL OPPORTUNITIES,* Massachusetts : Massachusetts Institute of Technology.

Princeton Energy Resources International, LLC, 2001. *Wind Turbine - Materials and Manufacturing Fact Sheet,* Rockville: Office of Industrial Technologies, US Department of Energy.

Weramwanja, P. M., 2010. *Aluminium Material Flow and Value Chain Analysis in the Kenyan Industry,* Nairobi: Jomo Kenyatta University of Agriculture and Technology.

World Bank, 2017. *State of Electricity Access Report,* Washington DC: documents.worldbank.org/curated/en/364571494517675149/full-report.

WWF, 2018. *Small-scale renewable energy technologies in East Africa: An overview,* Cape Town: WWF South Africa.