The insertion of local actors in the global value chains for solar PV and wind turbines in Kenya

Ulrich Elmer Hansen
PhD, Senior Researcher
UNEP DTU Partnership, Dept. of Management and Engineering
Technical University of Denmark

IREK
Innovation and Renewable Electrification in Kenya

This research is supported by the Danish Ministry of Foreign Affairs, Grant: DFC 14-09AAU.
IREK is a development research project on Innovation and Renewable Electrification in Kenya with research partners at Aalborg University (Denmark), African Centre for Technology Studies (Kenya) and Moi University (Kenya). IREK seeks to provide a better foundation for selecting and deploying available technologies in a way that increases inclusiveness and contributes to poverty reduction.
Read more about the IREK project at
IREKPROJECT.NET

How to cite this publication: Hansen, U. E. (2018). *The insertion of local actors in the global value chains for solar PV and wind turbines in Kenya* (IREK Working Paper No. 2). Copenhagen/Nairobi/Eldoret: AAU, ACTS and MU.

The insertion of local actors in the global value chains for solar PV and wind turbines in Kenya

Ulrich Elmer Hansen, PhD, Senior Researcher, UNEP DTU Partnership, Dept. of Management Engineering, Technical University of Denmark.

Abstract

With the increasingly market-based uptake of renewable energy technologies across countries in Sub-Saharan Africa (SSA), the extent to which and the nature of the involvement of local industrial actors merit attention. This report analyses the manner in which solar PV and wind turbines are transferred and diffused into Kenya, focusing on the involvement of local industrial actors in the import, local manufacture, distribution, sale, operation and service-related activities. The global value chain (GVC) perspective is used as the analytical framework and the report draws on primary and secondary data collected in Kenya. The report shows that the GVCs for wind turbines and solar PV in Kenya differ with respect to their organisation, technology origin and chain actors. Overall, the report finds that most of the key components and products are imported from producers located abroad. Hence, the extent of local production of wind turbines, solar panels and balance of plant components, such as batteries or inverters, is relatively limited. Most of the involvement of local industrial actors in the GVCs for wind turbines and solar PV is related to downstream activities, such as distribution, installation, and marketing and after-sales services. The report points at a need for further research exploring the insertion and upgrading in GVCs in the context of downstream activities both in relation to RE technologies in SSA and generally.

1. Introduction

The increasing uptake of renewable energy (RE), such as wind and solar PV, in Sub-Saharan Africa (SSA) is a prominent feature of the global transition toward sustainable sources of energy. It is, among other factors, made possible by the significant decrease in the costs and by the improvement in the efficiency of core technologies, such as solar panels, wind turbines, batteries, inverters and LED lights, the increasing purchasing power, the use of mobile phones and the new business models based on advanced information and communications technology (Nygaard et al., 2016). The shift away from conventional carbon-intensive sources of energy widely used in Africa, such as diesel and coal, toward the increasing adoption of RE takes place at an unprecedented scale, which is characterized by a movement from delivery models based mainly on donor and NGO-funded projects toward large-scale diffusion of RE technologies based on market conditions and private sector involvement (Hansen et al., 2015).

Such a transition raises interest into exploring the nature of the participation of local actors in the transfer and diffusion of RE technologies into SSA. So far, however, limited empirical research has been undertaken to address the extent to which and how local industrial actors in SSA countries are engaged in the import, local manufacture, distribution, sale, operation and service of the RE technologies. Indeed, detailed accounts of the specific mode or configuration of how RE technologies and related components are transferred and diffused in specific SSA countries remains largely under-researched. To contribute to overcome this knowledge gap, this report makes use of the global value chain framework (GVC) (Kaplinsky and Morris, 2003; Gereffi et al., 2005) to analyse the specific configuration of the GVCs for Solar PV and wind turbines in Kenya. The report focuses particularly on providing a detailed account of the degree and the specific character of the insertion and upgrading of local actors in the GVCs for solar PV and wind turbines in Kenya. Kenya is particularly interesting in this respect as it has spearheaded the market development in East Africa in terms of installed capacity, private market development, local industry formation and favorable national policy environment (Hansen et al., 2015). As has been shown in the technology life cycle literature (Huenteler et al., 2016), the industrial dynamics across solar PV and wind turbines differ. Accordingly, there are reasons to believe not only that the GVCs for wind turbines and solar PV differ, but also that the degree and nature of the insertion of local actors will vary. The main research questions addressed in the report are as follows:

- How do the GVCs for wind and solar PV in Kenya differ in terms of organisation, technology origin and chain actors?
- To what extent and how are local actors involved in the value chain activities?

The report is structured as follows. Section 2 presents the theoretical framework and the research methodology of the report. Section 3 provides a brief background on market development and renewable energy policies in Kenya. Section 4 will analyse the GVCs for wind turbines and solar PV. This provides a background for analysing in Section 5, the structure, the involved actors and the prospects for the insertion and upgrading in the value chains for wind turbines and solar PV in Kenya. Section 6 presents the main conclusions of the report.

2. Analytical framework and methodology

2.1. Insertion and upgrading in global value chains

The global value chain (GVC) framework has been developed as an analytical tool for understanding the implications of economic globalization and international trade on the competitiveness of firms in developing countries (Gereffi et al., 2005). It provides a perspective with which to analyse the full range of activities along the value chain involved in bringing a product or service from its initial conception and production to its end use and beyond (Kaplinsky and Morris, 2000). This involves analysing the structure, actors and dynamics of value chains, including the types and locations of chain actors, their mutual ties, and the dynamics of their inclusion and exclusion. It also entails understanding the structure of rewards, the division of labour along a chain, and the distribution of added value.

The GVC framework place particular emphasis on how so-called 'lead firms' organize and control activities with the purpose of achieving a certain functional division of labour along a value chain. By coordinating the functional division of labour, lead firms create governance structures that determine barriers to entry and the distribution of value-added activities in the value chain. Related to this is the concept of 'upgrading', which is used to describe how the competitiveness of developing-country firms may be improved by moving toward more rewarding functional positions in a value chain or by making products that have more value-added invested in them (Gereffi, 1999; Gibbon and Ponte, 2005). Lead firms accordingly play a key role in determining the opportunities for the insertion and upgrading of local suppliers in GVCs.

This conventional understanding of upgrading involves a gradual 'upward' movement in GVCs whereby local suppliers initially start out as sub-suppliers of parts or sub-systems of other companies’ products to eventually developing the skills to manage the design and branding of their own products (Humphrey and Schmitz, 2002). This upgrading process is shown in Fig. 1 below, which is typically referred to as 'functional' upgrading. Insertion in the value chain as producers of components is therefore typically considered a critical pre-condition or starting point in order to make further upward progress (Morrison et al., 2008). As formulated by Caniëls and Romijn (2008;260), upgrading therefore "*usually starts with the setting up of a new firm, or constructing a new production line in an existing firm, for the purpose of using a locally new production process in order to manufacture a new product that was hitherto imported, or locally unavailable at all*". Upgrading may also take place through the introduction of new techniques or machinery enabling local suppliers to turn inputs into outputs more efficiently (*process* upgrading) or by moving into the manufacture of more advanced products within the same product line (*product* upgrading).

Fig 1. GVC upgrading trajectory.

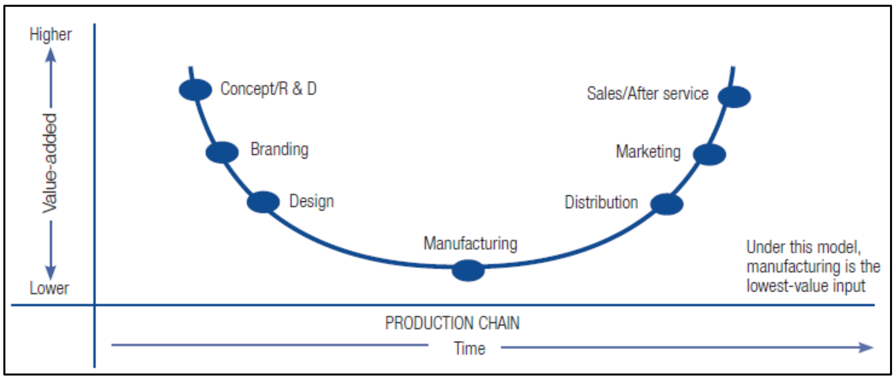
ASSEMBLY ↓	The focus is on production alone, often following buyers’ specifications and using materials supplied by the buyer .
ORIGINAL EQUIPMENT MANUFACTURE (OEM) ↓	The supplier takes on a broader range of manufacturing functions, possibly including the sourcing of inputs and logistics functions. The buyers is still responsible for design and marketing.
ORIGINAL DESIGN MANUFACTURE (ODM) ↓	In addition to manufacturing, the supplier carries out parts of the design process, possibly in collaboration with the buyer. In the most advanced cases, the buyer merely attaches its own brand, or “badge” to a product designed and made by the supplier .
ORIGINAL BRAND MANUFACTURE (OBM) ↓	The supplier takes on a broader range of manufacturing functions , possibly including the sourcing of inputs and logistics functions. The buyer is still responsible for design and marketing.

Source: Modified from Hobday (1995) and Gereffi (1999).

The upgrading process shown in Fig. 1 refers mainly to advancements made on the 'left' side of the typical 'smiling curve' of various GVCs where the initial insertion in value chains as local manufacturing involves the lowest value-added activities (see Fig. 2). While most GVC research on upgrading focuses on production-related (upstream) activities, this report places equal attention on analysing insertion in GVCs in the context of the (downstream) deployment, distribution and end-use segments of the value chain, which may include sale, marketing, advertising, brand management and after-sales services (i.e. the 'right' side of the smiling curve in Fig. 2) (Mudambi, 2008). This focus on the deployment-side is based in the understanding that the specialisation in downstream activities can also be a feasible strategy for local firms to improve their competitiveness and possibly reap some of the gains in value chains. Such a perspective is highly relevant in the context of the

GVCs analysed in this report where the end-markets and final byers are placed in the Global South (in this case, in Kenya) and, as we will see later, where the main technology and component suppliers are often imported from producers and developers located in the North. Hence, in contrast to the typical 'South-North'-oriented GVCs studied in the literature, the direction of the GVCs examined in this report are both 'North-South' and 'South-South'-oriented. Further, as the insertion of local suppliers in developing countries in downstream activities of GVCs has been left largely unaddressed in the literature, a conceptual terminology of upgrading in relation to downstream activities is currently lacking. The development of such a terminology is beyond the scope of this report and the focus will therefore mainly be on analysing the insertion of local actors in specific the downstream activities along the value chain. Finally, it should be noted that there is increasing attention on the chain-external conditions that may affect the prospects for insertion and upgrading in GVCs, such as national industrial policy, institutional aspects, national innovation systems (Bolwig et al., 2010; Pietrobelli and Rabellotti, 2011; Liu, 2016; Larsen and Hansen, 2017). The analysis of such conditions are not the main focus of this report, but will be dealt with where relevant.

Fig. 2 The GVC framework's 'smiling curve'[1].



Source: UNCTAD (2015).

2.3. Research methodology

The report is based mainly on a review of various reports prepared on the global value chains and the local industries in Kenya pertaining to wind turbines and solar PV systems. This includes consultancy reports, industry-specific reports and peer-reviewed papers of relevance for the topics addressed in the report. To verify the findings from these documentary sources, the report also draws on data obtained from fieldwork conducted in Kenya as part of the Innovation and Renewable Electrification in Kenya (IREK) project (see http://irekproject.net/). This includes interviews conducted in 2017 by project team members. The primary and secondary sources of data collected was analysed based on the key features of the GVC framework described above.

3. Renewable energy market development and policies in Kenya

Before proceeding, some brief remarks merit attention about the empirical context in which the transfer and diffusion of RE technologies in Kenya take place. The Kenyan solar PV sector has emerged since the 1980s, which in the beginning was mainly driven by international donors and NGOs who played a key role in providing rural institutions, such as schools and health clinics with solar-based lighting, water pumping and vaccine refrigeration (Ondraczek, 2013). Over time, donor support has gradually reduced and giving way for a more market-based development, especially since the 1990s in which private companies and consumers have driven the diffusion of solar PV

[1] Often the higher value-added activities at both ends of the smiling curve are portrayed in the GVC literature as being undertaken in developed countries while low value-added manufacturing is outsourced to developing countries (see e.g. Gereffi and Fernandez-Stark, 2016).

(Hansen et al., 2015). Especially the market for small-scale solar home systems have grown significantly and it is estimated that over 320,000 rural households have installed solar home systems (SHS) as of 2012 (Lay et al., 2013). Other markets have emerged more recently, which include a rapid increase in the sale of small-scale solar PICO systems, such as solar lanterns and lightning, and private businesses providing such systems (Nygaard et al., 2016). Further, the development of solar-based mini-grids and large-scale solar power plants has also recently become a reality in Kenya although still at a limited scale. The development of the market for wind turbines in Kenya has developed somewhat differently. The use of small-scale wind turbines in Kenya date back to the 1980s and has mainly been related to water pumping. By 2005 about 300-350 windmills were in operation. The market for electricity-producing (small-scale) wind turbines in Kenya has only made limited progress in terms of installed capacity and sales. Indeed, Vanheule (2012) estimates that a total of around 500-1000 small-scale wind turbines have been installed in Kenya since the 1980s, corresponding to a total installed capacity of around 20 MW (Tigabu et al., 2017). More recently, a number of larger scale wind turbines have been implemented as part of wind-powered mini-grids and large-scale wind power plants, not least the Lake Turkana project (Hansen, 2017). Some of the main policies adopted in Kenya to stimulate the diffusion of solar PV and wind turbines includes the Energy Act (2006), the Kenya Rural Electrification Master Plan, the Feed-in Tariff, the Kenya Vision 2030 and the National Climate Change Response Strategy of 2010 (Tigabu et al., 2017). The Kenyan government has also removed value-added tax (VAT) on imported renewable energy equipment and accessories.

4. Analysis of the GVCs for wind turbines and solar PV

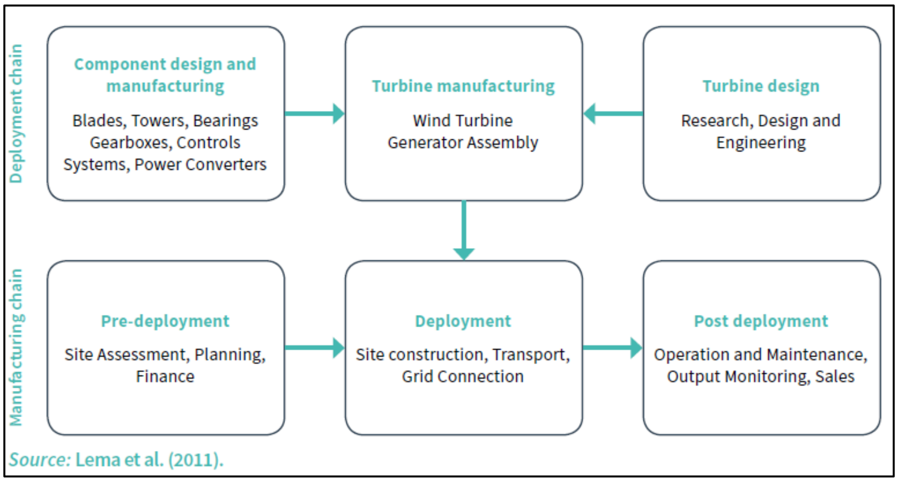
4.1. The global wind turbine value chain

The global wind turbine industry resembles a so-called producer-driven value chain (Gereffi, 2001), in which lead firms coordinate the production networks of component suppliers, and where competition is mainly based on technological progress through continued R&D. The industry is dominated by a few large lead firms mainly from Europe but increasingly also from Asian countries, in particular China and India. The large lead firms include Vestas, Siemens, General Electric, Gamesa, Sinovel, Goldwind and Suzlon. The tendency among these lead firms is to focus their activities increasingly on the parts of the value chain with the highest value-added, such as R&D, engineering and other knowledge-intensive activities (Lema and Lema, 2012). Over the past decades, the scale, efficiency and technological complexity of wind turbines developed by lead firms has increased significantly. While the capacity of an average wind turbine increased from 75 kW between 1980 and 1990, average capacity reached 750 kW in 1995-2000 and 1,800 kW in 2005-2010 (IEA, 2013).

Various studies have analysed the development of local wind turbine industries, focusing mainly on Europe and the US (Garud and Karnøe, 2003), but increasingly also in relation to China and India (Mizuno, 2007; Lewis, 2011). While these studies forms the basis for elaborating the basic conditions for the insertion and upgrading in the wind turbine GVC either through local manufacturing or other forms of activities, they are based on studies of firms engaged in large-scale wind turbines (<20kW and up 850kW). It is prerogative to note that in the Kenyan context a variety of wind turbines exist of a much smaller scale and capacity comparably and the GVC conditions may thus differ accordingly (see Section 5.1 below).

The prospects for the insertion in the wind turbine GVC for large-scale wind power through the establishment of local manufacturing of key wind turbine components in Kenya is limited in relation to core components, such as blades and nacelle components, including gearboxes, bearings and generators (see Fig. 3). This is due to the significant barriers to entry arising from the high quality requirements, which means that lead firms typically either retain in-house control of the development and production of the core wind turbine components or outsource these to a few specialized global first-tier suppliers, such as LM Wind Power in the case of blades. Components that are less complex to produce and which are cost-effective to localise in terms of production due to their bulky nature, such as towers or castings, for example, may involve lower barriers to entry for local producers (Elola et al., 2013). On this basis, Schmidt and Huenteler (2016;12) suggests that local production of wind turbine components in a lower middle income developing country, such as Kenya, can only be expected "*for bulky and rather easy-to-manufacture parts*" (including so-called 'peripheral components', such as input materials, steel and mounting structures) (see Fig. 4). Local involvement may however also be expected in relation to installation and deployment-related activities, suggesting that downstream activities could potentially involve opportunities for insertion and upgrading of local producers in the GVC for large-scale wind turbines. Lead firms are expected to play a smaller role in the GVC for small-scale wind turbines since most of the lead firms focuses on the global market for large-scale plants. Moreover, due to their lower complexity and scale compared to large-scale wind turbines, small-scale wind turbines may be produced and diffused exclusively by local producers and suppliers. The suggestion in Schmidt and Huenteler (2016;15) is therefore that for so-called 'simple technologies' (see Fig. 4), such as small-scale wind turbines, local welders, technicians, and businesses are able to capture "*large shares of the value chain*" (see also Leary et al., 2012).

Fig. 3. Global wind turbine value chain.



Source: Lema et al. (2011).

Fig. 4. Anticipated localization of production of key wind turbine and solar PV components.

Table 1
A heuristic to anticipate localization effects beyond operation and maintenance of deployment policies for different types of technologies and countries.

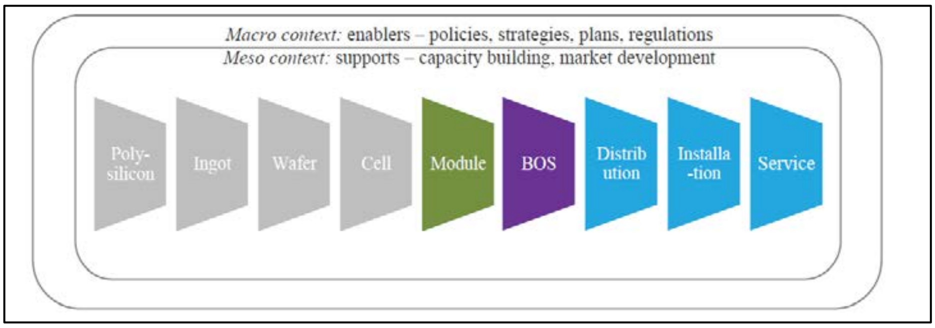
	Low-income country	Middle-income country	High-income country
Simple technologies	• Large shares of value chain	• Large shares of value chain	• Large shares of value chain
Design-intensive technologies	• Peripheral components	• Installation • Components	• Core components • System integration
Manufacturing-intensive technologies	• Installation	• Installation • Production	• Installation • Production • (Manufacturing equipment)
Design- and manufacturing-intensive technologies		• Installation • (Simple) components	• System integration • Core components • Manufacturing equipment

Source: Schmidt and Huenteler (2016).
Note: Wind turbines falls within the category of 'Design-intensive technologies' while solar PV falls under the category of 'Manufacturing-intensive technologies'.

4.2. The global solar PV value chain

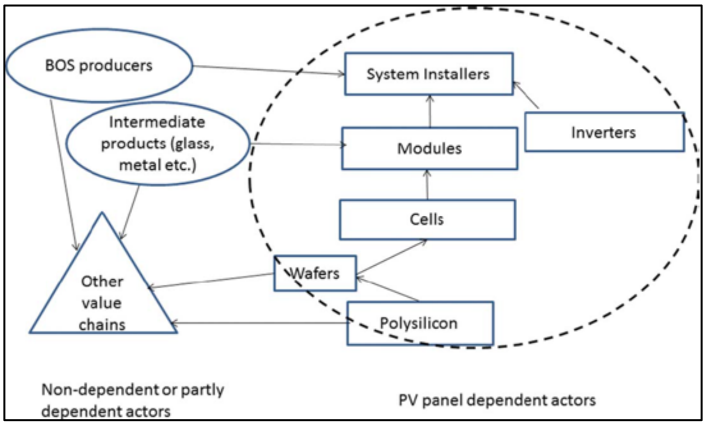
The global solar PV value chain is characterised by various activities centred around the production and deployment of solar modules as the main component used in solar plants deployed at various scales globally. The manufacture of solar panels and larger modules in assembly plants comprises a set of interconnected activities and input materials, which include four main steps: (i) the casting of silicon into ingots; (ii) the slicing of a wafer from the ingot block; (iii) turning the wafer in to a cell through etching and polishing, cleaning, application of anti-reflective coating, screen printing; and finally (iv) soldering cells together into modules (Zhang and Gallagher, 2016) (See Figures 5 and 6 below). The lead firms that dominate the manufacturing of (crystalline-based) solar modules in the global solar PV value chain includes companies mainly from Germany, China, Japan and the US, such as Kyocera, Sharp, Yingli, Sanyo, Schuco, Solon, Schott, Conergy, REC, Solarworld, Canadian Solar and ET Solar. While some companies are specialised in upstream activities, such as ingot and wafer production, there has been a trend toward vertical integration in the industry. This means that lead firms increasingly control and have ownership over the upstream production activities from ingot and wafer production to the production of cells and assembly of solar panels and modules. The production of solar panels and modules in assembly lines is typically a highly specialised and automated process, which is similar to other mass-produced goods and commodities, such as consumer electronics (Huenteler et al., 2016).

Fig. 5. The solar PV value chain.



Source: ISEI (2012).

Fig. 6. Production network for solar panels.

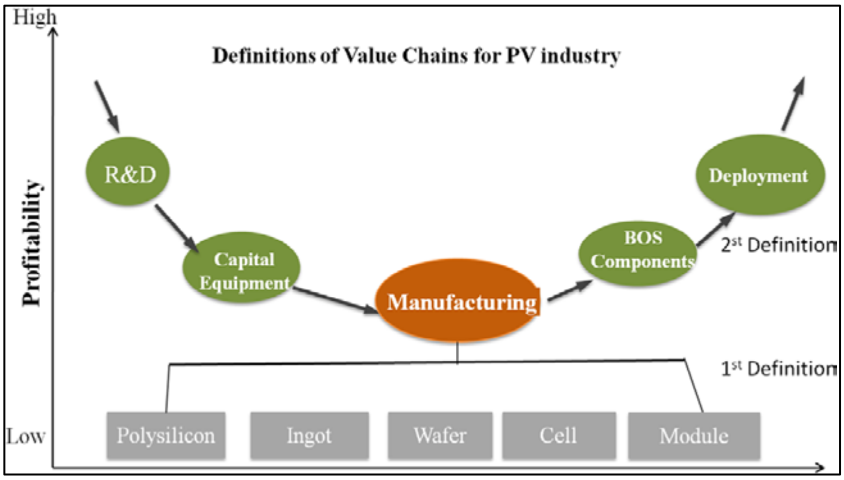


Source: Curran (2015).

While R&D activities in solar PV technology are mainly undertaken at universities and within R&D departments in lead firms in Europe, the US, Japan and South Korea, manufacturing activities in the global solar PV value chain have increasingly become concentrated in China. The closure of the Spanish PV programme in 2008 led to a substantial global overcapacity in PV cell and module production (Bazilian et al. 2013). The resulting overcapacity led to increased competition among module suppliers and further improvements in economies of scale, which resulted in a general industry 'shake out' and consolidation of production activities in a few, large producers concentrated in China (REN21, 2013). As a result, China produced more than 74% of global PV modules in 2014, which can be ascribed to a combination of a number of factors, such as lower labour costs, availability of local raw materials and components and larger production systems (economies of scale).

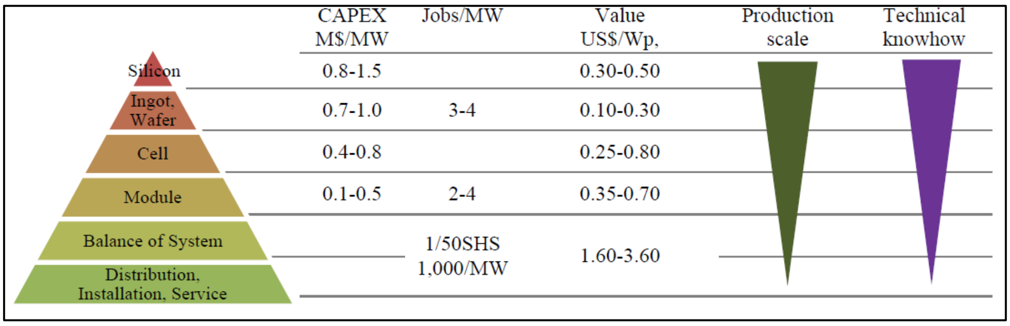
Value-added activities in the global solar PV value chain can also be described in terms of a smiling curve in which the manufacturing and assembly of solar PV panels and modules constitute the lowest level of value-added (Fig. 7). R&D activities have traditionally focused on process efficiency improvements and economies of scale to reduce manufacturing costs in cell and module production plants (Jäger-Waldau 2013). Value-added in the downstream activities in the value chain is related to the input of auxiliary balance of plant (BOS) components, such as inverters, charge controllers and batteries, and the integration, installation and operation of total PV systems (Zhang and Gallagher, 2016). Fig. 8 provide an illustration of these downstream activities in terms of the potential prospects for employment, barriers to entry (measured by required investments) and value-added.

Fig. 7. The smiling curve of the global solar PV value chain.



Source: Zhang and Gallagher (2016).

Fig. 8. Solar PV industry investment, jobs, value added and barriers to entry.



Source: ISEI (2012).

The barriers to entry in the global solar PV value chain by becoming a global supplier of solar panels and modules are currently very high given the strong competitive position of Chinese suppliers (ISEI, 2012). In contrast, the prospects for the insertion of local suppliers in the solar PV value chain through the establishment of local solar module assembly plants targeted at the national and regional markets are brighter. Fully operational solar PV module assembly lines can be purchased and installed as a package from international suppliers at relatively low costs and the operation of such plants does not require highly specialised technical expertise. The establishment of local solar PV assembly plants will however also depend on the size of the demand, economies of scale, the maturity of existing supply chains and input factor costs. As the barriers to entry in downstream activities are much lower and at the same time involve significant opportunities for employment and value-added, insertion of local suppliers in a lower middle income developing country, such as Kenya, are very likely to materialise (see also Fig. 4 with reference to 'manufacturing-intensive technologies'). Indeed, as argued by Schmidt and Huenteler (2016), "*a local industry around downstream activities (e.g. installation) can be anticipated..resulting in domestic assembly of solar cells into modules. In these cases, (mostly regional) export might be possible*".

5. The national value chains in Kenya for wind turbines and solar PV

5.1. The value chain for wind turbines in Kenya

The manner in which wind turbines and related components are developed, transferred and diffused in Kenya seem to differ across the scale and capacity of the specific types of wind turbines in question. Therefore, the nature of the value chain and the inherent value chain characteristics, including the governance structure, the importance of lead firms and the entry barriers for local suppliers, differs across the specific types of wind turbines. As shown in Fig. 8 below, one may distinguish between three types of wind turbines imported, locally produced and sold in Kenya, depending on their main technological characteristics. To this comes a fourth category, which involves wind turbines with capacities significantly above 10 kW and up to 850 kW used in the large-scale wind power plants constructed in Kenya.

Fig. 8. Types of wind turbines manufactured and imported in Kenya.

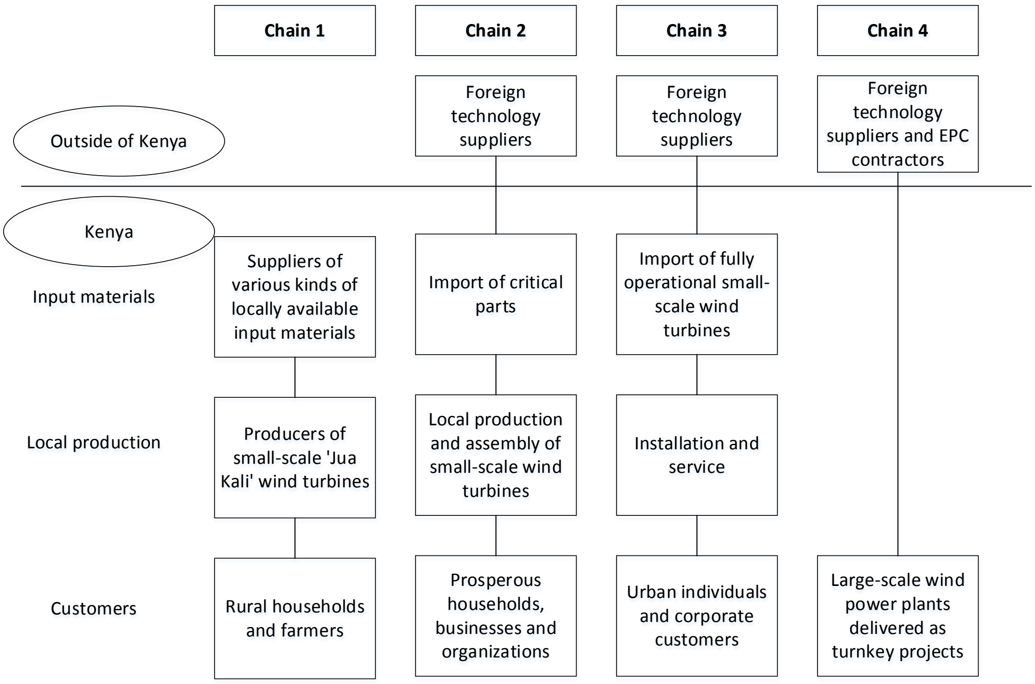
Table 3: Characteristics of Jua Kali, formally manufactured and imported turbines

Aspect	Informal manufacturing	Local manufacturing	Imported turbines
Production	(Very) small scale Local scrap/ spare parts	Small scale local (quality) materials	Mass scale
Power	20-300W	200W – 10kW	200W-10kW
Efficiency	Very low	Medium	High
Cost	Very low – low	Medium	High
Quality	Low	Medium	Reliable and well-tested
Repair and maintenance	Can be locally repaired (spare parts available)	Can be locally repaired Spare parts available	Local skills and spare parts may not be available

Source: Vanheule (2012).

The value chain related to the first category of so-called 'informal manufacturing' is highly localised and characterised by relatively simple and short linkages between local producers of small-scale 'Jua Kali' wind turbines (20-300W) and suppliers of various kinds of locally available input materials. These local (informal) producers typically consist of local welders, craftsmen, electricians and mechanics, who are involved in the design, manufacture and sale of these small-scale wind turbines themselves, mainly to supply rural households and farmers (see Fig. 9). The technologies are small and relatively simple systems that are developed based on own designs mainly from copy and imitation of imported goods, catalogues and from other local artisans (Vanheule, 2012). The barriers to entry are relatively low and mainly require some level of basic understanding of wind turbines and electro-mechanics.

Fig. 9. Value chains for wind turbines in Kenya.



Source: Authors elaboration.

This is contrasted to the value chain conditions related to the second category of so-called 'formal manufacturing' of wind turbines with a higher capacity (200W-10kW), which involves a smaller number of enterprises with a formal license to operate, which among others include the companies Craftskills, WindGen (now called PowerGen), WinAfrique, Access:Energy, Chloride Exide and RIWIK (AHK, 2013; Carbon Africa Limited, 2015). These companies produce wind turbines in local factories mainly based on open source designs and by using locally available spare parts and materials. Vanheule (2012) estimated that in 2012, around 120 to 150 turbines in this category had been sold in Kenya by such local producers. The wind turbines are sold under their own company brand names primarily to prosperous households, businesses and organizations and the wind turbine suppliers are involved in all aspects from production to installation and maintenance. As shown in Fig. 9, this typically involves local production and assembly of the wind turbines, including import of critical parts, and after sale service to customers. The entry barriers to becoming inserted in the value chain through formal manufacturing are somewhat higher compared to informal manufacturing as it requires an established brand name with higher quality requirements for the wind turbines in order to meet the expectations of higher income customers. Typically, therefore, investments in improving and maintaining higher quality standards are essential aspects to consider in order to sustaining trust in the company and the technology in order to gaining market shares (Leary et al., 2012).

The third category of wind turbines to be found in the Kenyan market involves the import of fully operational, pre-fabricated systems from renowned wind turbine suppliers abroad. Such systems appear to have been used in the three existing hybrid wind-diesel mini-grids constructed in Kenya until now in Marsabit, Habaswein and Ngong (Hansen et al., 2017). There are around 20 companies in Kenya involved in the import such systems, which include companies such as EAWEL and Davis and Shirtliff, who mainly operate as wholesalers and distributors (Kamp and Vanheule, 2015). Their offices are located in Nairobi and in other large cities in close vicinity to their main customers, which mainly include wealthy urban individuals and corporate customers, such as telecommunications companies and hotels. The import and further sale of wind turbines by these companies is typically undertaken as a smaller part of a broader portfolio of products and services offered by these companies. The companies involved in importing wind turbines are therefore typically larger businesses compared to the abovementioned local companies involved in informal and formal manufacturing of wind turbines. Given the higher complexity of the imported wind turbines compared to the locally-produced wind turbines, the wind turbine importers also appear to be involved in the provision of a range of consultancy services in relation to the sale of wind turbines to local customers. The barriers to enter the value chain by importing wind turbines therefore seem to be higher compared to engaging in the segment for informal and formal manufacturing of wind turbines, as it requires specialised expertise in the operational aspects of the imported turbines. Such expertise is needed in order to offer related services to (high-end) customers, which can justify the higher price and quality standards compared to the locally manufactured wind turbines. It should be noted that reportedly some of the companies involved in importing wind turbines are considering importing Chinese systems in order to reduce the costs of their products (Kamp and Vanheule, 2015).

Finally, in the value chain related to large-scale wind power projects planned and constructed in Kenya, lead firms in cooperation with international construction and engineering companies play an essential role in all of the stages related to the import, installation and operation of the wind turbines used the plants. In these projects, lead firms, such as Vestas, General Electric and Iberdrola, are typically involved as total system suppliers - in so-called engineering, procurement and construction (EPC) contracts - under which they are responsible for the detailed engineering design of the project, the procurement of all the equipment and materials necessary and the construction and delivery of a fully operational (turnkey) plant to their clients. This means that in these plants all of the main components, such as blades, towers and nacelle comments, are imported (often from production facilities in Europe or China), and assembled on-site by the lead firms, who handle and control the entire value chain of the projects. Based on the available evidence, it appears that local entities have only to a limited degree been involved in these projects, mainly in relation to the construction and installation of the plants, including transport and logistics, as well as operation and maintenance. In the Lake Turkana project, for example, the involvement of local companies include SECO (site contractor of office buildings), and CIVICON (site contactor of roads) and the utility company KETRACO (transmission lines), while Vestas is reportedly responsible for maintenance and repair of components in large workshops on site: out of a total of 150 engineers currently working on-site, 95% are international and 5% are local technicians. The barriers to entry for local companies to advance beyond these project-related construction activities, for example by engaging in the EPC activities undertaken by lead firms, are very high as it involves significant technical expertise, and organisational and financial capacity to be contracted in the projects and to executive them effectively.

5.2. Discussion of key findings on wind turbines in Kenya

It is evident there are indeed a number of local actors, such as companies, entrepreneurs and technicians, which are engaged in downstream activities in the value chain for small-scale wind turbines in Kenya. These downstream activities include installation and end-use-related activities, such as service, repair and maintenance. In relation to such relatively 'simple technologies', local actors are thereby able to capture large shares of the value chain as predicted by Schmidt and Huenteler (2016). There may be a possibility for the 'upgrading' of local companies from informal to formal manufacturing by investing in the production of higher quality (value-added) activities and possibly even to 'advance' further to become involved in the import and sale of high quality wind turbines from abroad. However, this should not be interpreted as a linear trajectory of progression, but rather as separate segments of the value chain that local companies may enter and become specialised depending on the chosen strategy. Interestingly, reaping benefits in the value chain for small-scale wind turbines in Kenya not only involves specialising in local production, but also in downstream activities, including installation, service, operation and maintenance and consultancy services. Therefore, it appears that overall there is a multitude of ways for local actors to become inserted in the value chain for small-scale wind turbine turbines in Kenya, which depends in particular on the scale and complexity of the turbines. In this context, it should be noted that contrary to expectations, a global lead firm in the wind turbine industry, Vestas, is currently in the process of developing a small-scale, low-cost and partly locally-produced wind turbine in Kenya[2]. While it is too early to analyse the implications for the local small-scale wind turbine industry in Kenya, two opposite scenarios could be conceivable. The establishment of local production and the development of a competitive technology could squeeze local competitors out of the market with a consequent loss of employment and income-generation. Conversely, local production of a Vestas turbine could contribute to create employment in manufacturing and opportunities for becoming inserted in the value chain for sub-suppliers and in downstream activities.

The opportunities for insertion and upgrading of local companies in higher value-added activities related to large-scale wind power plants hinges critically upon linkages to lead firms as basis for learning through spillovers. This seems to create a catch-22 situation for the local companies: they need to become involved, for example, in the project-related engineering activities in order to learn and acquire capabilities from lead firms, but they need such skills to become contracted to undertake engineering tasks in the first place. The localisation of production of key wind turbine components used in these large-scale plants also seems unlikely in Kenya due to the high quality standards and the limited market opportunities. Local production of towers could however materialise, for example under license agreements with foreign technology suppliers as have been observed in South Africa for example (Rennkamp and Boyd, 2015). The localisation of production of wind turbine components may be supported through local content requirements or similar industrial policy measures (Johnson, 2016; Larsen and Hansen, 2017). There may also be opportunities for local companies and individual craftsmen, welders and technicians to become

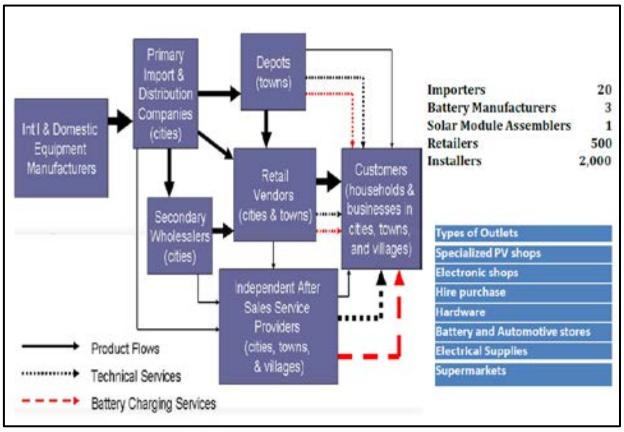
[2] http://www.unepdtu.org/newsbase/2017/01/udp-part-of-new-project-in-kenya-an-example-of-strong-public-private-partnership?id=861237d3-edf9-45df-92bf-dda109a218c6

inserted in the value chain for large-scale wind power projects in relation to maintenance activities as the competence requirements are lower compared to core engineering tasks.

5.3. The value chain for solar PV in Kenya

Solar PV panels are imported, produced and diffused in different markets in Kenya, which span from small-scale solar home systems (SHS) to mini-grids and large-scale (utility) power plants (Pedersen, 2016). The PV systems installed across these market segments share in common that they all involve solar panels as the core component, which differ in terms of their design and capacities. Due to the modularity of the solar panels, they can be installed as single panels in smaller units or as modules combined in larger arrays comprising multiple modules. The value chain for solar PV in Kenya may be described according to three main segments: (i) primary import of key components; (ii) local production and assembly of core components; and (iii) wholesale, retail and local distribution (see Fig. 10).

Fig. 10. Solar PV value chain in Kenya.



Source: Muchunku (2013).

There are number of local companies in Kenya involved as primary importers of solar panels and auxiliary components, such as inverters, charge controllers and batteries, under agreements with foreign suppliers to distribute and sell their products. Estimations suggest that there are around 10-20 local companies involved in the import and further sale of solar panels and auxiliary components to projects and systems at various scales in Kenya (AHK, 2013; Muchunku, 2013). These companies, which include Chloride Exide, Centre for Alternative Technologies (CAT), Davis & Shirtliff, Solar Works and Harmonic Systems, are typically larger businesses that offer a range of products and related engineering and consultancy services. An illustrative example is the Kenyan-based company, Solar Works, which imports solar panels and inverters from German companies, such as Energiebau Solarstromsysteme GmbH, Schott Solar, SMA Solar Systems and (Hille and Franz, 2011; AHK, 2013). Similarly, Davis & Shirtliff imports solar panels from Yingli in China and batteries from Yuasa in Japan. In other cases, the importers operate as local subsidiaries of foreign technology suppliers, such as in the case of the companies Suntech Power Ltd. and Dreampower Ltd., which import solar modules from their parent companies in China and Italy. Hence, there are both vertically integrated forms of relationships between the primary importers of solar panels and foreign technology suppliers, and other types of relationships that are based on sales agreements and arms-length transactions. In some cases, these primary importers supply components and engineering consultancy in relation to individual projects, including mini-grids and large-scale solar power plants (Hansen, 2017). In other cases, they supply individual components to wholesalers and local dealers further downstream in the value chain. It should be noted that in the case of large-scale solar plants, additional local engineering consultants are typically involved as turnkey contractors, such as Azimuth Power[3] and Questworks[4]. The entry barriers for small local companies (and start-ups) to becoming inserted in the solar PV value chain in Kenya as primary importers of core components are relatively high. This is due to the relative large size and organisational capacity of these companies and the appertaining skills in related engineering and consultancy services.

Local production and assembly of core solar PV components are limited to a few local companies mainly involved in the assembly of solar modules and local production of batteries. The only local assembly factory of solar modules in Kenya (and in East Africa) involves the company Solinc East Africa Ltd., which was established in 2009 (which, at that time, was called Ubbink East Africa Ltd). It was established as a joint venture between the Dutch company Ubbink B.V. and the Kenyan-based company Associated Battery Manufacturer Ltd. (ABM) [5]. Since 2015, the majority ownership of Solinc East Africa Ltd has been Kenyan. The company has teamed up with the local provider of batteries, Chloride Exide, to sell its solar modules to the Kenyan market, but the company also have local sales offices in the region. Currently, the only local manufacturer of batteries for solar PV systems is ABM[6], who produces batteries based on license agreements with various UK-based companies. There have evidently been a number of additional local producers of batteries to solar PV systems, most of which were mainly producers of car (lead acid) batteries, such as the company Automotive & Industrial Battery Manufacturers Ltd. (AIBM), and of other components, such as charge controllers and monitors. However, according to Byrne (2011;110;223) local manufacturing of such (BOS) components "*has almost disappeared as a result of Chinese-made products coming into the Kenyan market*", since "*Chinese firms were able to manufacture them with higher quality and lower prices than Kenyan firms*". Hence, the barriers to becoming inserted in the solar PV value chain as local producers of solar modules and other core components are quite high given the reduced comparative advantage of local production compared to the import of Chinese products. The establishment of local production and assembly lines also requires access to (upfront) investment capital and low cost subcomponents, such as wafers, frames, laminate and glass, which may not necessarily be available. Other factors of relevance for the establishment of local solar PV assembly plants include the size of the local and regional demand.

Finally, the downstream activities in the solar PV value chain in Kenya involves wholesale, retail vendors and local distribution of solar panels and components toward the final installation stage and end-use (Fig. 10). According to AHK (2013) and KCIC (2016), there are hundreds of retail shops that supply (mainly imported) PV panels and other auxiliary components directly over-the-counter to consumers throughout Kenya in local shops, supermarkets and stockists. Generally, it appears that the further downstream in the solar PV value chain, the more local actors are involved in the form of local businesses, technicians and individual operators that are (sometimes loosely) connected to solar distributors or retailers (AHK, 2013). Most of these local entities are involved in the supply of small-scale solar (PICO) PV systems and solar home systems to customers in rural areas, which has developed into a particularly vibrant local industry (Nygaard et al., 2016). To illustrate the scale of this local industry, IRENA (2017) estimates that the two dominating local suppliers of small-scale solar home systems based in Kenya, M-KOPA and Azuri Technologies, currently employ around 3,000 workers in East Africa, of which the majority work in Kenya (see also Rolffs et al., 2015).

5.4. Discussion of key findings on solar PV in Kenya

The insertion of local businesses and individuals in Kenya in the solar PV value chain has in particular taken place through engagement in downstream activities, such as wholesale, retail and

[3] http://azimuthpower.com/
[4] https://www.questworks.co.ke/
[5] http://www.solinc.co.ke/about-1/#history
[6] http://www.abmeastafrica.com/

distribution through local sales offices and installation tasks. While attractive for local suppliers to engage in downstream activities due to relatively low entry barriers, such a strategy may however in the long term according to Gereffi (2014;23) "*lock suppliers into slimmer margins and cutthroat competition*". Hence, the scale of the market and the specific activities undertaken by local actors in the downstream segments of the value chain will be elements to consider in terms of identifying a profitable strategy. The insertion in the solar PV value chain through the establishment of local assembly plants and local production of core components involves the lowest value-added potential and is furthermore complicated by the import of low-cost products from China. Not surprisingly, therefore, only a limited number of local companies have established local production, and, in line with expectations, these companies focus on the national and regional market as opposed to the global market (Schmidt and Huenteler, 2016). The local companies involved in the primary import of solar PV panels and modules have existed for an extended period and have developed into relative large companies. Not least due the establishment of direct linkages with foreign technology suppliers, these primary importers occupy a central position in the value chain, which creates high entry barriers for local companies aspiring to 'advance' into such a position. Finally, the involvement of local companies in mini-grids and large-scale solar power projects constructed in Kenya seem to be limited to a few local consultancy companies and local technicians involved in plant installation and operation. The local consultants have been involved in these projects as sub-contractors to the foreign EPC contractors responsible for the delivery of a fully operational turnkey plant (Hansen, 2017). However, over time it may be possible for the local consultants to independently venture into the development of projects on their own based on the accumulated expertise from prior project involvement. This will depend inter alia on the spillover of knowledge from the foreign contractors, but the manifestations of such effects on the local industry are not observable at this stage.

6. Concluding remarks

The point of departure of this report was the recognition of the increasing uptake of RE technologies, such as solar PV and wind turbines, across countries in SSA in general and in Kenya in particular. The transition away from the use of fossil fuels toward the increasing use of RE technologies is clearly demonstrated in the case of the accelerated uptake of solar PV and wind turbines in Kenya. The report set out to analyse the manner in which solar PV and wind turbines are transferred and diffused into Kenya focusing particularly on the possible involvement of local industrial actors in activities along the value chain. The report set out to address two inter-linked questions, which will be discussed in the following:

- How do the GVCs for wind and solar PV in Kenya differ in terms of organisation, technology origin and chain actors?
- To what extent and how are local actors involved in the value chain activities?

As shown in Table 1, the report finds that the value chains for wind turbines and solar PV in Kenya differ in terms of their organisation, technology origin and chain actors. The value chain for wind turbines in Kenya involves a number of local (informal and formal) manufacturers of small-scale wind turbines. In contrast, the value chain for (small-scale) solar PV in Kenya is dominated by a centrally placed node in the form of a number of primary importers of solar panels and modules and other core components (mainly imported from Europe and China), with only a few local production facilities and assembly plants. Generally, however, it appears that both value chains for solar PV and wind turbines in Kenya are dominated by a reliance on technologies and products imported from abroad. Moreover, the solar PV value chain in Kenya related to solar home systems involves a well-developed industry with numerous actors involved throughout the entire downstream value chain from wholesale, retail, to distribution and local sales outlets. The value chain for wind turbines in Kenya does not involve a similar pattern of interconnected retail and distribution networks throughout the country and is shorter and more 'localized' (Huenteler et al., 2016). This may be due to the nature of solar panels as a mass-produced good that can be purchased on an over-the-counter basis, which does not appear to be the case for small-scale wind turbines. In the case of larger scale systems, such as mini-grids and grid-connected power plants, some commonalities appear across the GVCs for solar PV and wind turbines. The solar panels and the wind turbines used in these plants are typically imported and installed with auxiliary (BOS) components on-site by the local companies involved as importers of the core components. In these plants, foreign lead firms play a major role as EPC contractors and the involvement of local companies are mainly confined to construction activities, operation and, to some extent, engineering consultancy. The GVCs pertaining to these plants may be described as highly project-based where the imported components are related to the individual plants (Hansen et al., 2014).

Table 1. Technology origin (foreign/local) and involvement of local actors.

	Large-scale wind turbines	**Small-scale wind turbines**	**Large-scale solar (mini-grids, grid-connected)**	**Small-scale solar systems (SHS, Pico systems)**
Core components	• Import of blades, towers and nacelle components	• Local assembly of turbines (20W-10kW) • Import of turbines (200W-10kW)	• Import of panels	• Import of PICO products and panels • One local solar panel assembly plant
BOS components	• Import of all BOS components	• Import of batteries, inverters, charge controllers,	• Import of monitoring equipment, charge controllers, inverters,	• One local battery production plant • Import of inverters, batteries, charge controllers,
Installation and operation	• Foreign engineers and system design • Local construction companies • Local operators	• Local suppliers responsible for all installation aspects • End-use by customers	• Foreign engineers and system design • Local construction companies • Local operators	• Local suppliers responsible for all installation aspects • End-use by customers
Planning and consultancy	• Foreign EPC/turnkey contractors • Local engineering consultancy companies	• Local suppliers responsible for all design aspects	• Foreign EPC contractors • Local engineering consultancy companies	• Local suppliers responsible for all design aspects

Source: Authors own elaboration.

The findings of the report give rise to a number of reflections about the GVC framework on upgrading. As mentioned, the conventional understanding of 'upgrading' in the GVC literature focuses narrowly on the initial insertion in GVCs as producers of components and subsequent functional upgrading toward higher value-added activities, such as design, branding and R&D. Based on this understanding, it would be logical to conclude that due to the relatively limited degree of local manufacturing of solar PV and wind turbines in Kenya, and the limited progression of local firms along the conventional OEM-ODM-OBM trajectory (see Fig. 1), only limited value chain insertion and upgrading has taken place in this case. However, the report clearly shows that local actors in Kenya are indeed inserted in the GVCs for solar PV and wind turbines although mainly in relation to deployment activities downstream, including distribution, consultancy, sales, installation, after-sales services, operation and maintenance, marketing and end-use. Based on this report it is not possible to assess the possible gains for local actors through their involvement in such activities in terms of capturing economic value and employment. Notwithstanding, the report highlights a need in the GVC literature to play closer attention to analysing insertion and upgrading in value chains in relation to downstream activities. Subsequent analysis could therefore not only benefit from additional empirical research along these lines but also from the development of a conceptual terminology for the understanding of upgrading in the context of downstream activities. Not least in the case of non-conventional North-South or South-South-oriented GVCs (as opposed to conventional South-North-oriented GVCs), such as renewable energy technologies, where the end-markets and customers are located in the Global South as has been shown in this report.

This should not be interpreted to suggest that the establishment of local manufacturing is irrelevant. Quite the contrary in fact, considering the general 'manufacturing deficit' through Sub-Saharan Africa, as reflected for example in the low share of manufacturing compared to service activities (Newman et al., 2016). Hence, reducing the reliance on import of products and components manufactured abroad through the localisation of such activities may still be a feasible strategy for local businesses. It may also still be a core topic for industrial policy to stimulate the insertion in GVCs through the adoption of measures to encouraging the establishment of local production of products and sub-components. Such measures may include local content requirements, dedicated training programs, direct economic support to businesses and measures to encourage the formation of linkages between local and foreign companies, such as license agreements or joint ventures. Indeed, supporting the local production of small-scale wind turbines with higher quality and of towers used in large-scale wind power plants could for example be a priority for policy makers as a starting point to support functional upgrading. The independent development of projects by local consultants involved as turnkey contractors could also become a reality as a form of functional upgrading, which could also be actively supported by government. Similarly, with regard to solar PV, policies could for example consider increasing import duties as a form of import substitution to further promote local production of previously imported goods, such as panels or batteries, although this may come at a cost of introducing a barrier to trade. Indeed, the role of the state and industrial policy could benefit from being given a more prominent role in GVC research not only in relation to the transfer and diffusion of RE technologies in SSA but more generally.

References

AHK, 2013. Target Market Study Kenya Solar PV and Wind Power. Delegation of the German Industry and Commerce in Kenya.

Bazilian, M., Onyeji, I., Liebreich, M., MacGill, I., Chase, J., Shah, J., Gielen, D., Arent, D., Landfear, D., Zhengrong, S., 2013. Re-considering the economics of photovoltaic power. Renewable Energy. 53, 329-338.

Bolwig, S., Ponte, S., du Toit, A., Riisgaard, L., Halberg, N., 2010. Integrating Poverty and Environmental Concerns into Value-Chain Analysis: A Conceptual Framework'. Development Policy Review, 28(2), 173-194.

Byrne, R., 2011. Learning drivers: rural electrification regime building in Kenya and Tanzania. Ph.D. Thesis, University of Sussex, UK.

Caniëls, M., Romijn, H., 2008.Strategic niche management: towards a policy tool for sustainable development, Technology Analysis & Strategic Management, 20(2), 245-266.

Carbon Africa Limited, 2015. Kenya Market Assessment for off-grid electrification. Carbon Africa Limited.

Curran, L., 2015. The impact of trade policy on global production networks: the solar panel case, Review of International Political Economy, 22(5), 1025-1054.

Elola, A., Parrilli, M., Rabellotti, R., 2013. The Resilience of Clusters in the Context of Increasing Globalization: The Basque Wind Energy Value Chain, European Planning Studies, 21(7), 989-1006.

Garud, R., Karnøe, P., 2003. Bricolage versus breakthrough: distributed and embedded agency in technology entrepreneurship. Research Policy, 32, 277-300.

Gereffi, G., 1999. International trade and industrial upgrading in the apparel commodity chain. Journal of International Economics, 48, 37-70.

Gereffi, G., 2001. Beyond the producer-driven/buyer-driven dichotomy: the evolution of global value chains in the Internet Era. IDS Bulletin, 32, 30-40.

Gereffi, G., Humphrey, J., Sturgeon, T., 2005. The governance of global value chains. Review of International Political Economy, 12, 78-104.

Gereffi, G., 2014. Global value chains in a post-Washington Consensus world, Review of International Political Economy, 21(1), 9-37.

Gereffi, G., Fernandez-Stark, K., 2016. Global value chain analysis: a primer. 2nd edition, The Duke Center on Globalization, Governance & Competitiveness, Duke University.

Gibbon, P., Ponte, S., 2005. Trading Down: Africa, Value Chains and the Global Economy. Philadelphia: Temple University Press.

Hansen, U., Fold, N., Hansen, T., 2014. Upgrading to lead firm position via international acquisition: learning from the global biomass power plant industry. Journal of Economic Geography, 16(1), 131-153.

Hansen, U., Pedersen, M., Nygaard, I., 2015. Review of solar PV policies, interventions and diffusion in East Africa. Renewable and Sustainable Energy Reviews, 46, 236-248.

Hansen, U., 2017. Mapping of Solar PV and Wind Energy Markets in Kenya: Current State and Emerging Trends. Report undertaken as part the IREK project.

Hille, G., Franz, M., 2011. Grid connection of Solar PV technical and Economical Assessment of Net-metering in Kenya. Deutsche Gesselschaft für Internationale Zusammenarbeit (GIZ).

Hobday, M., 1995. Innovation in East Asia: The Challenge to Japan. Brookfield: Edward Elgar.

Humphrey, J., Schmitz, H., 2002. How does insertion in global value chains affect upgrading in industrial clusters? Regional Studies, 36, 1017-1027.

Huenteler, J., Schmidt, T., Ossenbrink, J., Hoffman, V., 2016. Technology life-cycles in the energy sector - Technological characteristics and the role of deployment for innovation. Technological Forecasting and Social Change, 104, 102-121.

IEA, 2013. Technology Roadmap: wind energy. International Energy Agency (IEA), Paris.

IRENA, 2017. Renewable Energy and Jobs Annual Review 2017. International Renewable Energy Agency (IRENA).

ISEI, 2012. Solar energy vision for Ethiopia. Opportunities for creating a photovoltaic industry in Ethiopia. International Solar Energy Institute (ISEI).

Johnson, O., 2016. Promoting green industrial development through local content requirements: India's National Solar Mission, Climate Policy, 16(2), 178-195.

Jäger-Waldau, A., 2013. JRC Scientific and Policy Report: PV Status Report 2013, Luxembourg: European Commission, DG Joint Research Centre.

Kamp, L., Vanheule, L., 2015. Review of the small wind turbine sector in Kenya: Status and bottle necks for growth. Renewable and Sustainable Energy Reviews, 49, 470-480.

Kaplinsky, R., Morris, M., 2003. A Handbook for Value Chain Research. Institute of Development Studies, University of Sussex.

KCIC, 2016. Kenya Solar PV Market Asessment. Kenya Climate Innovation Center (KCIC).

Larsen, T., Hansen, U., 2017. Vertical and horizontal dimensions of upgrading in global value chains: the establishment of local wind-turbine component manufacturing in South Africa, Working Paper Series:2, UNEP DTU Partnership.

Lay, J., Ondraczek, J., Stoever, J., 2013. Renewables in the energy transition: evidence on solar home systems and lighting fuel choice in Kenya. Energy Economics, 40, 350-59.

Leary, J., While, A., Howell, R., 2012. Locally manufactured wind power technology for sustainable rural electrification. Energy Policy, 43, 173-183.

Lema, R., Berger, A., Schmitz, H. and Song, H., 2011. Competition and Cooperation between Europe and China in the Wind Power Sector. Institute of Development Studies, Working Paper (377), Brighton.

Lema, R., Lema, A., 2012. Technology transfer? The rise of China and India in green technology sectors. Innovation and Development, 2(1), 23-44.

Lewis, J., 2011. Building a national wind turbine industry: experiences from China, India and South Korea. International Journal of Technology and Globalisation, 5(3-4), 281-305.

Mizuno, E., 2007. Cross-border transfer of climate change mitigation technologies: The case of wind energy from Denmark and Germany to India (Ph.D. Thesis). Massachusetts Institute of Technology.

Morrison, A., Pietrobelli, C., Rabellotti, R., 2008. Global Value Chains and Technological Capabilities: A

Framework to Study Learning and Innovation in Developing Countries, Oxford Development Studies, 36(1), 39-58.

Mudambi, R., 2008. Location, control and innovation in knowledge intensive industries. Journal of Economic Geography, 8, 699-725.

Muchunku, C., 2013. Solar PV Market in Kenya: Status and Opportunities. Kenya Renewable Energy Association (KEREA). BSW-Solar Special Exhibit Rural Electrification. Intersolar 2013, Munich, Germany.

Newman, C., Page, J., Rand, J., Shimeles, A., Söderbom, M., Tarp, F., 2016. Made in Africa: Learning to compete in Industry. Brookings Institution Press: Washington.

Nygaard, I., Hansen, U., Larsen, T., 2016. The emerging market for pico-scale solar PV systems in Sub-Saharan Africa: From donor-supported niches toward market-based rural electrification. UNEP DTU Partnership.

Ondraczek, J., The sun rises in the east (of Africa): a comparison of the development and status of solar energy markets in Kenya and Tanzania, Energy Policy, 56, 407-417.

Pedersen, M., 2016. Deconstructing the concept of renewable energy-based mini-grids for rural electrification in East Africa. Wiley Interdisciplinary Reviews: Energy and Environment, 5(5), 570-587.

Ponte, S., Ewert, J., 2009. Which way is ‘‘Up’’ in upgrading? Trajectories of change in the value chain for South African wine. World Development, 37, 1637-1650.

Rennkamp, B., Boyd, A., 2015. Technological capability and transfer for achieving South Africa’s development goals, Climate Policy, 15(1), 12-29.

REN21, 2013. Renewables 2013: Global Status Report. Paris: Renewable Energy Policy Network for the 21st Century (REN21).

Rolffs, P., Ockwell, D., Byrne, R., 2015. Beyond technology and finance: pay-as-you-go sustainable energy access and theories of social change. Environment and Planning A, 47, 2609-2627.

Schmidt, T., Huenteler, J., 2016. Anticipating industry localization effects of clean technology deployment policies in developing countries, Global Environmental Change, 38, 8-20.

Tigabu, A., Kingiri, A., Odongo, F., Hanlin, R., Andersen, M., Lema, R., 2017. Capability development and collaboration for Kenya’s solar and wind technologies: analysis of major energy policy frameworks. A policy analysis report of the IREK project.

UNCTAD, 2015. Tracing the value added in global value chains: product-level case studies in China. United Nations Conference on Trade and Development (UNCTAD).

Vanheule, L., 2012. Small Wind Turbines in Kenya. An analysis with Strategic Niche Management. Master thesis, Unpublished, Delft University of Technology.

Zhang, F., Gallagher, K., 2016. Innovation and technology transfer through global value chains: Evidence from China's PV industry. Energy Policy, 94, 191-203.