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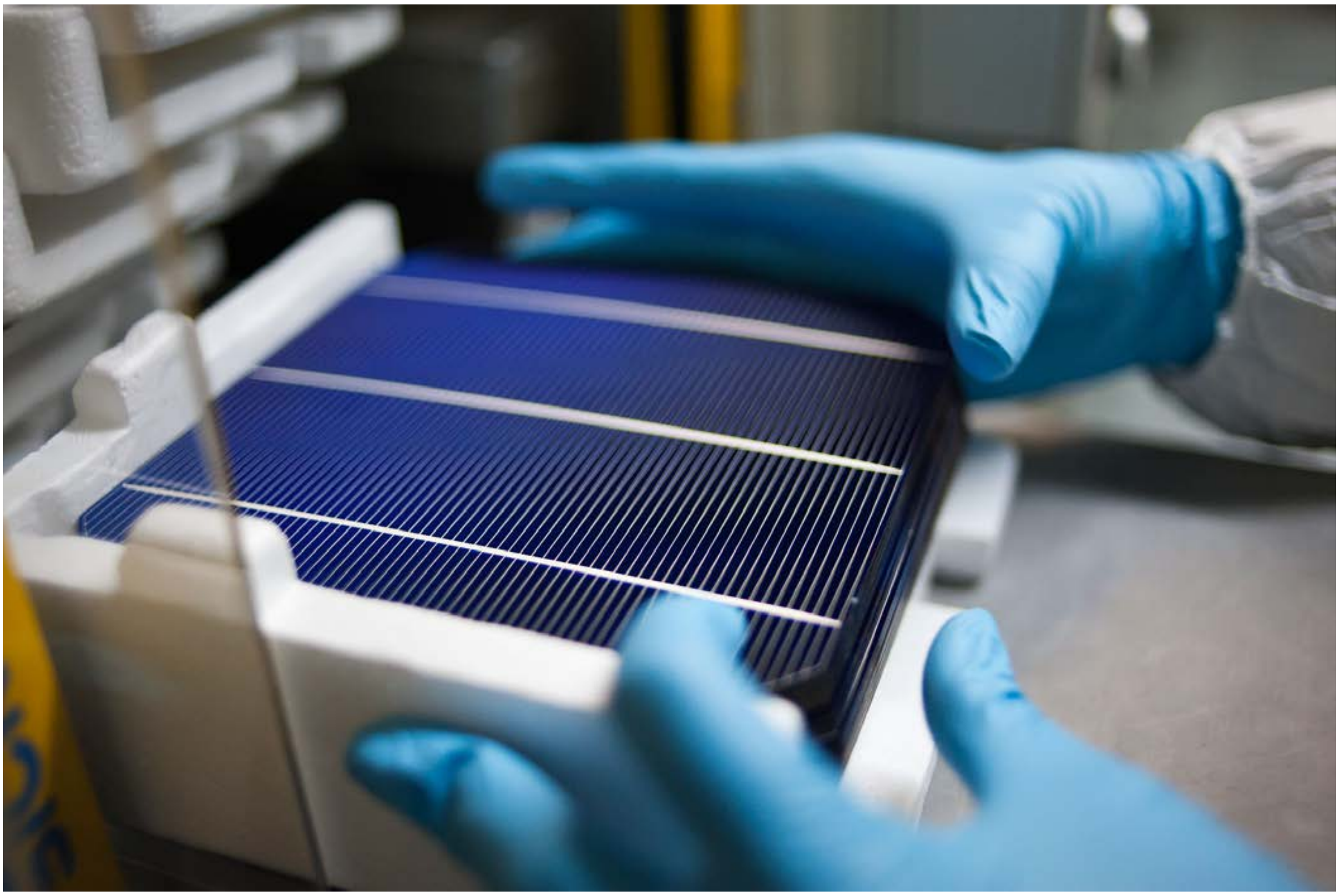

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Kenya Miniwind

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Cover photo

Finished solar cells ready to be transferred to the module assembly step.
SolarWorld manufacturing facility Hillsboro, Oregon.

Photo credit: Flickr.com

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The Kenya Miniwind project aims to explore and develop a market for a partly locally produced kW wind turbine to be integrated into a PV mini-grid for rural electrification in order to reduce the cost of electricity and support local value creation.

On this basis, the long-term objectives of the project are to contribute to poverty reduction, stimulate economic growth and increase sustainable energy supply. The short to medium term objective is to explore the market potential and learn more about how to design the right solutions and business models suitable for rural electrification. The project will therefore conduct a market study, engage in dialogue with the local communities and authorities, and demonstrate the technical, social and economic feasibility of integrating a kW wind turbine into a smart solar-powered mini-grid in Kenya. The project will also demonstrate assembly and production of a relevant component for the demonstration wind turbine. The project will finally work to improve the mini-grid developer sector both in Kenya and in the region. The aim is that the knowledge generated through these activities will help develop the concept into a viable business model for the private companies involved, paving the way for large-scale deployment of rural wind.

The project is funded by Danida as part of the Danida Market Development Partnerships and is a partnership project between SustainableEnergy, Vestas Wind Systems A/S, Technical University of Denmark, Kenya Climate Innovation Center and Rural Electrification Authority.

MINISTRY OF FOREIGN AFFAIRS OF DENMARK
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Abstract

Component production in the renewable energy (RE) sector, specifically of solar PV and wind turbine components, has been localised across various countries in Africa as part of the increasing diffusion of these RE technologies over the past decade. Local factories have been established in spite of ever cheaper world market prices for RE technologies, which would appear to favour the importation of components from abroad over local production. In this report, we address this apparent paradox by analysing the conditions enabling the development of local RE component production facilities in Africa. We adopt a multiple case-study approach focusing on the histories of two solar PV module assembly plants in Kenya and Senegal respectively, which were established around the same time. We find that the solar PV factory established in Kenya managed to maintain its production, while in Senegal the assembly plant only succeeded in doing so for a short period of time. We provide a discussion of some of the possible explanations for the observed differences in these two development paths. The report ends by providing insights of relevance to the debate on establishing and sustaining the local manufacture of RE technologies in Africa.

1. Introduction

A recent surge in investments in renewable energy (RE) has taken place across the African continent in the past ten to fifteen years, especially in solar photovoltaic (PV) and wind power. The total installed capacity of solar PV and wind power in Africa consequently increased from 108 MW to 6,100 MW and from 739 MW to 5,500 MW respectively between 2009 and 2018 (IRENA, 2019). A parallel increase in the establishment of RE manufacturing has occurred: according to IRENA (2016) twenty local solar assembly plants have been established in Algeria, Kenya, Nigeria, South Africa, Tunisia, Egypt and Ethiopia since 2005 with a total annual capacity of around 650 MW. Similarly, local wind-turbine component production units have been set up in a number of African countries, such as Kenya, South Africa, Morocco and Egypt (Leary et al., 2012; Kamp and Vanheule, 2015; Lema et al., 2018). However, it remains unclear how many of these factories are still in operation, thus raising a question about the long-term durability of such investments in productive assets. Furthermore, the rapidly and significantly decreasing unit costs of these RE technologies over the past decade would appear to encourage their importation from abroad in place of local production. The establishment of these local factories thus presents an apparent paradox that has not been subject to research previously. However, recent contributions have attempted to provide new knowledge in this area (see e.g. EIB, 2015; Schmidt and Huenteler 2016; Baker and Sovacool, 2017; Matsuo and Schmidt, 2019).

In this report, we contribute to taking this emerging literature on the key factors underlying the localization of RE component production in Africa further by adopting an exploratory, case study-based approach. Accordingly, we analyse the development of two solar PV assembly plants in Kenya and Senegal respectively. As these factories were conceived and established around the same time, an analysis of their individual development trajectories have the potential to generate interesting insights.

The report is structured as follows. Section 2 presents the research methods used. In Section 3 the solar PV value chain is briefly described, followed in Section 4 by a presentation of the two case studies. Section 5 provides a discussion of the key findings presented in the case studies. Finally, in Section 6, the conclusions of the report are presented.

2. Research methods

The information included in the two case studies presented in this report appears in greater detail in more extensive reports issued as part of research carried out within the "Kenya Miniwind project", a research project funded by the Danish Development Agency (DANIDA) (Wakesa and Davy, 2019; Nygaard and Hansen, 2019). These reports can be obtained from the project's website (https://unepdtu.org/project/kenya-miniwind/). While data for the Solinc case study were collected as part of the Kenya Miniwind project, the SPEC case study in Senegal is based on data collected under the project "Exploring the development of large-scale solar power in Sub-Saharan Africa", funded by the UU Environment Programme. The data collected for the two case studies also include numerous interviews carried out with key stakeholders in the solar PV and wind power sectors in Kenya and Senegal respectively. This includes interviews with representatives of firms, government agencies and development donors. Various sources of documentary material have also been collected and analysed as part of the case-study research, including consultancy reports, peer-reviewed literature and firms' records.

3. The global solar PV chain

The global solar PV value chain is characterised by various activities centred on the production and deployment of solar modules as the main component used in crystalline-based solar plants deployed at various scales globally. The manufacture of solar panels and larger modules in assembly plants entails 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 into a cell through etching and polishing, cleaning, the application of anti-reflective coating and screen-printing; and finally (iv) soldering the cells together into modules (Zhang and Gallagher, 2016). It is the last step in the process of solar module assembly that we are concerned with in this paper.

In 2003 production of solar PV in China was only around 2% of global production. By 2008, however, China had become the largest producer of solar PV modules in the world, overtaking Japan and Germany. By 2012 China accounted for 64% of worldwide production and in 2017 eight of the top ten global module suppliers were Chinese companies, including Jinko Solar, Trina and Yingli (Behuria, 2020). While some companies specialise in upstream activities, such as ingot and wafer production, there has been a trend toward vertical integration in the industry. This means that the lead firms increasingly control and own upstream production activities, from ingot and wafer production to the production of cells and the assembly of solar panels and modules. Moreover, the leading companies are increasingly moving into activities further downstream in the value chain, such as project development. Over the past decade, the solar PV value chain has undergone a process of elimination, which has led to the industry being dominated by smaller numbers of large lead firms, mainly Chinese, involved in the production and deployment of solar PV systems. The development and competitiveness of local solar PV assembly plants in Africa should thus be considered in light of the opportunities that now exist to import systems from China at a low cost.

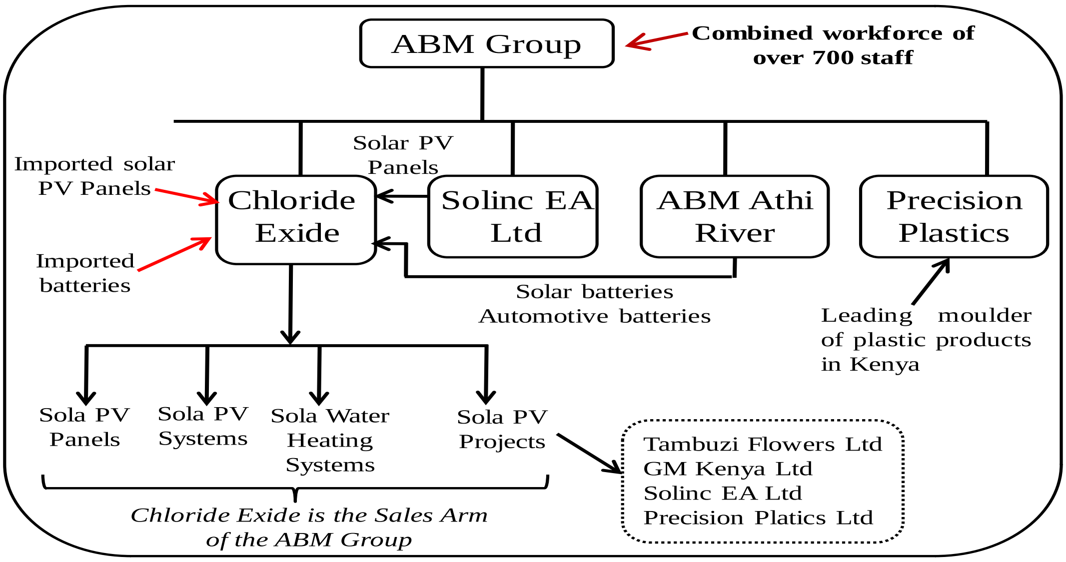
4. The case studies

In the following, two case studies are presented in the form of brief narratives summarising the main insights obtained based on the data collected. In order to provide a coherent and easily readable narrative, we have limited our use of references. The reader may consult the detailed reports referred to above for the relevant references and additional information.

4.1. The case of Solinc in Kenya

There has been at least one previous attempt to establish the local manufacture of solar PV modules in Kenya, which involved a Chinese company considering establishing a joint venture to manufacture amorphous solar PV modules in Nairobi. However, the only known successful attempt involves the creation of the company Ubbink East Africa Ltd., which was officially registered in 2010 and began assembling polycrystalline modules in Naivasha, Kenya, in August 2011. The establishment of this assembly factory was the result of a process that started around 1999 in the Kenya-based parent company, Chloride Exide. Ubbink East Africa Ltd. was established as a joint venture between the Dutch company Ubbink B.V. and the Kenyan company Associated Battery Manufacturers Ltd. (ABM). Later on, in 2015, ABM acquired majority shares in Ubbink East Africa Ltd., which was then renamed Solinc EA Ltd. (henceforth called 'Solinc'), while Chloride Exide became integrated into the larger ABM Group (see Figure 1). The funding enabling the initial start-up of Ubbink East Africa Ltd. was provided by the Private Sector Investment (PSI) programme, administered by the Netherlands Enterprise Agency. Initially three technicians were then sent to the Netherlands for a month of training, and six more employees were trained upon their return to Kenya. This process continued, and now around 78 Kenyans have evidently been trained to operate the machines in the assembly plant.

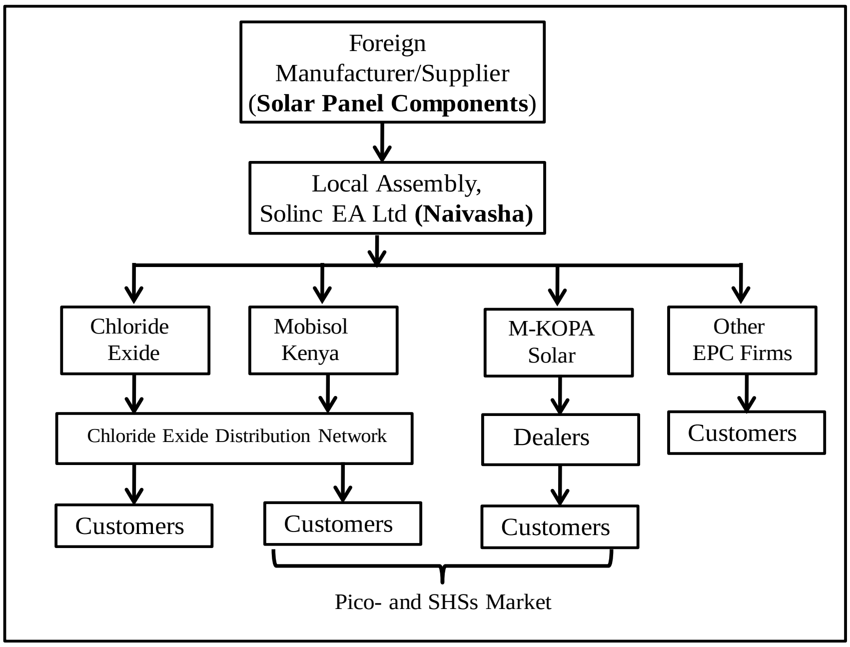
Figure 1. ABM Group of Companies.



Source: Authors' own compilation.

Since its establishment, Solinc has grown to become a market leader in solar panel distribution and delivery in Kenya and is in the process of achieving market leadership in neighbouring Uganda and Tanzania as well. Kenya is the largest country market that Solinc serves, with the largest market located in western Kenya. The company currently produces an estimated 140,000 solar panels per year and has a manufacturing capacity of 8.4 MW/year. The solar cells and auxiliary sub-components, such as glass materials, are imported from abroad and assembled into modules at the factory (see Figure 1). The assembled solar modules are of different sizes depending on the end market. The modules produced for the off-grid market are divided into two categories: 20Wp to 150Wp, which can be connected directly to a 12V battery system; and 160Wp to 200Wp, providing sufficient voltage to directly charge a 24V battery system. In 2014 Solinc entered into a partnership with the German company Fosera to manufacture and distribute solar home-system products in East Africa. Over time, Solinc has gradually moved into supplying solar panels to larger scale solar power projects ranging from 20kW to over 500kW, mainly to flower farms and industrial clients. In such projects, Solinc supplies modules with sizes ranging from 250Wp to 300Wp. These projects are usually developed by so-called engineering, procurement and construction (EPC) companies, which supply the projects on a turnkey basis. It appears that these EPC contractors generally prefer to source the panels locally from Solinc as opposed to importing them from abroad. This is due to the lengthy and costly approval procedures at the customs entry points, which are related to the import exemptions governing imported solar system equipment in Kenya.

Figure 2. Solinc EA Ltd's supply chain.



Source: Authors' own compilation

Solinc has benefitted greatly from being part of a larger group of companies. This has enabled the company to utilise the expansive distribution network of the battery supplier Chloride Exide (see Figure 2), spanning a total of twelve countries. Indeed, by adding solar panels to its product portfolio, the ABM Group has become a vertically integrated entity, controlling solar modules, solar batteries and other balance of system components. Solinc is therefore part of a company that can undertake all aspects of sector activities, from systems integration, project development and customer service to product distribution. This provides an opportunity for the ABM Group to offer a set of complementary products, which means that most of the value in the solar PV chain remains within the group. Being integrated into a group of companies that has existed since the 1960s has also enabled Solinc to make use of the well-developed understanding of the business climate in East Africa.

The majority of Solinc's total sales are targeted at the off-grid market focusing on small-scale (PICO) appliances and solar home systems. The products are sold to key off-grid solar suppliers, including Mobisol and M-KOPA (see Table 1). Since these off-grid suppliers rely significantly on donor funding, Solinc has benefitted indirectly from these funds in developing this market segment.

Table 1. Solinc EA Ltd.'s solar PV modules categories and target clients/distributors

Category	Module Capacity (Wp)	Target Client/Distributor
1	13, 20, 40, 50, 60, 80	M-KOPA and Mobisol
2	100, 120, 150	Mobisol and Chloride Exide
3	160, 200	Chloride Exide
4	250, 300	EPCs

Source: authors' own compilation

4.2. The case of SPEC in Senegal

As in Kenya and a number of other African countries, the idea of setting up the local assembly or manufacture of solar panels in Senegal had been discussed among NGOs, researchers and government officials for some time. However, such plans did not materialise until 2009, when a decision to establish a Senegalese-owned solar PV module assembly plant was taken by two established business men, Mr Fall and Mr Sow.

The factory was procured from a Swiss company, 3S Swiss Solar Systems AG (henceforth '3S'), which is part of the Meyer Burger Technology Ltd group, also in Switzerland, and which specializes in setting up fully operational, semi-automated factories on a turnkey basis. The factory, which was located in Dakar, was designed for annual module production of 16 MWp, with an option for an extension to 25 MWp. The company was set up to produce panels of 150 and 250 Wp, the larger size being a standard product for roof-top and utility-scale installations. Given the relative cheapness of labour in Senegal, a semi-automated rather than a fully automated production line was chosen. In practice, this meant that the cells were soldered manually and the laminated solar panel was manually equipped with glass, connectors and frames at the assembly plant.

3S was responsible for starting up and testing the factory, as well as providing on the job training for the operators on the production line, with special training for the computer specialist. To ensure a smooth transition from test production to full production, 3S was also able to take remote control of the production line and to help with various operational problems. The production line was set up in accordance with the highest quality standards, and the panels the factory produced achieved TüV accreditation. The pursuit of high-quality standards came at the cost of imports of Bosch PV cells, and also glass, frames and lamination from overseas suppliers, mainly European. Due to high price competition from Chinese manufacturers, SPEC had already started to test other cells from Chinese and Indian manufacturers shortly after production started in 2011.

The main investor in the factory, Mr Fall, is a wealthy, self-made Senegalese entrepreneur and businessman. He himself did not have any technical knowledge of solar PV manufacturing, but he did have experience in running high-tech businesses. Besides his construction business and other ventures, he was also at the time the co-owner of a large company called IRIS, which produced advanced identity cards. Mr Sow, the co-founder, minority shareholder and CEO of the company, did not have any knowledge of industrial manufacturing, nor of solar PV technology, but had been trained as an engineer in information technology. He also held an MBA and was an experienced businessman who had come from the automotive import and distribution sector in Senegal. As CEO he set up a management team consisting of a production manager and a project department manager.

A computer specialist was employed in the production department, being responsible for maintaining the production line, adjusting the line to new products and quality-testing the modules. Other staff, a total of 25, on the production line included line operators, solders and technicians to mount the panels. Another twelve members of staff worked in the sales department and administration, besides secretaries, drivers and security personnel. The project department consisted of four engineers, who developed feasibility studies and project proposals for projects in Senegal, as well as elsewhere in the region, including feasibility projects in Mali and Cameroon.

The company was set up as a shareholding company, with equity mainly provided by Mr Fall, who held 65% of the shares, while the CEO held 20%, and one of the two engineers who came up with the idea for the company held 5%. The total investment was about 3 billion CFA (6 Million USD), of which about 1 billion (2 Million USD) was in the form of equity, the rest being financed by loans from the Bank of Africa (BOA) and the Banque Internationale pour le Commerce et l'Industrie du Sénégal (BICIS). The start of production was delayed for about six months for various reasons, among them the need to acquire TüV accreditation. This delay was important because it caused a loss of about 0.34 Million USD, which reduced the company's working capital and limited its room for manoeuvre during its first few months of operation. The company started production in June 2011 and achieved TüV accreditation in December 2011. Until it was closed down in early 2013 it produced around 1 MW of panels, of which 0.2 MW was sold to a project in Chad, while around 0.9 MW was sold to a street-lighting project through a contract negotiated with the state-owned AGEROUTE. Only smaller numbers went to retailers in Senegal.

The CEO, Mr Sow, was removed by the company board in October 2012, only eleven months after full production had started, and a new director was appointed from another of Mr Fall's companies. SPEC was closed in early 2013 following a management decision to wait for the national market to materialise. In January 2016 Mr Fall brought in technicians from Z-ONE with the objective of restarting production. Z-ONE is a UEA-based investment and technology company that was involved in the whole solar PV value chain in Africa, from manufacturing and distribution to project development. Mr Fall had had experience of long-term business collaboration with Z-ONE through his company IRIS. At the time, he remained the 100% owner of SPEC, and experts from Z-ONE were hired as consultants to revitalize the factory. Although Mr Fall announced in 2016 that production would start in a few weeks' time, the factory never restarted.

5. Discussion

The above accounts clearly show that the establishment of local solar module assembly plants targeted at both national and regional markets are possible in Africa. However, it is equally evident that the two solar PV assembly plants analysed here had very different development trajectories in terms of the longevity of their operations. While Solinc has managed to continue production, SPEC only succeeded in sustaining production for a relatively short period of time from 2011 to 2013. Interestingly, both factories were conceived and established around the same period in 2010 and started production at a similar point in time. In the following, we will discuss the possible reasons for the observed differences in the development of the two factories.

As pointed out above, market opportunities in Kenya and its neighbours seem to have been more favourable to Solinc than to SPEC. Indeed, Solinc were able to benefit from increasing demand from companies like Mobisol, which supplied off-grid solar PV solutions in Kenya and in turn were supported by funding from various donor programs. Indeed, the market for off-grid solar systems increased rapidly and significantly in Kenya from 2011 onwards, creating a vibrant market with numerous system providers and private customers (Nygaard et al., 2016). Demand also started to emerge from industrial users in Kenya, which Solinc was able to serve, thereby enabling the company to move into the supply of larger systems. In contrast, the market for off-grid solar PV systems did not develop to a similar degree in Senegal, which meant that SPEC could not grow its operations by serving a similar increase in market demand. One of the reasons for this lack of market demand in Senegal is the continued delay in deciding a policy to provide a regulatory set-up for solar PV. Investors may thus have refrained from pursuing investments due to uncertainty concerning the economic incentive structures and regulation. Furthermore, the possibility of pursuing directly negotiated contracts with the government, which SPEC had previously been involved in, appeared to become a non-viable strategy as a national preferential market in Senegal did not materialise. It appears, however, that the market demand for both off-grid and grid-scale solar PV systems increased significantly in Senegal after 2016, and especially from 2017 onwards. Consequently, the timing of the establishment of the solar PV assembly plant in Senegal might have proved more favourable at a later point in time, when the conditions may have been more conducive.

Solinc and SPEC also differed significantly in their company structures, which may help explain some of the observed differences in their respective development paths. Solinc was established as part of a larger conglomerate of companies under the ABM Group, which meant that it could produce solar PV systems to Exide Chloride, who in turn could expand its portfolio with solar panels. The embeddedness of Solinc within a larger existing company structure provided the opportunity to utilise the expansive distribution network of Chloride Exide. In contrast, in order to serve the market for off-grid solar PV systems, SPEC would have to allocate significant resources to develop a wide-ranging network of distributors, retailers and sales offices across the country. The ability of Solinc to avoid such investments provided it with a more advantageous starting point compared to SPEC.

Finally, we point at the importance of the differences in linking up with foreign companies in the solar PV value chain as a key element determining the different development paths of Solinc and SPEC. Solinc was able to link up to foreign companies specialising in related technological areas both initially, through a joint venture with a Dutch company, and later with a German company, in order to increase the distribution and sales of solar home systems. These links with external technology suppliers appeared to have provided Solinc with access to specialised knowledge and technology, enabling the exchange of know-how on a longer term basis. In contrast, SPEC simply purchased a fully operational assembly plant line from a European company and then started producing with only short-term assistance. SPEC thus represents an example of arm's length transactions that differs greatly from more interactive forms of engagement with foreign technology suppliers. Solinc may thus have acquired important knowledge and experience through these relationships compared to the founders of SPEC, who had only a very limited understanding of the solar PV technology and market.

6. Conclusion

At the start of this report, we alluded to the observed increase in the number of local RE component production facilities established recently across the African continent. We stressed the lack of detailed assessments of the factors enabling and impeding the establishment and sustenance of such manufacturing facilities. By adopting a multiple case-study approach in this report, our aim has been to provide further insights to improve this understanding.

We find that the two solar PV assembly factories followed very different development paths, despite the similarities in their initial starting point in terms of the timing of their establishment, the size of the panels produced and the scale of their operations. While Solinc managed to maintain its production, SPEC only managed to do so for slightly over a year. We have pointed out a number of possible reasons for the observed differences in the longevity of their operations. First, the rapid and increasing development of the Kenyan market provided a conducive environment for Solinc to develop its operations, while in Senegal a similar market only developed recently, at a point when the plant had already long been closed. Secondly, Solinc's company structure provided it with a favourable starting point compared to SPEC, given its access to an already established network of distributors and sales offices throughout the country. Finally, we pointed to the significance of longer term links with foreign technology suppliers in the case of Solinc compared with the purchase of ready-made assembly-line equipment in the case of SPEC.

This report thus represents an exploratory attempt to improve our understanding of the conditions enabling and impeding the development of local RE manufacturing in Africa. As such, its findings should be interpreted as a starting point for further research on this subject. It is clear that significant opportunities exist to obtain important insights by undertaking research on the development of specific factories. Such micro-level analyses can help identify mechanisms of change and key variables of interest as a starting point for analysing larger samples of factories established across the continent. The report demonstrates the particularities and context-specific conditions for the establishment and sustenance of local solar PV assembly in Africa. Specifically, we stress the need to consider market-related issues, company-specific elements and the dynamics of global value chains as key elements in such analyses. While our approach in this report is mainly empirically driven, a more theoretically oriented research design could provide a logical approach going forward. Theoretically, guided research could build upon the analyses presented in this report, in particular the possible factors of relevance we have stressed in seeking to account for the different development paths observed in the two cases.

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