IREK WORKING PAPER NO. 8

Building competences and capabilities through projects: examples from Kenya's renewable energy sector

Rebecca Hanlin
PhD, Senior Researcher
African Centre for Technology Studies, Kenya

Josephat Okemwa
Research Assistant
African Centre for Technology Studies, Kenya

Cecilia Gregersen
PhD Fellow
Aalborg University, Denmark

IREK

Innovation and Renewable Electrification in Kenya

MINISTRY OF FOREIGN AFFAIRS OF DENMARK
Danida

Read more about the IREK project at
IREKPROJECT.NET

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. The Ministry of Foreign Affairs of Denmark supports the research: Grant DFC 14-09AAU.

How to cite this publication: Hanlin, R. Okemwa, J. and Gregersen, C. (2019) *Building competences and capabilities through projects: examples from Kenya's renewable energy sector* IREK Working Paper, http://irekproject.net

Building competences and capabilities through projects: examples from Kenya's renewable energy sector

Rebecca Hanlin, Josephat Okemwa and Cecilia Gregersen

Abstract

Kenya is one of the fastest growing promoters of solar and wind power in Africa. These two energy sources are increasingly being utilised to provide clean energy into the national electricity grid system as well as in off-grid alternatives for hard to reach areas of the country and/or to supplement organisations and businesses due to the inefficiencies of an expanding grid system. The dominant argument for their promotion is that these energy sources are clean and affordable; provide a means of increasing energy access to 'the last mile'. However, little attention has been paid to the projects that are responsible for the introduction of these energy sources into the power supply, specifically from the perspective of their potential benefit to industrialisation and inclusive economic and social development in Kenya. This paper investigates how wind and solar energy development projects provide opportunities to build competences and capabilities that have the potential to enable more inclusive economic and social development in Kenya. Specifically, it investigates how competence and capability building are undertaken in solar and wind energy projects in Kenya and if, and how, their promotion is written into, realised and utilised in wind and solar energy projects. The findings of a number of case study projects show that flow of technologies (hard and soft) within the project cycle have a role to play in providing opportunities for building technological capabilities, core competences and individual skills leading to upgrading at the project, firm and individual level. Specifically, project level collaboration and the resulting interactive learning have been key to this competence and capability building and resulting upgrading.

Introduction: The wind and solar energy sector in Kenya

The Government of Kenya has stated that current fixed capacity was 2,234.83MW in 2017 and will rise to 7,213.88MW in 2030 and to 9,932.44MW in 2037. The energy mix is expected to increasingly rely on wind and solar raising from 1.1% of fixed capacity in 2017 to 8.5% in 2037 for wind and from 0% to 8.6% for solar over the same time period. Geothermal and hydropower make up over 50% of Kenya's fixed capacity in 2017 (Republic of Kenya, 2018).

However, hydropower is increasingly vulnerable to weather and climatic shocks. In addition, the electric power sector is characterized by power shortages, supply disruptions, and high cost of generation, leading to deficit between demand and supply. This has created serious obstacles to economic activity in recent years (MoEP, 2015). As such the Kenyan Government stresses that to realize accelerated and inclusive economic development, provision of reliable, affordable, and sustainable energy services to all sectors and households is needed (MoEP, 2015). Increasing the level of wind and solar power generation are seen as two ways to achieve this. Recently Kenya has added to the grid two of the largest wind and solar parks in Africa: the 300MW Lake Turkana Wind Project (LTWP) farm that came online in October 2018[1] and; the 54MW Garissa Solar Project farm that was commissioned in November 2018[2].

At the same time there is a large portion of the population who will not access grid connectivity. In recognition of this, the Government of Kenya has set up the Kenya Off Grid Solar Access Project (K-OSAP) which will focus on 14 counties with the least access to grid connectivity (mostly located in the North of Kenya) with a total estimated population of unconnected households of 1.2 million.[3] In addition, there are several successful companies (notably, Powergen and Powerhive) promoting off-grid mini-grids for use by isolated communities. There are also, off-grid renewable mini-grids using wind and solar being promoted to power schools, businesses (factories) and powering infrastructure (telecoms especially) either because they are based in isolated locations from the nearest grid connection or because the current grid connection suffers from power fluctuations and/or power outages. As of 2018, Kenya Power operated 27 mini-grids across the country and was planning to develop 26 more while there are approximately 22 mini-grids that are privately owned in Kenya and a further 11 community based projects funded by external funds. In addition the K-OSAP project looks to build a further 121 mini-grids (Kenya MiniWind, 2018).

Paper hypothesis

The interest in wind and solar as alternative energy sources is predominately related to the need to increase energy access and particularly clean energy access. However, this paper starts from a different hypothesis. We hypothesize that the promotion of wind and solar on- and off-grid energy projects, in addition to providing opportunities for improved clean energy access, has a valuable role in contributing to the economic growth and development of the country.

African countries are increasingly promoting large infrastructure projects with the hope of boosting economic development (Africa Renewable Energy Initiative, 2016a). For example, the Kenyan Vision 2030 puts infrastructure among the key pillars that anchor economic progress. Therefore, the strategy puts infrastructure development as a key priority of action (Government of the Republic of Kenya, 2007). The more recent 'Big Four Agenda' which is now driving all government policy initiatives in

[1] https://www.the-star.co.ke/news/2018/10/23/turkana-power-to-hit-full-speed-by-end-of-october_c1839020 (accessed 25/01/19)

[2] https://www.businessdailyafrica.com/economy/Launch-of-54MW-Garissa-solar-plant-/3946234-4857630-d72uiq/index.html (accessed 25/01/19)

[3] http://www.kplc.co.ke/content/item/1943 (accessed 25/01/19)

Kenya requires energy as an enabler of these four areas of growth focus (manufacturing, food security, universal health coverage and affordable housing) (Hoka et al, 2018).

There is in fact a large body of evidence that shows a positive relationship between infrastructure development, economic growth and development. For example through a cross-regional comparative perspective, Calderon and Serven (2010) show that infrastructure development (both quantity and quality of services of infrastructure) is significantly associated with growth and equity across Africa. Using 13 years of panel data from 24 Chinese provinces, D´emurger (2001) shows that infrastructure endowment significantly explains observed differences in growth performance across provinces in China. At micro levels, Khandker et al. (2009) also show that investment in public infrastructure, such as construction of rural roads have increased wages of male farmers in rural villages of Bangladesh, improving household livelihoods significantly.

Despite this, little research exists on the role solar and wind energy infrastructure, specifically, plays on economic growth. This paper is therefore interested in understanding – through the investigation of various critical case studies – the ways in which renewable energy projects, both on- and off-grid, contribute to economic growth and development. Specifically, how they do this through the opportunities afforded by collaborations with external and internal actors, to build different types of capabilities and competences within local firms. These opportunities might be an explicit part of a collaborative agreement between two firms, a publicised commitment or objective of one of the project partners or related stakeholders, or it could occur more implicitly as an 'added extra' as a result of routine project activities.

This is important as such issues have also now entered the policy discourse in Kenya. In the latest energy policies there is increased recognition of the importance of local content and local capacity building. The newly revised Energy Act (2019) specifies the need for the development of local capabilities to manufacture, install and maintain renewable technologies (clause 44 (1)(o)). Energy and Petroleum Regulatory Authority (EPRA - formerly known as the Energy Regulatory Commission) the authority to enforce local content requirements including the use of Kenyan contractors and Kenyan staff where qualified and skilled staff/ companies are available. Firms involved in energy production are also expected to submit annual and long term local content plans.

Why capability building through projects

Building on the conceptual starting points of the IREK project (Lema and Andersen, 2019) this study is taking as its focus large and small scale renewable electrification projects and the ways in which competence, capabilities and upgrading are possible through these projects.

Projectisation of the Kenyan energy sector

Kenya's attempts to use renewable energy supplies to 'reach the last mile' and improve energy access is focused on a range of different renewable energy strategies; some involving large scale on-grid projects using solar and wind technology and other off-grid solutions; as noted above. The development of these usually operates using a 'project' approach. In these situations, the design, installation and operation of these renewable technologies are managed by one lead partner and can involve a series of other partners to provide technological or other inputs as needed. This approach is very different to vertically integrated government infrastructure projects for energy electrification.

In fact, the move away from vertically integrated government infrastructure projects has taken place over the last 20 plus years in a range of sectors across the globe. The most often discussed examples are in health and education. Although very well researched in high income countries, the change in focus has also been felt in Africa too with the rise of public-private partnerships and contracting out of service provision in various sectors (Liu et al, 2008; Farlam, 2005). This move has seen the rise of publicly funded infrastructure projects being contracted out to the private sector using a range of different forms such as ‘build-operate-transfer’ (BOT) or ‘build-own-operate-transfer’ (BOOT) while others also include the contracting out of design process also (DBOT). Often promoted in Africa due to the inefficiencies of government funded, run and operated infrastructure projects, these alternative approaches assume that by bringing in private sector partners the efficiency of the project process and operation of infrastructure will improve. As such, they have been promoted by the World Bank and IMF amongst others and have their origins in the ‘new public management’ wave of thinking that started in the late 1980s in the US and has since become a core way of thinking in international development and public administration around the world; although there are now alternatives being promoted (Brinkerhoff and Brinkerhoff, 2015). It has been indicated that such approaches could be prone to a range of issues such as the high cost of services, corruption, and other abuses by politicians and business elites. A case in point is the Bujagali Hydropower Public Private Partnership Project between the Ugandan Government and Bujagali Energy Ltd in Electricity Generation. This project was marred with delays, protests and finance issues, although Kabanda (2014) reported that the involvement of Bujagali Energy was quite successful in generation of electricity in Uganda, which gave an impetus to solicit more private sector involvement in public infrastructure projects.

While there has been a push-back on new public management, the general approach of improved management of projects has not reduced in popularity. The idea of ‘project management’ as a concept and practice has become very well established in the last 30 years; although the concept and approach started in the 1930s and 1940s with military and process engineering in the USA (Brady and Hobday, 2011) and is seen by many as an important tool in ensuring projects – of all types – are managed effectively. Brady and Hobday (2011) distinguish between five types of project management style. The first, matrix organizations, are those where resources are integrated. The second, functional organizations, rely on a standardized set of systems and procedures. The third form of project management style is more adaptive and consumer orientated within a flatter organizational structure and is what they term adhocracies. The fourth form is what they term the Scandinavian form of PM where projects are temporary organizations found within larger permanent firms or networks. Finally, they also refer to the PM style of ‘project business’. It is this last style that has resonance with the type of activity this project and this work package of the IREK project in particular is focused on. Brady and Hobday (2011) argue this style started in the late 1990s and is focused on the creation of new markets through project activities.

Project business is about how a firm or network uses projects as a way of achieving its objectives (Artto and Wilkstrom, 2005). For Artto et al (2011) project business occurs in four different ways. The first is project specific; i.e. a firm uses a project to create new markets and achieve its objectives as a one-off endeavour. The second is a firm that works through projects as a matter of course – what Hobday (2000) refers to as a ‘project based organization’. The third revolves around the management of a business network. The final approach to project business, and the one of interest to this project, is the management of a project network. This is about how a group of businesses work together around a project.

Successful articulation and management of project business requires systems integration capabilities (Brusoni, Prencipe and Pavitt, 2001) says Artto et al (2011) and therefore requires knowledge and capability on the governance of the situation. Governance and its relationship to project management are recognized as important by Cacciatori and Jacobides (2005). Also important are ties and network control says Artto et al (2011). Others, on the other hand, have indicated the importance of the value chain and the institutional fit of a product into the vertical structure of the sector. In this regard, Jacobides (2006) states that value chains (of technologies) are both country and sector specific and are major determinants of the expansion of the operation of firms in other national contexts. Jacobides argues that for successful expansion, firms must have a service or product that fits well with the ways that labour is distributed and divided among vertical participants within a value chain of a specific sector or country. In this instance the value chain equates to the project cycle. Others, such as Davis and Brady (2016), state that links between project capabilities at the operational level and dynamic capabilities at the strategic level are important. They state that 'individual routines' form the evolutionary building blocks of project capabilities. In other words, individual capabilities collectively form project capabilities.

These authors further identify two types of projects in relation to dynamic capabilities: 'routine projects' and 'innovative projects'. Routine projects are projects that utilize existing and mature products and technologies to satisfy current customer demands. These types of projects require traditional and routine forms of project management capability. Their major strength is exploiting the 'economies of repetition'. Innovative projects, on the other hand, aim at identifying and experimenting with new ideas and approaches that create entirely new market segments, technologies, products, services, and approaches. These are highly risky and unpredictable endeavours with substantial difficulty to plan in advance. Such projects require novel ways of organizational planning and a complete shift from existing and prior project routines and capabilities both at the strategic and operational levels (Davis and Brady, 2016). With respect to the links between project and dynamic capabilities, Davis and Brady (2016) state that "dynamic capabilities at the strategic level of the firm decide how to create and mobilise project capabilities to support ambidexterity" at operational levels. Top managers utilize accumulated knowledge of dynamic capability to decide when to launch routine projects or innovative projects taking consideration of existing project capabilities in relation to existing resources, competitive advantage and changing circumstances.

Key to all is competences at project level

If the interest of this working paper is project business, then an investigation of how this is successful – specifically, how this builds local capabilities – places a focus not just on the ability to conduct routine firm related functions (technology and business management relating to project business as outlined above) but also their ability to manage relationships with other firms involved in the project (either in their role as project manager or as a member of the project team). This requires not just firm level capabilities building (firm and individual) but linkage level capabilities (Lall, 1994). Thus the conceptual framework for this work package recognizes this and the literature in this area, starting with the general literature on technological capability building.

Bell (2009: 11) sums up his understanding of the capabilities needed into two types of technological capability. The first is that which is required for ongoing operations with existing forms of technology already in use or the routine technology and business management routines mentioned above. These capabilities are referred to in the literature as 'production capabilities'. The second type of capabilities referred to by Bell (2009) which has taken hold in the literature is that of innovation capabilities or the ability to recognize the need for different forms of technology that are not currently in use in the firm. It is the ability to understand the need for new technology and the ability to know where to get it, how to get it and how to successfully introduce it.

In this context, the term 'technology' is not just referring to physical products but also to a range of different forms of knowledge. Archibugi and Coco (2005) refer to technological capabilities as being possible to group into three different sets of contrasts:

1. As being either embodied physical technologies or disembodied technologies or knowledge
2. As being either codified or tacit in nature with regards the degree to which the product or knowledge can be easily understood through written instructions, plans or diagrams
3. As being about generation but also about diffusion of products and knowledge. Thus, not all firms will generate new or modified technologies or knowledge but will gain new capabilities through the use of technologies and knowledge developed by others.

It is perhaps not surprising therefore that Bell (2009) develops a typology of technological capabilities with four different types:

1. Capital embodied technology or what can be termed physical capital i.e. tangible assets such as turbines, solar photovoltaic (PV) panels or the diagnostic equipment used to maintain these.
2. Disembodied technology or what can be termed knowledge capital. These are intangible assets and examples would be product designs, instructions, component specifications or schematics or plans.
3. Skills and people-embodied technology or the human capital. These again are intangible assets such as the engineers, designers, technicians working on a project.
4. Organizational aspects of production or what can be termed the organizational capital. These relate to organizational assets such as the ability to manage projects; to bring partners together and manage a joint venture or public-private partnership.

Bell recognizes in his 2009 paper that his typology is different from that of some others as it makes assumptions that others don't agree with in regards to the distinction between production and innovation capabilities and in terms of the types of these capabilities and what's included in each. Lall (1994) for example puts more emphasis on the different elements of a firm's operation (investment, production and external linkages) and also recognizes that there are degrees of complexity in the creation of capabilities. Others (see review by Hansen and Ockwell, 2014) focus on a continuum of technological capabilities from production through to innovation and focus on the way firms change from being able to conduct capabilities that are new to the firm, through to those that are new to the market and eventually to those that are new to the world i.e. ever increasing levels of innovativeness.

Others focus on specific elements of technological capability. There is a large literature specifically focused on what Bell refers to as 'organizational capabilities' but Lall refers to as 'linkages with the economy'. This is the systems integration role referred to above; the ability to understand what is needed in terms of organizational arrangements (and for some also knowledge and technological arrangements also) in terms of linkages with other firms as well as such arrangements inside the firm also. Prahalad and Hamel (1990) refer to these as a firm's 'core competences' or the skills needed to 'coordinate diverse production skills and integrate multiple steams of technologies'.

Others focus more on the knowledge and learning elements of technological capabilities. This can be seen in terms of a specific focus on one of the sub-sets of technological capabilities identified by Bell (disembodied knowledge and skills and people embodied technology) and their relative importance as capabilities vis à vis the other forms of capability. Without strong focus on these, the other forms will not be successful. Bell (2009) himself recognizes this and talks of the importance of implicit and explicit 'learning by doing' as being essential and refers to the concept of 'absorptive capacity' (Cohen and Leventhal, 1990; Zahra and George, 2002) or the ability to identity, assimilate, transform and exploit knowledge from external sources.

A whole other set of related literature focuses on knowledge spillovers and their ability to lead to upgrading in firms. This literature is often specifically focused on the important role of technology clusters and regional development (see Kesidou and Romijin, 2008 for a good example). However a wider literature on knowledge, learning and knowledge economy exists (Lundvall, 1992; Jessop, 2000; Roberts, 2009) but it is the former set of literature that is most relevant to this work package. The knowledge spillovers literature is focused at firm level and is focused on how local or international level firm interactions leads to opportunities to leverage new knowledge and learning into a firm.

As a result of these different foci on technological capabilities there are different perspectives on how to measure them. Coombs (2006) provides a good overview of different measures of technological capability at firm level. He – as have others (Archibugi & Pianta, 1996; Hall & Bagchi-Sen, 2002;

Coombs & Bierly, 2006) – recognize that prevailing literature often focuses on patent data as a proxy indicator for R&D intensity in firms as an indicator of technological capability. However, this is insufficient given the different forms of technological capability identified above. Some (see Flatten et al, 2011) have developed multi-dimensional typologies and collected data using mixed methods (quantitative and qualitative) in order to focus on wider understanding of absorptive capacity and technological capabilities. The most comprehensive found during this literature review which is focused at country level and therefore provides a good basis for a typology of indicators if not the instruments to collect them was Archibugi and Coco (2005). Others (see Ulrich and Ockwell, 2014) use a wholly qualitative approach and focus specifically on learning that occurs between firms and others external to the firm.

Technological capabilities and competitiveness

The development of technological capabilities provide firms with a means to become increasingly competitive. There are two parts to this argument. First that export oriented firms are more likely to develop more relevant technological capabilities than those that are focused on a national market. Lall (1994: 30) argues that "inward-oriented regimes foster learning to "make do" with local materials, "stretch" available equipment for down-scale plants, while export-oriented regimes foster efforts to reduce production costs, raise quality, introduce new products for world markets, and often reduce dependence on (expensive) imported technology." Interestingly a set of literature that has become prominent in the innovation and development field argues that innovation in scarcity conditions is a positive attribute (regardless of a firm's outward or inward looking orientation), because it usually ensures that only those innovations and related capabilities are built that are needed by society (Sutz and Srinivas, 2006).

The second set of arguments here relate to the global value chains literature and as such is linked to the arguments of Lall above. The overarching argument of this literature is that developing country firms would benefit from insertion into global value chains and global production networks. This literature focuses on two main areas of thinking that are relevant here: (i) firm level – upgrading within the firm (process, product or function) or (ii) linkage creation and capabilities building/ upgrading along the chain (Haakonssan, 2009). This WP is interested in both but assumes the first as a result of the second. Therefore the primary interest is the second focus area. In addition, the focus of Global Value Chain literature is predominately on upgrading in firms or linkages between firms as a result of exporting activity but it is actually possible to learn from importing (Haakonssan, 2009). It is learning through importing that our WP is interested in.

Competence building and upgrading determined by context and adaptation

In the preceding sections, we have indicated that technological capability is key for successful project development, innovation processes, and competitiveness of firms. However, buying and acquiring a (foreign) technology by a firm does not automatically lead to innovative capability. It requires a learning process in which 'know-how' and 'knowledge-what' are also transferred, new skills are learned and technical competence are accumulated over time (Lundvall and Johnson, 1994; Ockwell et al., 2008). This means that successful technological learning and capability development processes are not exclusively internal activities of a single firm. In fact firms that actively engage in learning from other firms and partners substantially increase their technological capabilities compared to those that do not (Hansen & Ockwell, 2014).

Scholars from innovation studies have also asserted that successful innovation by firms depends on the degree to which a firm establishes 'interactive learning' relationships with agents external to it, including with users. Jensen et al. (2007), for example, show that interactive learning-based experiences between producers and users of knowledge are key drivers of innovative processes in addition to formal research efforts. Interactions within and among groups of firms and individuals is determined by norms, habits and routines that are highly entangled within a society, implying that development of competence for innovation is determined by nationally bounded institutions. Differences in time scale of projects among national contexts, trust among economic agents, 'communicative rationality', formal institutions such as intellectual property rights, contract laws, corporate law, arbitration institutions were found to be institutional factors varying across nation-states that determine innovative activities (Lundvall et al., 2002). This observation suggests that national specificities in terms of the intensity of interactive learning among key actors and national institutional conditions or also called National Innovation Systems are key determinants of technical competence and upgrading. This is supported by empirical research. For example, Gu & Lundvall (2006) show that systematic and pragmatic policy efforts aimed at strengthening the national innovation system of China has been central for rapid endogenous innovation and technological success. This is achieved through active encouragement of domestic demand for Chinese technologies, strengthening technological competence of users, stimulating and upgrading the technical competence and knowledge base of strategic sectors and investment on social capital, i.e. putting up platforms and institutions that encourage citizens to collaborate and exchange experiences and information (Gu & Lundvall, 2006).

Another element of context which is important relates to the physical technologies themselves and how they are designed and adapted for different environments. There has been an interest recently in a second wave of so-called 'appropriate technologies' that have been designed and manufactured in developing countries such as India, China or Brazil and which are deemed to therefore be more appropriate in terms of usability, durability, repairability and cost than technology from Northern economies such as Germany, the UK or the US (Kaplinsky and Hanlin, 2016).

Conceptual framework and research questions

Based on the literature review outlined above it is possible to develop the conceptual framework outlined in Figure 2. Our primary interest is on the technological capabilities that result as a function of interactions within the project cycle by different project partners through learning by importing or the transfer in of technologies from other countries. Specifically we are interested in upgrading opportunities through value chains for the project leader but also for other local partners involved. Thus our overarching research question is:

> *What is the relationship between imported technology, the development of new technological production and innovation capabilities and upgrading in firms involved in renewable energy electrification projects in Kenya?*

Specifically in order to answer this question we need to answer the following sub-questions:

1. Do Southern based inputs build stronger capabilities?
2. Have the developed capabilities led to upgrading and, if so, what type of upgrading?
3. Does it matter were in the project business cycle a firm is in terms of the type and level of capabilities that are built?
4. What contextual factors impact on the ability for a firm to build capabilities and upgrade?

This paper proposes to use a number of indicators for the assessment of capabilities and upgrading. These are outlined in Table 1.

Table 1: Indicators to be used to assess capabilities and upgrading

	Capabilities and upgrading	Indicators
Micro level inputs	Individual skills	1. Government minimum standards 2. Additional 'on the job' skills identified 3. Training opportunities
Meso level inputs	Technological capabilities	4. New physical technologies (e.g. new piece of testing equipment) introduced into the firm that results in new business opportunities at any stage in the project cycle 5. New knowledge introduced into the firm that results in new business opportunity at any stage in the project cycle (e.g. recruitment of a staff member with EPC[4] experience or training of existing staff in how to install a specific new invertor design)
	Core competences	6. Function as an EPC contractor 7. Evidence of ability to leverage new partnerships on the back of previous work
Outcomes	Upgrading	8. Process upgrading (e.g. increased efficiency of installation process – speed/ manpower requirement) 9. Product upgrading (e.g. from using Chinese to German inverters) 10. Functional upgrading (e.g. move from being a contractor to doing full EPC) 11. Chain upgrading (e.g. move from installing solar heaters to installing mini-grid systems)

Methodology

The methodology for this project is in part determined by the conceptual framework and builds on the lessons of others that have studied similar issues as outlined in the literature review section. This section discusses case study choice as well as research design. It outlines a range of potential ways of researching the different questions, depending on the level of emphasis given to the different research questions above and/or the focus placed on different types of firms or elements of the project business lifecycle depending on what access is available.

Case study choice

This paper presents results from a number of case studies of renewable electrification projects in Kenya. These cases were chosen based on a review of the answers given to a question 'what have been the most important energy projects for Kenya in the last 10 years' during a survey conducted as part of the IREK project found that LTWP was the most frequently cited large scale project (Hanlin et

[4] EPC stands for engineering procurement and construction. It refers to a particular type of project management approach utilised in construction and infrastructure projects whereby the same company is in charge of all of these elements (instead of each element being managed by a different firm).

al, 2017). For small projects, the survey identified the most frequently named project as Kitonyoni solar project (13.5Kwp). In addition, a decision was made to choose a small number of mixed projects in terms of characteristics or what are sometimes referred to as 'maximum variation cases' (Flyvbjerg, 2006). Table 2 outlines details of the projects chosen highlighting how they differ in terms of the origin of the equipment, the project size, focus energy source and grid connectivity. Further differences include: different sized lead firms, different organisational project set-ups, different investors and different locations.

While ideally we would have like to have included a large scale solar off-grid and a small scale wind on-grid project to be studied as well, unfortunately, we have found it difficult to identify a suitable project candidate in each of these two categories. This difficulties of finding small scale wind projects in Kenya have been explored by another colleague in this project (Wandera, 2018).

Table 2: Case studies outlined

	Large scale (>100KWp)	**Small scale (<100KWp)**
Solar on grid	Garissa (50mwp, Chinese technology)	SOS children's village Mombasa (60kwp; German technology)
Solar off grid		Kitonyoni solar project, (13.5kwp; EU technology)
Wind on grid	Turkana (300mwp; Dutch technology)	

A broad history of case studies – broken down by project cycle element – is provided in Table 3 below.

It should be noted that while we took these projects as case studies through which to study the existence of capabilities and competences, the analysis in the results section is mostly focused on the firms involved in the projects. This is because the competences and capabilities reside in the staff and resources of the firm and not in the projects themselves. The projects are the vehicles through which experience and capabilities are developed.

Table 3: Project cycle and technology type by case study project

	Garissa	LTWP	SOS	Kitonyoni
Dates	Agreement with China signed 2013; Construction started January. 2017; Commissioned October. 2018	Construction started Oct. 2014; Commissioned November. 2018	Conceived 2010; Construction 2011; Renovation 2018	Conceived 2012; Construction 2012; Commissioned 2012
Size/ Type	55 megawatt, solar	310 Megawatt, wind	60 Kilowatt, solar	13.5 Kilowatt, solar
Employment numbers	*At peak construction:* 350 workers (100 unskilled general construction work; 250 skilled installing panels). Of the 250 skilled 100 were from Garissa environs. In addition, 80-90 of the 250 were Chinese nationals. *O&M:*[5] 5 Kenyan nationals (although appear to only be 2 onsite at any one time) and 4 Chinese. Local Kenyan workers will be employed to clean panels every 3 months.	*At peak construction:* 180 staff on site. 24% of support staff during construction were from the local area. *O&M:* Vesta service team is 17 technicians and two supervisors (all Kenyan). Supported by 3-5 experienced service technicians from outside Kenya NB: Vestas required all contractors and sub-contractors contracts to include a target of 20% of the total employment being from the communities in the region. Vestas had a target to move from employing majority international experts to majority local employees. In practice, finding local skilled engineers not difficult so changed target to movement from 95% percent national Kenyan employment to 95% employment from the Northern Kenyan region.	*At peak construction:* 2 technicians from Germany *O&M:* staff from SOS Childrens Village clean the panels. Originally, they also replaced panels when they broke. More recently, Knights Energy did a major renovation using Kenyan solar technicians. SOS Childrens Village are in the process of training a member of staff who will become responsible for the system on a day-to-day basis.	*At peak construction:* This project involved bringing in a 'ready to go' system which was installed through a combination: - UK university engineers (9); - Steel construction company (3) - UK electrical engineering firm (3) - Engineers from Chloride Exide - Local villagers x 4. *O&M:* 1 Kenyan locally based technician and 1 manager of Makueni County Solar Supply Co-operative Society.
Project cycle				
Project idea/ owner	Rural Electrification and Renewable Energy Corporation (REREC), formerly known as Rural Electrification Agency (REA) Have 25 year power purchase agreement with Kenya Power at 5KShs/KWh	A holding company through LTWP consortium (made up of a number of equity investors). Have 20 year power purchase agreement with Kenya Power at 8KShs/KWh	SOS International	Project idea was by Prof. Abubakr Bahaj, a lecturer at the Southampton University, UK. Owner of the system is the Makueni County Solar Supply Co-operative Society

[5] O&M refers to Operations and Maintenance activities

Project financing	EXIM Bank of China totalling Kshs. 13.5 billion	11 multi-lateral lenders including African Development Bank and a variety of equity investors including Norfund and Industrial Fund for Developing Countries (IFU).	SOS International and German government funding. For example, the renovation in 2018 was funded through the "German Energy Solutions Initiative" of the German Federal Ministry of Economics and Energy.	UK government funding through Southampton University
Design and engineering	IT Electronics Eleventh Design & Research Institute Scientific & Technological Engineering Corp Ltd (China)	Worley Parsons (South Africa office) had the engineering, design and construction management (EDCM) contract with LTWP.	African Solar Design (ASD) set up to enable a joint venture with Asantys Systems (Germany)	University of Southampton, UK
Installation/ Construction	China Jiangxi Corporation for International Economic and Technical Cooperation Company Maknes was site agent	Vestas (Denmark) installation team managed the arrival and erection of the turbines. Various other subcontractors hired: - EGMF – EPC for concrete foundations - Anopsitiki (Greece) – specialised lifting and installation of the blades. (Sub-contracted this to SECO (Kenyan company) - Civicon – site road construction - Siemens (France) – site power lines construction - RXPE (China) – transmission system construction In addition: Daher (France) and Bollare Logistics were contracted to transport equipment for Siemens and Vestas respectively.	ASD and Asantys Systems (Germany)	University of Southampton with Chloride Exide. Construction of the concrete slab, construction of the security fence and installation of CCTV done by a local (Kenyan) contractors. Local villagers x 4 helped with the installation.
Operation	Kengen (on behalf of REREC) with Chinese technical support for 2 years	LTWP run day to day operations of the plant. Have recruited staff from other parts of Kenya's power sector e.g. Kengen	SOS Childrens Village staff until 2014/15 when the system broke down	Training of local staff to run the system immediately after set up. But in effect a single local technician being in charge on a day-to-day basis. Supported by Southampton for three years with

				monitoring being done from UK Fully handed the project to Makueni coop energy society in 2015
Maintenance	Kengen with Chinese technical support for 2 years	Vestas has a service contract to keep turbines operational	SOS Childrens Village staff would clean panels and replace panels until invertors stopped working in 2014/15	One local technician. Gets support by WhatsApp/ skype from Southampton engineers as needed
Renovation	Too early for this stage yet.	Too early for this stage yet.	Knights Energy contracted to renovate the site in 2018. Installed Chinese panels to replace broken ones (1/3 of the site)	Not needed yet due to regular on-going maintenance
Other	Primary school and dispensary amongst other things built as part of CSR activities. Kenyan (Garissa based) contractor to build borehole for community. Landmark transported tech from Mombasa port to site.		SOS Children's Village solar system was supposed to be the first 'ready-for-net metering' project. However, still no finalised contract with Kenyan Government on power purchasing but power from their system enters national grid.	Chloride Exide sub-contracted another firm, Gilgil Electrics, to do power distribution work related to construction because Chloride Exide didn't have the expertise in house.
Hardware technology				
Major tech	200,200 Jinko solar panels; Huawei inverters; transformers (all Chinese)	365 Vestas wind turbines (model V52-850) (Denmark)	312 CentroSolar Solar PV panels (Germany) SMA invertors (Germany) Chinese panels with SMA invertors during the renovation	Victron (Netherlands) provided: quatro inverter chargers, solar PV panels, charge control cables Chloride Exide batteries (Kenya)
Other tech	Panel frames/ mountings (Chinese)	RXPE transmission system (Chinese)	Panel frames/ mountings (Germany)	Antares (UK) payment system Steel construction work (UK company)
Consumables	Sourced in Kenya were the electrical cabinet boxes, switch boxes, circuit breakers		In the renovation screws and other consumables were locally sourced in Kenya.	

Research methods

The case studies was researched using a mix of quantitative and qualitative methods as per Table 4 below. A mix of methods was necessary in order to gain all the information needed to answer the research questions of interest to this study. A brief overview of each of the research methods has been given in this section before specifics on the data collected which has been provided in the next section. All research has been conducted in accordance with good practice following ASA recommended practice (http://www.asanet.org/membership/code-ethics). This includes asking for informed consent before any interview, observation or survey is conducted. Interviewees were asked if they wish their answers to be anonymised and every care was taken through aggregation to ensure anonymity of individuals was ensured as much as possible. All interviewees received a copy of the interview notes for review and further comment. The final research protocol and research instruments has been reviewed by ACTS' internal ethics group. ACTS is allowed to conduct research in Kenya under the STI ACT of 2013 (section 12) as an acknowledged research institution in the country.

Table 4: research methods utilized

Desk review of all grey and published material from multiple sources to understand the history and detail of each of the four projects, notably formal capability building stories as outlined in policies or project proposals.
Observation at each project site and project team members' own organisations to triangulate interview data.
In-depth interviews with engineers and operators/ maintenance staff of solar PV and wind systems was undertaken to understand the extent of capability building taking place. A total of 12 interviews were conducted. This focused on a 'day in the life' type approach to understand how knowledge and skills are transferred amongst team members and the degree to which these occurred as a result of external assistance. It specifically focuses on how individuals in each organisation interacted with the physical technology (solar PV system or wind turbine or elements of these).
Semi-structured interviews with key project staff and other relevant stakeholders to garner more in-depth detail on each of the projects, the challenges and opportunities to project activities including technology capabilities building. A total of 14 interviews were conducted.

Desk review

An initial desk review was conducted in order to gather data on:

1. The history and detail of each project in terms of how long the project has been in operation, the phases of the project, costs and specifics of project activities together with a general idea of any key challenges and opportunities that have presented themselves along the way.
2. Details of project team members including their degree of involvement and its change over time, quantity of investment etc. Also an analysis has be conducted of how this project fits within their overarching portfolio of work. A review of company strategy and its change over time will also be conducted in order to get a sense of whether the company has any policies or specific project proposals that focus on the development of technological capabilities. It has also considered how the company responds to public attitudes towards the development of technological capabilities
3. Any further policy data and analysis that is useful. In particular a review of the policy situation and its change over time has provided background on external influences on project design,

build and operations together with project team member organisations' own strategy decisions.

This initial desk review was used to refine the interview guide and observation check list.

Desk review work continued at a much less intense rate throughout the WP to enable us to keep abreast of any major policy issues or changes to the enabling environment that might have a baring on the fieldwork data and its subsequent analysis and write up.

Observation

During the collection of data using interviews and performing the capability survey, researchers recorded observations of their interaction with the six research project team members and operations. Records of each site visit was kept detailing not just where a research activity took place and who was involved but also any additional comments on general or 'off the book' conversations that were heard, participation in any additional company events (team meetings, site activities, training events etc.) together with any sights, sounds, smells etc. that they encountered which might be of relevance to the project. This data has been used to triangulate or verify the data collected during the in-depth interviews and generally to gain a much better understanding – 'feeling' even – of each of the six projects.

Semi-structured interviews

A small number of core project team members were interviewed including the project managers, lead engineers, client, HR manager, community liaison officer or equivalent in each project's lead firm and partner firms. In addition, interviews with other relevant stakeholders (ministry staff, industry association representatives etc.) were conducted where appropriate. These interviews was used as a means of gaining information specifically for sub-research question 4 on the enabling environment but also provided an opportunity to gain context to the data collected to answer sub-research questions 1, 2 and 3.

In-depth interviews with engineers and maintenance staff

A number of specific individuals who work with the technologies of interest in each organisation involved in a project were asked for an in-depth interview. This was to ask questions with regards the type and form of technology capability building that is conducted focusing of capabilities that are not physical embodied technologies (which are assessed through the technology assessment outlined above). Specifically, it focused on the mechanisms for development of these capabilities or *how* these capabilities are built. This was done through a series of questions that asked details of how knowledge and skills are transferred across staff and departments in the organisation and how this is impacted by external partners during a project cycle.

Data collected

Each of the different research methods collected data against each of the various sub-research questions. The types of data collected are outlined below by sub-research question, sometimes in the form of questions.

1. <u>Do Southern origin inputs build stronger capabilities (or simply complement better existing capabilities of developing countries)?</u>
    - What makes Southern technologies distinctive from Northern?
    - How do these play out in the way the technology is utilised?

2. <u>Have the developed capabilities led to upgrading?</u>
    a. What capabilities are built in terms of: capital embodied technology (e.g. physical equipment); embodied technology (e.g. skills and knowledge in employees and contractors); organisational capabilities (e.g. project management systems in place)
    b. What has been the result of these new capabilities in terms of this project, new project proposals, staff changes (staff moving on and taking skills with them; staff moving to new positions in the company), new opportunities for individuals and firm, new collaborations etc.
3. <u>Does it matter where in the project business cycle a firm is in terms of the type and level of capabilities that are built?</u>
    a. This was assessed based on a comparison of general data collected with regards the firms' activities in the project and business history with the capabilities data collected.
4. <u>What contextual factors impact on the ability for a firm to build capabilities and upgrade?</u>
    a. What has been the result in terms of the enabling environment; systems building i.e. building new training facilities/ curricula, changes in legislation etc.?

Data analysis

Each data collection method resulted in various data sets being collated. The desk review resulted in various notes being written. Each observation (i.e. each fieldwork related trip) results in a field report being written. Each interview has been transcribed or has detailed notes written up. All of this data has been reviewed and cleaned as needed before detailed data analysis was conducted. Qualitative data from the desk review notes, field reports, in-depth interviews and capability survey was analysed using grounded theory techniques. Notably, the data was coded by emergent theme manually.

All data collected was stored in secure password protected files only accessible by IREK team members. All data was anonymised for data analysis and reporting unless otherwise agreed with the respondent. Data was aggregated during reporting wherever possible to increase anonymity.

Research results

Evidence of individual skills building

We start this section with a discussion of the skills available within the firms interviewed and an assessment of the quality and quantity of skills available for the renewable electrification sector from the interviewees. We then discuss the availability of training opportunities given to staff in the firms interviewed. This includes both in-house informal 'on the job' training as well as more formal training through workshops and certification programmes.

In-firm skills

One of the interviewees from Knights Energy acknowledged that the majority of the electrical technicians who were involved in the construction of solar projects are all certified by EPRA following the directives by EPRA who have offered some specifics such as T1, T2, and T3 which are for solar. This assertion was echoed by a CEO of firm, ASD, and by engineers working with KENGEN. He also noted that Kenya is the only East African country to have introduced a certification scheme for solar technicians. In addition, many of the staff in all of the firms were also certified as electrical engineers by EPRA (grade classes A, B and C). This is important because firms need to be able to show a certain number of certified staff in order to win tenders for mini-grid and other types of projects.

Many of the staff we interviewed also highlighted the important role of professional development courses and/or specific formal training courses which have provided staff in firms with key skills relating to certain technologies and/or routines. These are provided by universities (notably Strathmore University's Energy Research Centre) or industry associations (such as the Kenyan Association of Manufacturers and KEREA, Kenya's Renewable Energy Association).

Many of the firms working in the solar or wind sector in Kenya are relatively small companies in terms of size of employees. One example of the type of firm that is highly involved in solar mini-grids is Knights Energy who described their technical staff set up as follows:

> "The firm has 2 graduate electrical engineers. We also have two T2/T1 certified technician from ERC [now EPRA]. These are not the optimum requirements, as, our engineers are keen to partake examinations on classes C1, classes B and classes A. The full team is composed of graduates from different fields- telecommunications, renewable energy, environmental management, business management and finance. Additionally, the chief technicians have energy management certificates. The key job descriptions are electrical engineers who can design power plants, work with low and medium voltage power systems (interconnecting safely, systems diagnostics, and electrical equipment operations). Moreover, the workers in monitoring possess skills in networking and systems diagnostics. The renewable energy experts possess knowledge in sizing solar systems, developing financial proposals for the renewable energy plants."

One of the engineers from Chloride Exide acknowledged that for one to be hired for an engineering job, one needed to be 'trained in college and acquire a diploma or certificate in electrical and then advance to higher levels by attending the academies like Strathmore energy research, university of Nairobi and Technical university where you would learn solar.'

Additional on the job training skills identified

Since formal qualifications are not sufficient, as a way of building individual skill, engineers and technicians have an opportunity to learn by themselves through day-to-day work routines and as a result of working on specific, non-routine tasks and/or longer term projects.

For example, two engineers who work with University of Southampton informed us that while they received formal training externally (see below) they were being trained 'on-the-job' by their foreign counterparts. As a result, they were picking up experience and knowledge through experiential learning.

Virtually all the interviewees from local firms identified that they learnt on the job through either very informal experiential learning or through more formalised on-the-job training (i.e. forms of apprenticeship schemes or as a result of regular supervisory check-ups on work).

Employees at Knights Energy noted how they learnt how to angle panels on roofs more effectively through learning on the job. Those in Firms Knights Energy, Chloride Exide, Gilgil Electrical and Makueni Coop Energy Society all commented on learning how to monitor mini-grid systems more effectively through experiential learning opportunities given to them by working on projects.

In fact the CEO of ASD acknowledged that, while the solar engineering certification (T1,T2 and T3 qualifications) are important from a licencing perspective, his best technicians are those that don't have these qualifications but have learnt their skills 'on the job'.

Finally, more ad hoc learning takes place through staff attending webinars of interest and routine staff led seminar series at Knights Energy while those from Chloride Exide and Makueni Coop Energy Society noted being able to call technical support staff from partner organisations.

Formal Training

In many of the firms, there were as evidence of two types of formal training that was undertaken. That which occurred in-house (i.e. internal to the firm) and that which was delivered off-site by external suppliers. As noted above, many of the firms send their staff for formal training to local suppliers such as Strathmore Energy Centre for solar engineering certification for example. However, firms also acknowledged the importance of training from technology suppliers. For example, Knights Energy sent its staff to Germany for training on SMA inverter systems; staff in KENGEN were sent to China to see other largescale solar projects in action and get training on the Chinese equipment they would use in their projects. In other cases, e.g. LTWP, the trainers come into the firm and provide formal training courses (e.g. Global Wind Organisation blade repair training). Some of these trainings lead to different forms of certification. One of the firms involved in our case studies projects, Chloride Exide, had set up a formal training centre within their organisation for continuous professional development. Knights Energy, at the time of the case study, was in discussions with a major technology supplier to start its own training centre at the time of the interviews.

In the cases of Knights Energy and Chloride Exide, when staff go outside for training, they are expected to come back and train others. In the case of LTWP, a formal 'trainer of trainers' system is being introduced. These mechanisms ensure that learning isn't just embodied in one individual but that it is shared across staff.

Most of the firms have some form of formal learning commitment to staff in their staffing policies and sometimes this comes down to project level learning contracts (ASD and Kengen).

Training and skills development are therefore taking place in local firms engaged in solar and wind projects that were examined for this study. Much of this is concentrated at the installation stage. However, there is also evidence that training takes place for maintenance and upkeep of the installations once installed. This is certainly the case with firms LTWP, Makueni Coop Energy Society and SOS Childrens Village. Interviewees also expected it to happen in the case of Kengen.

That said, in some cases, staff – while they appreciate the trainings (formal and informal/ on the job) – do state that often the learning that they receive on these workshops and courses, does little to change the way they work. To paraphrase one interviewee:

> *'In terms of technology not much has been learned since we have been doing the same and using the same technology.'*

Evidence of technological capabilities building

Beyond training, we were also interested in the existence of firms who bring in new physical technologies (e.g. a new piece of testing equipment) or new knowledge (e.g. recruitment of a staff member with EPC experience or training of existing staff in how to install a specific new invertor design) and results in one or more new business opportunities at any stage in the project cycle.

New physical technologies

During fieldwork we found evidence of new physical technologies (new piece of testing equipment) being introduced into firms which had resulted in new business opportunities within different stages of the project cycle.

Knights Energy had bought in new monitoring equipment for solar plants (SMA Data Manager with EnnexOS Platforms), new technologies for solar water heating applications (ELWA systems), and Electric vehicles from Nissan (Nissan Leaf and Nissan e-NV200). Further, the firm's interviewees noted that they had found themselves selling more electrical vehicles and were less focused now on construction of solar plants. This has allowed them to expand their business operations into new areas. Specifically, as a result of them importing electrical vehicles, they now focus their solar micro and mini-grid solutions on incorporating electric vehicle charging stations. This has provided them with new business opportunities such selling monitoring equipment, power storage equipment as well as Electrical vehicles (EVs) chargers as part of the solar installations.

Firms involved in the large scale wind projects had imported new equipment for the projects. Specifically Bollare and SECO, both bought in new plant equipment, trucks and trailers. Civicon worked with the manufacturer of the trailers to make sure that they were the right design of the blades and turbines that they were going to have to carry. In addition, Bollare brought in new data log equipment that measures the vibrations on the truck to ensure that the cargo did not get damaged. The interviewee from this firm told us that they now use this data log equipment as standard on all out of gauge cargo that they transport as a result of the success and usefulness of the equipment during their work on the wind turbine transportation job.

The use of imported equipment was widespread across both small projects and large projects. For example, one of the engineers interviewed from University of Southampton noted that they were using Victron Quatro inverter chargers and this was a new piece of technology he interacted with on the project. Knights Energy utilises inverters from Germany while those involved in the Garissa project were using inverters from China.

However, SECO utilised equipment that it had manufactured in Kenya (modified containers, steel base plinths for example). However for the most part, most of the firms interviewed whether working on large scale wind/ solar projects or small scale micro and mini-grids talked only of using local consumables such as screws and some basic tools (although often these too are imported into the country; just supplied from a domestic retailer).

New knowledge

In addition to new physical technologies, firms are also likely to need to bring new knowledge into the firm. This new knowledge is bought in to exploit and develop new business opportunities at a relevant stage in the project cycle (e.g. recruitment of a staff member with EPC experience or training of existing staff in how to install a specific new invertor design).

New knowledge has been a key element of the strategies of all the firms interviewed who were involved in the case studies we looked at. For example, one of the directors of Asantys that worked with a local firm ASD, acknowledged that they brought new staff into the firm to work on the solar mini-grid project. Specifically, this was as a result of a joint venture partnership between themselves and a local firm. Staff who worked on the project remained at the local firm afterwards to work on other projects.

Joint ventures and other forms of contracting arrangements have proven to be extremely useful in bringing in new knowledge embodied in project managers or experienced engineers who then train others from Kenya. In one of the large scale projects, extra hands were brought on board by having three to five experienced service technicians (with 5-6 years of experience running the equipment elsewhere) come in from abroad for the project period. They were specifically given the task of training up local staff.

The new knowledge embodied in staff does not always stay at the same firm. In the case of the large wind turbine projects, we have seen a lot of staff movement across firms with project managers moving from one firm to another as projects finish and another one starts. As such, while their old firm might still work on the new project, their knowledge that they have embodied within them is technically no longer available to their old firm.

Evidence of core competence building

Competence building as defined earlier is having the ability to 'coordinate diverse production skills and integrate multiple steams of technologies'. It is essentially the skill of knowing what knowledge and technologies are needed and how to integrate them. As such, in this study we were looking for evidence of firms functioning as an EPC (engineering, procurement and construction) contractor i.e. being responsible for all elements of the project cycle until handover for operation. This is because the role of an EPC is to manage multiple stages of the project cycle in house. We were also looking for evidence of the ability of firms to leverage new partnerships through their activities in these projects in order to conduct more elements of the project cycle.

EPC contractors

EPC contractors are responsible for all the activities ranging from design of a project, engineering the project, procurement of equipment, construction of the project, to commissioning and handover of the project to the final user or owner of the project. Evidence from the case studies has shown that some firms have grown to be EPC contractors.

One of the firms interviewed has been identified by another interviewee as 'the top EPC contractor in the market now for solar mini-grid installations'. Specifically an interviewee from ASD noted that when the small scale solar power project was first constructed they had no choice but to utilise an EPC contractor from Asantys in Germany because there wasn't local expertise in this field. However, the interviewee went on to state that 'in the intervening seven years there are now at least four Kenyan firms that provide as good, or nearly as good, EPC solutions as foreign firms'. In fact, the interviewee actually said this change had occurred in the last three years only.

Knights Energy, over the timeline of our case study projects, has moved into the mini-grid space from the information technology field to become a leading EPC contractor with over 20 EPC projects on their portfolio. Another firm, ASD, when their Director was interviewed, noted that their firm conducts activities at all stages of the project cycle and that these were their core functions: engineering, designing, installation and advisory services.

EPC contractors are the norm in large scale projects as we noted in our literature review on projectisation. What is interesting is that one of the large scale case study projects actually featured what might be termed 'nested' EPC activities. The project as a whole was managed under an EPCM contract[6] and then those who conducted the various different elements of the work managed their contract with the principal EPCM Company using EPC models. To take one example, SECO was in charge of the building of the permanent buildings on the project site. They were given an EPC contract to do this in that they were contracted to conduct the engineering, procurement and construction of the buildings. They were managed on a day to day basis by the EPCM Company who ensured that they stayed on time and in budget.

Leveraging new partnerships

Data collected shows that most projects have been executed by a network of organizations who perform different roles which have different implications on the project. For instance, in the case of one of the small scale solar case studies, Chloride Exide recognised the need to subcontract, Gilgil Electrics, which is an a electrical engineering firm because they (Chloride Exide) didn't have the power distribution skills in house for the project. Also, in the same project, one of the interviewees noted that the project ensured firms came to the project utilising their respective competitive advantages. Thus, Antares, a UK company, brought to the project a new pay-as-you-go software system whereas

[6] EPCM differs from EPC in that the M stands for management and refers to the fact that the firm with this contract oversees the management of the engineering procurement and construction. It essentially acts as the macro level project manager. It does not necessarily conduct any of the engineering, procurement or construction activities itself. However, it provides a barrier between these contractors and the lead client.

University of Southampton brought other physical technologies that it had expertise in fitting including charge control cables, solar PV and Victron inverters.

The partnership between ASD and Asantys enabled ASD to acquire EPC skills because they partnered with a top EPC contractor who had expertise in mini grid and turnkey solutions. This collaboration saw ASD conduct the initial site audit and developed an initial system design and - in partnership with Asantys – they provided system configurations, procurement, delivery and installation of the solar system.

In fact, whether on paper or not, all the case studies we have considered, highlight how the project format, provides an opportunity for leveraging of new partnerships and requires a partnership approach in its operation. Thus, just as the small scale solar mini-grid projects resulted in firms partnering with each other to ensure the necessary skills and technologies were in place, so too do we find this (and in even more complex arrangements) in the large scale projects. The result is multiple layers of contracts and sub-contracts with multiple interactions. Thus one company is hired to do earthworks, construction or catering by one project partner and then is asked to do the same for another project partner. In order to complete some of these on time and in budget, the lead contractor might sub-contract to a third party. Thus SECO was tasked with constructing buildings on the large scale wind project site not just for the EPCM Company but also for a number of the other contractors who were working on the site. However, in order to complete a contract on time, they sub-contracted another firm to do the plumbing work (an area where they, SECO, had less expertise).

Evidence of upgrading

The final area where we were looking for evidence of competences building was in the area of upgrading. Upgrading strategies not only require acquisition of competences but also changing relationships with buyers in the market. Upgrading offers many opportunities to firms ranging from increased efficiency and output in accessing new market networks as well as industrial knowledge. Upgrading in a firm is characterized under different categories. Specifically, we are looking for process upgrading (e.g. increased efficiency of the installation process for example in terms of the speed or manpower requirement of an install), product upgrading (e.g. from using Chinese to German inverters or invertors that are deemed to be of higher quality), functional upgrading (e.g. where a firm moves from being a contractor to doing full EPC) or evidence of chain upgrading (e.g. move from installing solar heaters to installing mini-grid systems). We now give an overview of the evidence we find of each of these in the case studies.

Process upgrading

We found very little evidence of process upgrading. In the case of Bollare there was evidence that the firm, through their contract on a large scale wind project, had decided to introduce 'just in time' production techniques to manage their transport of the wind turbines. We were informed this was the first time they had utilised this management technique. Similarly SECO had introduced a one month advance procurement planning process to ensure that they did not receive delays in manufacturing because inputs were delayed in transit. These are forms of process upgrading. It isn't clear that these have since been mainstreamed into the two firms on a regular basis.

We have no evidence of process upgrading by firms involved in the small scale projects.

Product upgrading

We find a complex situation with regards to product choice by retailers and installers in Kenya working on the solar PV projects. There is a distinct decision by firms to use and promote products of different origins depending on the product itself. Thus, we don't often find a firm that utilizes only Chinese equipment (except in the instance of Garissa solar project which is Chinese financed). Instead we find that firms are increasingly utilizing Chinese PV panels but will not, out of choice, utilize Chinese origin inverters. There appears to be an increasing trust in Chinese PV panels as noted by the SOS children's village example whereby the original German PV panels are being swapped out for Chinese panels when they need replaced. This is due to a decision by the repair firm that the cost-benefit ratio for Chinese panels is sufficient to warrant their use (instead of German panels).

Functional upgrading

Where we have seen most activity by local firms through involvement in these projects is in the area of functional upgrading. However, because functional upgrading (moving to a new set of product offerings that have higher value added) does not happen overnight, we find that much of this has taken place across the space of several years and not as a result of one of our case study projects per se. Thus, Knights Energy, as a result of its experiences of work on various mini-grid projects, including the SOS Children's Village, has moved from being a contractor on a project to becoming the EPC contractor i.e. in charge of the whole project cycle. The firm assert that they are now focusing on EPC contracts first and foremost. In fact, as ascertained earlier, many firms are now capable of EPC contracts which wasn't the situation even three or four years previously. Three of the solar PV installation companies we spoke to all now consider themselves EPC contractors. In addition, at least one of the logistics firms (SECO) also consider itself an EPC contractor.

Chain upgrading

As with functional upgrading we have examples of firms that have been able to utilise their involvement in renewable energy projects as a way of leveraging a move across value chains. This is visible in a number of areas. Firstly, we have Knights Energy who have seemingly moved from being a solar heater installer to an EPC contractor in the mini-grid sector to now selling electric vehicles. Secondly, we have Gilgil Electricals who have moved from being solely the producer of automotive batteries to now being a leading supplier of batteries for renewable energy projects and in turn have gotten involved in renewable energy projects. Thirdly, we have the mini-grid project at the community level which has allowed the local energy cooperative running the project to consider engaging in new business opportunities; not just selling electricity but conducting grain milling services for example. Finally, SECO noted that working on the large scale solar project has enabled them to move further into camp management and hospitality; providing them with a major initial contract in which to 'pilot test' their capabilities. They also noted that they have moved from being only involved in road construction to now being able to construct buildings and other structures.

Enabling environment

While recognising that firms have taken the initiative a great deal to ensure that upgrading or competence and capability building has occurred, whether implicitly or in a designed manner; much of this is also the result of facilitative government policy. Therefore, it is important for this results section to spend a little time expanding on how various policy initiatives have provided an enabling environment for competences and capabilities to be built by the firms interviewed through these projects.

Government minimum standards for training and skills

Government actions and policy initiatives have the power to create an enabling environment for building of individual skills. For instance, the Kenyan EPRA has been mandated to licence all engineers working on solar projects, EPRA is the sole entity that regulates all electrical contractors and all electrician contractors who work on solar projects in ensuring that they are all licenced and/or that a company working on these projects has at least one licensed electrical contractor. The Energy ACT, 2019 states that a person who wishes to carry out the generation, exportation, importation, transmission, distribution and retail supply of electricity must apply for a license. Further the Act sets out that a person who wishes to carry out electrical installation work must be licensed as an electrical contractor by the Authority. In addition, a license for electrical installation work shall be issued for a term of three years and may be renewed for a similar term upon expiry, subject to the licensee having undertaken any required additional training. In fact, to be an electrical contractor, a person must be a certified electrical worker; or have in his employment a certified electrical worker. In addition, the Act stipulates the need for specific certification of solar system installation contractors.

The two types of licensing that the Act refers to are as follows and are outlined in more depth in Annex 1:

- General electrical licencing types: Class A, B and C
- Solar PV technician certificates: Class T1, T2 and T3

Other rules and regulations

In addition to rules on certification of electrical contractors, there are local content regulations in place as outlined at the start of this paper with regards the use of local personnel and materials. It also promotes the creation of backward linkages in the value chain through these regulations by requiring companies involved in electrical engineering firms to utilise local firms for security, transport, clearing and forwarding etc. when conducting projects.

There are also other regulations that have been gazetted to assist the local renewable electrification sector. This includes, the Finance Act, 2018 which has given out provisions for tax exemptions for the supply or importation of equipment and materials for development and generation of energy for solar and wind energy technologies. Similarly, the First Schedule to the Value Added Tax Act, 2013 (revised 2018) focuses on specialized equipment for the development and generation of solar energy, including deep cycle batteries which use or store solar power.

Finally, Kenya's Bureau of Standards, regulates the standards of all solar equipment that is manufactured and imported into Kenya.

Discussion

An overview of the results of the fieldwork are presented in tabular form in Table 5 below. This details which Kenyan firms outlined during interviews benefited from being involved in the solar and/or wind projects and how they have benefited. It should be noted that the evidence of upgrading is not specifically related in all cases to the projects reviewed but as a result of general time spent in the industry.

Table 5: Overview of skills and technological capability building in Kenyan firms through project activities

Kenyan firm	Increased skills through informal in-house knowledge transfer	Increased skills through formal training (in-house or externally provided)	Increased firm capability through introduction of new physical technology	Increased firm capability through introduction of new staff members	Evidence of leveraging new partnerships to bring in skills/ knowledge/ physical technologies	Evidence of upgrading (process, product, functional or chain)
Knight Energy and Apps	X	X	X		X	X
Chloride Exide	X	X			X	
Gilgil Electricals	X		X		X	
ASD	X			X	X	X
Landmark						
KENGEN		X				
Maknes						
Bollore	X	X	X	X	X	
SECO	X	X	X	X	X	X
Makueni Coop Energy Society	X	X				
LTWP	X	X		X	X	

NB: No interview was done with Landmark while Maknes was found not to have increased skills, capabilities or competences during our analysis of interview data.

Answering the research questions

Below we provide an overview of how the results presented above provide evidence that answers (or otherwise) our original research questions. In some cases we find that our original research questions were in fact the wrong questions to be asking; especially in the case of the type of technology. Whereas with other sectors (see Kaplinsky and Hanlin, 2016), the origin of the technology mattered, in this case it has not. On the other hand, the project process has turned out to be very important to understanding the opportunities for upgrading and capabilities building. We discuss these matters below in more depth once we have given an overview of our assessment of the answers to our original research questions.

Do Southern based inputs build stronger capabilities?

Our starting premise for this project was that both our large scale projects used foreign technology; one predominately Chinese technology and the other Danish technology. For the most part this turned out to be correct. Similarly, our small scale projects we assumed would be dominated by European technology. However, we found a more complex picture in the smaller projects. Table 5 outlines the differences in tabular form.

Table 5: Technology types

	Starting premise	**What we found**
Garissa	Chinese technology	Only Chinese technology
Turkana	Danish technology	Danish technology but also Chinese technology
SOS Children's Village	German technology	German technology but increasing use of Chinese technology following renovation
Kitonyoni	EU technology	A combination of UK, Dutch and Kenyan technology

Despite the finding that a mix of technologies was in place, in all interviews held the overwhelming response received – borne out by the fact that the projects are being implemented by local Kenyan technicians and not those from the country of origin of the equipment – is that, in the case of renewable energy technologies in Kenya, the origin of the equipment isn't an issue. This was determined to be the case because of the level of engineering training available in Kenya. It was considered the case that, once you learnt the underlying principles of how the technology worked; where the technology came from wasn't a problem; other than when the instructions weren't available in English. However, in all cases, training by the vendors of the technology was available and was given in all cases (at some point in the project or before – as part of general in-house capacity building by firms).

Firms in the mini-grid sector appear to have a preference for certain types of equipment and align with manufacturers of that equipment to receive training. This is little different from in other sectors such as car mechanics or farming where a mechanic or farmer tends to buy a particular make of tyre or fertilizer to use either due to the cost or the customer service received from the supplier. In the case of these renewable energy firms, the reasoning was however the quality of the equipment. Thus we found very few examples of Chinese inverters being used and instead a preference for European inverters.

Have the developed capabilities led to upgrading and, if so, what type of upgrading?

One case study – the SOS Children's Village mini-grid – is a story of upgrading by firms over a period of time (and not only influenced by the project itself). It highlights how the solar engineering sector in Kenya has developed in the space of five years. It is also the case of where a particular partnering decision (for a joint venture) provided fertile ground for upgrading; providing evidence of the need to consider whether more specific supportive legislation is required to promote more opportunity for upgrading. Specifically; we have two instances of upgrading in the case of SOS Children's Village.

The first, is the case of Knights Energy. This firm was not involved in the initial design and build of the SOS Children's Village's solar plant in 2011. At that time it was just establishing itself as an information technology consulting firm. It became involved only during the plant's renovation in 2018. However, in the intervening period it has become an established EPC contractor for small mini-grid projects across Kenya. When the SOS Children's Village's solar plant was designed and constructed there was no obvious Kenyan EPC contractor working in the country. It is for this reason that a joint venture was needed between a German EPC solar engineering firm and a new Kenyan firm.

Which leads us to our next story of upgrading in this case study. The new Kenyan firm set up in 2011, ASD, entered into the Joint Venture to provide a Kenyan base for the development of the solar mini-grid at the Mombasa SOS Children's Village. What is interesting is that in the last five years, the company has since moved away from conducting installation of mini-grids to acting as a consultant on design and engineering of mini-grid projects across East and Southern Africa.

Finally, what is perhaps even more interesting is that there has been such a massive movement in this sector that Knights Energy has moved from 2010 when it was established as an information technology firm to being a solar PV EPC to now moving into a whole new value chain relating to electric cars (promotion and sales). Again, this hasn't occurred as a function of our case study, the SOS Children's Village. However, it highlights – along with the changes within ASD – how much potential there is for upgrading through involvement in solar PV mini-grid projects more generally.[7]

We however found only a little evidence of upgrading from firms working in large scale projects. This appears to be because of the nature of these projects which means that firms who interact in them do so in an established 'business as usual' manner i.e. the contracts they receive on these projects are no different from the contracts and terms of engagement that they have for other similar projects. We discuss the implications of this in a further section below.

Does it matter were in the project business cycle a firm is in terms of the type and level of capabilities that are built?

As can be seen from Table 2, despite Kenyan ownership of the power generation plants in all four case studies, we do not see a leadership role taken by Kenyan firms at the initial stages of project design and engineering. This is the situation in the case studies with the partial exception of ASD who were partners with the German firm who were the EPC for the SOS Children's Village initial design and install. There is more Kenyan firm participation at installation/ construction phase and even more still during the operation and maintenance phase; although on large projects there are service contracts involving foreign firms in both of the case studies.

That said, the use of Kenyan technicians and labourers is higher than was originally expected when we started this study (and higher than expected by those involved in the case studies i.e. in the case of Vestas' expectations of needing to utilise foreign engineers). In fact, as stated earlier in this paper, the issue isn't so much the technology type because the level of basic skills in the engineering field is sufficient in Kenya. Instead, the issue is knowledge of the finer points of specific pieces of technology.

---

[7] All things being equal. Obviously a set of wider enabling factors need to be in place/ available to the firm such as financing, access to equipment suppliers, conducive policy environment etc.

Thus, the majority of capabilities building has taken place in the installation and operations phases of the projects. Kenyan engineers have received specific training – both in Kenya and abroad – on how to utilise specific 'pieces of kit' e.g. SMA invertor systems and/or the maintenance of such kit e.g. Global Wind Organisation blade repair training (especially how to work at height). Those trained in these firms have fed this training back to colleagues through in-house firm level training where appropriate. In some cases, firms have introduced new pieces of kit which enhances their technological capabilities to offer enhanced services.

As outlined in Table 5, while the majority of capabilities built relate to skills training; there has been a significant level of capabilities building that has taken place across the firms interviewed in the area of leveraging new partnerships to bring in skills, knowledge and/or physical technologies. As such, a key competence that firms involved in all the case studies are gaining more experience in is around partnership relations and, in the case of EPC or EPCM and/or hands on owners of the plants, how to manage multiple partners. We come back to this below.

What contextual factors impact on the ability for a firm to build capabilities and upgrade?

As noted in various places already in this paper, the state of Kenya's education base and the availability of qualified engineers has had a positive impact on the ability of firms to build capabilities and upgrade. Kenya's requirement that all engineering firms working in the renewable electrification space have some of their staff certified by the KPRA and all those working on solar PV should be T qualified does appear to be responsible, in part, for the level of staff expertise in this area (despite the number of those interviewed who complained about the relevance of some of the material taught). In addition, the availability of this training in Kenya and the role of some key training and research institutions, notably Strathmore Energy Research Centre, should also be noted.

It is too early to tell if the local content rules that have now been introduced in the 2019 Energy Act will have an impact. However, we can see that the case studies where there was significant local ownership and involvement of the owners across the project cycle (LTWP for example) there is a greater focus – through implicit company mandates – to ensure as much local content (and use of local labour) as possible. Unfortunately the lack of local manufacturing capability in the area of renewable electrification technologies (except on the instances of batteries for solar PV plants and some consumables) has significantly limited the local content options beyond labour.

There is no evidence that there is other advantageous legislation that impact on firm abilities to build capabilities and upgrade in this sector. What appears to be the key contextual factor of importance (again as mentioned already above) is the type and nature of the partnerships and networks that exist in this industry and between Kenyan companies and foreign companies. Linked to this is the strong role of certain industry associations such as KEREA which have championed the importance of training standards in this sector.

Further discussion of issues raised and linkage to the literature

In the process of answering the research questions, a number of specific areas of interest – and future research – were identified. These specifically relate back to the status of the academic literature on these matters as well as recommendations for policy and practice.

Project types, specifically the focus on EPC vs. EPCM

One of the interesting observations from this analysis of the four case studies has been the increasing opportunity for EPC roles by Kenyan firms in small solar PV plant projects. We have noted in the paper that this change has occurred in a relatively short time (one respondent argued it had occurred in the last three years only i.e. since 2016). It highlights a significant change from 2001 when Murphy, in a well cited paper, stated that the low technological capability of project managers led to the abandonment of many solar PV systems.

At the same time, we note that in the large scale projects different models were evident. The Garissa project involved a Chinese led EPC style of project management while the LTWP involved an adapted EPCM style of project management. In all four cases reviewed in this paper foreign EPC firms have played a central role either across the whole project cycle or for a significant part of the project cycle.

Vidican (2012) noted in the case of Egyptian solar PV plant projects that having a local EPC facilitated more local company involvement in the solar PV project value chain because there was more chance that local sub-contractors would be utilised. Morris et al. (2012) also noted the same with regards to resource extraction projects in Africa, noting that where there was a local lead firm, the projects are more embedded into the local economy and are more committed to local development.

While we do not see any cases during the initial design/ engineer and installation/construction phases where there is a significant role played by local firms in any of the four cases, it must be mentioned that the LTWP did have (and maintains for operational purposes) a site and project owner who were hands-on throughout the project cycle. This owner identifies as being Kenyan and the LTWP consortium is incorporated as a Kenyan company. At the same time, this project – as opposed to our other large scale renewable electrification project example of Garissa solar park – also involved a significant number of sub-contractors; many of which were Kenyan companies or sub-contracted Kenyan companies. The LTWP, as noted above, had a sizable local content element to the project in terms of firm involvement.

We would argue that a key enabler for this was the type of contract that was given to the EPC firm, even though they were a foreign firm. Specifically, Worley Parsons were given an EPCM (engineer, procure and construction *management*) contract and not the usual EPC contract. The rise of the EPCM has come about as a result of the difficulty of finding a single supplier who can provide an EPC role (including bank-rolling this activity) for large scale projects – which have a high degree of risk and uncertainty (Loots and Henchie, 2007).

Therefore we would argue that a key enabler was not just having a local hands-on owner of the project but also that they specifically focused on local content clauses which included a desire to see – whether implicitly or explicitly – the use of local firms through a decision to hire a construction management firm and not one turnkey firm to conduct the whole value chain in house. It has been found elsewhere (although not in a large study) that utilising an EPCM contract has advantages for enhancing the potential involvement of local suppliers in the project process than EPC forms of contract strategy (Awuzie and McDermott, 2016).

Implications for the literature

This paper took as its starting point a set of literature on project management and the role of project management as a means of enhancing work organisation and innovative activity. However, this project has highlighted that the question to ask isn't just over the type of project management (outlined by Brady and Hobday (2011) as matrix, functional, adhocracies, Scandinavian or project business) but also the contractual relations involved within these project management approaches.

In investigating this issue, there appears to be a set of work around project contract types and the creation of social value through infrastructure projects (c.f. Awuzie and McDermott, 2016). Further research would be useful to interrogate the relationship between this literature and that of innovation, project management and capabilities building.

In addition, Loots and Henchie (2007) in their definition of the difference between an EPC and an EPCM contract note than an EPCM contract is a 'professional service contract' because the provider is not the principal. As such it is not responsible for the actual construction of the solar PV or wind generation plant. Vidican (2012) for example notes that in Egypt the solar PV plants she investigated required project execution capabilities as well as production capabilities and innovation capabilities. Similarly Figueiredo and Piana (2018) specifically focus on 'knowledge intensive service' enterprises in the mining sector (such a geotechnical engineering or R&D in environmental services firms). Davis and Brady (2016) therefore talk of project capabilities at the operational level and dynamic capabilities at the strategic level. As we will discuss below recognising the importance of different types of capabilities for different elements of project management (phases and types of project management contract) appears to be more important than first expected.

Implications for policy and practice

There are two major implications here:

1. More consideration as to whether certain types of project management contract should be promoted to enhance local content/ involvement of more local firms.
2. The importance of project management and experience of EPCM project management is needed if Kenya is to stop having to rely on foreign firms to manage this activity, especially for large scale projects.

Project size and potential for capability building

The capability building story has turned out to be much more complicated than expected. Our original proposition was that 'small is beautiful' i.e. that small scale projects are more likely to be developed by indigenous owned and run firms and that the firms involved in the design and construction of the projects are likely to benefit substantially in terms of skills gained and ability to then utilise those skills in other jobs. This doesn't always run true however. The Kitonyoni project is similar to a number of other projects whereby stakeholders design the project and the kit is installed with minimal local staff content. An internet search and literature review found two more projects like this also developed by the same UK university, 4 containerised solutions produced and sold through an energy supplies firm in Nairobi and at least two other containerised solutions introduced to two communities in Turkana region by a Kenyan company. It is unclear how much local[8] input goes into these containerised solutions. This differs however from SOS Children's Village which fits our proposition and where local firms have benefited (including through upgrading) as a result of their involvement in small scale mini-grid renewable electrification projects. However, nuances arrive when you start looking at employment figures and longer term employment opportunities.

On the basis of employment figures, large scale projects we have investigated provide – on paper - the highest opportunities for capabilities building. For example, we were informed by interviewees from LTWP company and its contractors that there was a workforce ranging from 180 to 400 people involved in the construction of the project (depending on how many sub-contractor staff are included in the calculations). The Garissa project was also found to employ around 300 people during the main construction period. As one of the EPC contractors on the project noted, many of the day labourers left the project with skills they didn't have before (such as carpentry or masonry skills) and which they will take with them when they leave. That said, these jobs are time bound; once the project is

[8] We note – as one of the authors does elsewhere (Gregersen, 2019) – that there are different definitions of 'local' i.e. local to the surrounding area and local as in within national boundaries plus a series of options in between. The lack of information about who is providing what and from where (a general finding throughout the IREK project under which this study was undertaken) is a key hindrance in developing a clear understanding of what capabilities are being built and by who.

completed, many of these workers do not move with the contractors to the next job; especially the day labourers.

As such, when we consider only engineers and related job positions in contractors working on the large sites, we find that the numbers required a much less (around 20 – mostly from Kenya; especially in the case of LTWP). In small scale mini-grid projects the numbers of engineers involved was less than 10 in each project. In both large and small scale projects, engineers (as opposed to less skilled workers) were also more likely to be retained by the company after the project. As noted above, we also find that engineering capability is highly mobile – with staff moving from project to project and company to company on a regular basis.

This high level of staff movement and a wider focus of project management on ensuring that sub-contractors with the knowledge required are brought in to complete specific tasks within limited timeframes limits the interaction with other actors, or is rather narrowly focused on issues of timing and avoiding budget overruns and delays. Rather than an interactive type of knowledge transfer or capability building, different organisations may focus internally on building capabilities within their teams to complete their tasks. Future research may explore the implications of individual vs wider organisational capability building. At the broader macro level, questions may also be raised as to whether and how these capabilities may be diffused to future wind and solar projects? Will it be carried on through individuals, firms or other types of organisations? Could a wider intra-organisational interaction be encouraged to ensure a wider transfer of knowledge within the innovation system for renewable energy technologies in Kenya?

What does this mean for capability building and subsequently economic development?

The four case studies highlight strong evidence of learning from partnerships and interactions with other firms, especially those from outside the country. As noted earlier, these case studies highlight evidence of 'learning from importing' (Haakonssan, 2009; Blalock and Veloso, 2007). These studies focus predominately on the importation of technologies (defined as physical products). These are deemed to create opportunity for new knowledge creation, result in improved productivity or cost of domestic production or, change the way goods are made/ what goods are made in a country (Foster-McGregor et al, 2013). New knowledge creation can be within the firm receiving the technology about how the technology works, is maintained and how it can be utilised to improve productivity, reduce cost or produce a new or improved good (Foster-McGregor et al, 2013) or it can be arms-length knowledge spill overs to peers in business who see how their competitor is utilising a new piece of equipment (Bisztray et al, 2018).

This links to a broader set of literature on how (a) linkage building is a tool for economic growth (Hirschman, 1981) and (b) technology transfer is beneficial to firm performance and therefore economic performance of countries – what is known as 'technology gap theory (Fernandez and Gavilanes, 2017; Coe and Helpman, 1995). An increasing focus on developing countries achieving economic growth through innovation is based on the idea that they will innovate new technologies (Zanello et al, 2016). However, fundamental innovation of radical new technologies is difficult for developing countries because of a lack of absorptive capacity (skills and knowledge), social, economic and political conditions that are not conducive which means institutional arrangements are insufficient. The result is that "external sources of technology account for a large component of productivity growth in most developing countries" (Zanello et al, 2016: 2). Therefore what is put forward as being needed is to tap into 'existing knowledge and know-how from foreign countries' or to 'facilitate the exchange of both external and local knowledge within a country' (Zanello et al, 2016).

The learning from importing that we are seeing in these case studies is not simply related to what is available through a 'piece of kit' – what Haakansson and Slepniov (2018) have discussed as 'learning by suppliers' through 'technology transmission'. It is more congruent with a broader definition of technology as outlined above – as embodied in a physical entity or defined as skills, knowledge and know-how. It also highlights the importance – in the context of the discussions of the type of technology and knowledge that is important for economic growth – of these linkages and interactions that are playing out on the ground in these case studies.

In fact, it might be that these case studies are not so much about learning from importing as much as about the importance of learning through interacting. It reiterates the importance from a policy perspective on encouraging linkages between diverse groups of actors in a supply chain and providing appropriate incentives. Haakonssan (2009) highlighted the importance of joint ventures and foreign investors' role in promoting upgrading through upstream linkages with suppliers in the Ugandan pharmaceutical industry. In a more recent study she conducted with Slepniov (2018) Haakonssan notes the importance of local content and import substitution policies in China on technology upgrading in the Chinese wind turbine industry. Hanlin and Hanlin (2012) highlight the importance of 'facilitatory policy' such as local content rules relating to procurement (not just employment) in the mining industry in Tanzania and the Democratic Republic of Congo. Our four case studies are in Kenya and Kenya has different contextual situations in which businesses work than Uganda, Tanzania, Democratic Republic of Congo and China, however, the importance of linkages promotion by government policy cannot be downplayed.

Conclusion

The study has established that individual skills, core competences and technological capabilities have been built in local firms in different ways. This in turn has led to upgrading in some cases. The findings show that backward linkages are built in the different levels of the project cycle, skills are built as a result of registration by the relevant authorities like EPRA. Core competence are built from the interactive learning as well as the relationships within the firms. Also, as a result of partnerships between local and international firms, there is upgrading taking place.

The findings show that duration of contracts and ownership or leadership of projects influences the degree of focus on capability building within project teams thus indicating that the transfer of knowledge within projects might ultimately lead to capability building amongst organisations which is determined by the organisational arrangement of projects into distinct phases. Also, government policies and collaborations of firm in a project have created opportunities for capability building.

Hansen et al (2018:21) write that: "We posit that such an approach is highly relevant for the analysis of pathways − or 'directions of development' in the energy field. Such energy pathways of course rely on the specific core technology choices that determines its 'shape' in terms of a given energy mix, involving different renewable energy technologies. But we argue that equally, or even more, important is the issue of 'size' because of the ramifications of this choice for the sustainability and inclusiveness of the pathways. This choice may be particularly relevant for the prospects of producing technologies locally, using local services for constructing facilities, and involving local labour in operation and maintenance. The size choice is at the core as a defining element of alternative renewable electrification paradigms, regardless of whether such electrification is achieved by harnessing the sun, wind or water flows."

Our study of four project case studies of large and small wind and solar projects in Kenya match this argument but differ from it with regards the ability of small scale projects to also be a source of competence building in EPC contract management. More fundamentally our case studies highlight the importance of a set of 'base skills' and educational standards which allows more opportunity for Kenyan firms to benefit and build capabilities and competencies. It also highlights the important role of linkages – whether as formal contractual partnerships or more informal exchanges or linkages.

Providing the right policy mix is crucial for the promotion of a continued set of base skills and educational standards as well as promotion of linkage opportunities.

Further, the case studies reveal that a firm can engage in a series of activities to build its capabilities-sequential learning from the projects cycles. Also, the results reveal that the case studies are not so much about learning from importing as much as about the importance of learning through interacting.

References

Africa Renewable Energy Initiative (2016a): AREI Action Plan. Available at: http://www.arei.org /wp-content/uploads/2016/11/AREI-Action-Plan-Nov-2016.pdf. Accessed on 11 November 2019.

Archibugi, D., & Coco, A. (2005). Measuring technological capabilities at the country level: A survey and a menu for choice. Research Policy, 34, 175–194.

Archibugi, D., Pianta, M. (1996). Measuring technological change though patents and innovation surveys. Technovation 16(9):451-468, 1996.

Artto, K.A. and Wikström, K., 2005. What is project business?. International Journal of Project Management, 23(5), pp.343-353.

Artto, K., Davies, A., Kujala, J. & Prencipe, A. 2011. The Project Business. Analytical framework and research opportunities. In Morris, P., Pinto, J. & Söderlund, J. Eds. The Oxford Handbook of Project Management. Oxford: Oxford University Press.

Awuzie, B.O. and McDermott, P., 2016. The role of contracting strategies in social value implementation. *Proceedings of the ICE-Management, Procurement and Law*.

Bell, M. (2009). Innovation capabilities and directions of development, STEPS working paper 33. STEPS Centre, Brighton.

Bisztray, M., Koren, M., & Szeidl, A. (2018). Learning to import from your peers. *Journal of International Economics*, *115*, 242-258.

Blalock, G., & Veloso, F. M. (2007). Imports, productivity growth, and supply chain learning. *World Development*, *35*(7), 1134-1151.

Brady, T. and Hobday, M., 2011. Projects and innovation: Innovation and projects. In Morris, P.W., Pinto, J.K. and Söderlund, J. eds., 2011. *The Oxford handbook of project management*. OUP Oxford.

Brinkerhoff, D.W. and Brinkerhoff, J.M., 2015. Public sector management reform in developing countries: perspectives beyond NPM orthodoxy. *Public Administration and Development*, *35*(4), pp.222-237.

Brusoni, Stefano, Andrea Prencipe, and Keith Pavitt. "Knowledge specialization, organizational coupling, and the boundaries of the firm: why do firms know more than they make?." *Administrative science quarterly* 46.4 (2001): 597-621.

Cacciatori, E. and Jacobides, M.G., 2005. The dynamic limits of specialization: vertical integration reconsidered. *Organization Studies*, *26*(12), pp.1851-1883.

Calderon, C. and Serven, L. (2010). Infrastructure and Economic Development in Sub-Saharan Africa, Journal of African Economies, 19, i13–i87. doi:10.1093/jae/ejp022.

Coe, D. T. & Helpman, E. (1995): ‘‘International R&D Spillovers,’’ European Economic Review, 39(5), 829–859.

Cohen, W. M., Levinthal, D. A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. Administrative Science Quarterly, 35(1), 128-152.

Coombs, J. E., Bierly, P. E. (2006). Measuring technological capability and performance. R&D Management 36(4): 421-438.

D´emurger, S. (2001). Infrastructure Development and Economic Growth: An Explanation for Regional Disparities in China? Journal of Comparative Economics 29, 95–117 doi:10.1006/jcec.2000.1693.

Davies, A. and Brady, T., 2016. Explicating the dynamics of project capabilities. *International Journal of Project Management*, *34*(2), pp.314-327.

Farlam, P. (2005). Working Together: Assessing Public–Private Partnerships in Africa. The South African Institute of International Affairs.
https://www.oecd.org/investment/investmentfordevelopment/34867724.pdf

Fernández, J., & Gavilanes, J. C. (2017). Learning-by-importing in emerging innovation systems: evidence from Ecuador. *The Journal of International Trade & Economic Development*, *26*(1), 45-64

Figueiredo, P. N., & Piana, J. (2018). Innovative capability building and learning linkages in knowledge-intensive service SMEs in Brazil's mining industry. *Resources Policy*, *58*, 21-33.

Flatten, T.C., Engelen, A., Zahra, S.A. and Brettel, M., 2011. A measure of absorptive capacity: Scale development and validation. *European Management Journal*, *29*(2), pp.98-116.

Flyvbjerg, B., 2006. Five misunderstandings about case-study research. *Qualitative inquiry*, *12*(2), pp.219-245.

Foster, N., Isaksson A. and F. Kaulich. (2013). Importing, Exporting and Performance in Sub-Saharan African Manufacturing Firms. March 2013 wiiw Working Paper series.

Gregersen, C. (2019) Local learning and capability building in an energy transition context – experiences from two large wind power development projects in Kenya and Ethiopia. IREK Draft Working Paper 8, presented at the IREK Research Workshop, Nairobi, Kenya, February 2019.

Government of the Republic of Kenya (2007) *Kenya Vision 2030*. Nairobi: Government of Kenya.

Gu, S. and Lundvall, B.Å. (2006) China’s Innovation System and the Move Towards Harmonious Growth and Endogenous Innovation. Innovation, Management, Policy and Practice, 8, 1-26.

Haakonssan, S.J., 2009. ‘Learning by importing’ in global value chains: upgrading and South–South strategies in the Ugandan pharmaceutical industry. *Development Southern Africa*, *26*(3), pp.499-516.

Haakonssan, S. J., & Slepniov, D. (2018). Technology Transmission Across National Innovation Systems: The Role of Danish Suppliers in Upgrading the Wind Energy Industry in China. European Journal of Development Research, 30(3), 462-480. https://doi.org/10.1057/s41287-018-0128-5

Hall, L., Bagchi-Sen, S. (2002). A study of R&D, innovation, and business performance in the Canadian biotechnology industry. Technovation 22, 231-244.

Hamel, G. and Prahalad, C.K., 1990. Corporate imagination and expeditionary marketing. *Harvard business review*, *69*(4), pp.81-92.

Hanlin, R., & Hanlin, C. (2012). The view from below: ‘lock-in’ and local procurement in the African gold mining sector. *Resources Policy*, *37*(4), 468-474.

Hanlin R and Kaplinsky, R (2016) ‘South-South trade in capital goods: market driven diffusion of appropriate technology’ special section of *European Journal of Development Research*, Vol28(3).

Hanlin, R. et al (2017) Collaboration and capabilities in Kenya’s solar and wind industries: perceptions of stakeholders. IREK Report No. 3 https://www.irekproject.net/publications/ (accessed 07/06/19).

Hansen, U.E. and Ockwell, D., 2014. Learning and technological capability building in emerging economies: The case of the biomass power equipment industry in Malaysia. *Technovation*, *34*(10), pp.617-630.

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.

Hansen, U. E., Gregersen, C., Lema, R., Samoita, D., & Wandera, F. (2018). Technological shape and size: A disaggregated perspective on sectoral innovation systems in renewable electrification pathways. *Energy Research and Social Science*, 42, 13-22. https://doi.org/10.1016/j.erss.2018.02.012

Hirschman, A.O., 1981. Essays in Trespassing: Economics to Politics and Beyond. Cambridge University Press, New York.

Hobday, M., 2000. The project-based organisation: an ideal form for managing complex products and systems?. *Research policy*, *29*(7), pp.871-893.

Hoka, H. Njogu, H. and Obiero, B. (2018) *Realising the Big Four Agenda* Nairobi: KIPPRA Working Paper.

Jacobides, M.G., 2006. The architecture and design of organizational capabilities. *Industrial and Corporate Change*, *15*(1), pp.151-171.

Jensen, M. B., Johnson, B., Lorenz, E., & Lundvall, B. Å. (2007). Forms of knowledge and modes of innovation. Research Policy, 36, 680–693.

Jessop, B., 2000. The state and the contradictions of the knowledge-driven economy. *Knowledge, space, economy*, pp.63-78.

Kabanda, U. (2014). A Case Study of Bujagali Hydropower Public Private Partnership Project Between Uganda Government and Bujagali Energy Ltd in Electricity Generation in Africa.

Kenya MiniWind (2018) *Market for the integration of smaller wind turbines in minigrids in Kenya* October 2018. See https://www.kenyacic.org/sites/default/files/publications/Kenya-mini-grid-market-study-FINAL.pdf (accessed 25/01/19).

Kesidou, E. and Romijn, H., 2008. Do local knowledge spillovers matter for development? An empirical study of Uruguay's software cluster. *World development*, *36*(10), pp.2004-2028.

Khandker, S. R., Bakht, Z. and Koolwal, G. B. (2009). The Poverty Impact of Rural Roads: Evidence from Bangladesh, Economic Development and Cultural Change, 57, 685-722.

Lall, S. (1994). 'Technological capabilities' in J.J. Solomon et al (eds.) *The Uncertain Quest: Science, Technology and Development*. Tokoyo: UN University Press.

Lema, R. & Andersen, M.H. (2019). *Renewable Electrification and Sustainable Industrialisation: Conceptual Framework and Key Propositions for Research* (IREK Working Paper No. 4). Copenhagen/Nairobi/Eldoret: AAU, ACTS and MU.

Liu, X., Hotchkiss, D.R. and Bose, S., 2008. The effectiveness of contracting-out primary health care services in developing countries: a review of the evidence. *Health policy and planning*, *23*(1), pp.1-13.

Loots, P. and Henchie, N., 2007. Worlds Apart: EPC and EPCM Contracts: Risk issues and allocation. *International Construction Law Review*, *24*(1/4), p.252.

Lundvall, B.-A˚. (1992), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, Pinter: London, pp. 1-19.

Lundvall, B.Ä. and Johnson, B., 1994. The learning economy. *Journal of industry studies*, *1*(2), pp.23-42.

Lundvall, B.-Å., Johnson, B., Andersen, E. S., & Dalum, B. (2002). National systems of production, innovation and competence building. Research Policy, 31(2), 213–231.

MoEP (2015). Draft national energy and petroleum policy. http://www.erc.go.ke/images/docs/National_Energy_Petroleum_Policy_August_2015.pdf.

Morris, M., Kaplinsky, R., Kaplan, D., 2012. One thing leads to another–commodities, linkages and industrial development. *Resource Policy* 37 (4), 408–416.

Murphy, J.T., 2001. Making the energy transition in rural East Africa: Is leapfrogging an alternative?. *Technological Forecasting and Social Change*, *68*(2), pp.173-193.

Ockwell, D. G., Watson, J., MacKerron, G., Pal, P., & Yamin, F. (2008). Key policy considerations for facilitating low carbon technology transfer to developing countries. Energy Policy, 36(August 2016), 4104–4115.

Republic of Kenya (2018) *Updated least cost power development plan study report: 2017-2037* (June 2018). Nairobi: Kenya. See: https://www.erc.go.ke/wp-content/uploads/2018/09/Updated-Least-Cost-Power-Development-Plan-2017-2022.pdf (accessed 25/01/19).

Roberts, J. (2009) "The global knowledge economy in question" *Critical Perspectives on International Business*.

Srinivas, S. and Sutz, J., 2006. *Economic Development and Innovation Problem-solving in Scarcity Conditions*. Center for International Development at Harvard University.

Vidican, G. (2012). Building Domestic Capabilities in Renewable Energy. A Case Study of Egypt. *Building Domestic Capabilities in Renewable Energy: A Case Study of Egypt. German Development Institute, Studies Series*, *66*.

Wandera, Faith H. (2018). Applying the innovation systems framework to the study of the small wind turbine sector in Kenya: A review and research agenda (IREK Working Paper No. 3). Copenhagen/Nairobi/Eldoret: AAU, ACTS and MU.

Zahra, S.A. and George, G., 2002. The net-enabled business innovation cycle and the evolution of dynamic capabilities. *Information Systems Research*, *13*(2), pp.147-150.

Zanello, G., Fu, X., Mohnen, P., & Ventresca, M. (2016). The Creation and Diffusion of Innovation in Developing Countries: A Systematic Literature Review. Journal of Economic Surveys, 30(5), 884-912.https://doi.org/10.1111/joes.12126

Annex 1: EPRA requirements for electrical contractor licencing

1. **Solar PV technician licence requirements**[9]

"ERC categories solar PV Technicians into three classes as follows;

T1 – Entitles the holder to carry out solar PV system installation work for small systems or single battery

DC systems of up to 100Wp (watts peak).

T2- Entitles the holder to carry out solar PV system installation work for medium systems or multiple

Batteries which may include an inverter.

T3 –Entitles the holder to carry out solar PV system installation work for advanced projects, including grid connected and hybrid systems.

Qualifications and Experience

1. **For T1**

- KCPE, Electrical Government Trade Test 2 and basic solar training with a verifiable 2 years solar installation experience

1. **For T2**

- KCSE, Certificate in Electrical and/or Electronic and Intermediate Solar Training with verifiable 4 years solar installation experience
- KCSE, Diploma in Electrical and/or Electronic and Intermediate Solar Training with verifiable 2 years solar installation experience
- BSc Electrical Engineering or relevant degree or Higher National Diploma with one year of solar installation experience.

1. **For T3**

- KCSE, Diploma in Electrical and/or Electronic and Advanced Solar Training with verifiable 4 years solar installation experience
- BSc Electrical Engineering or relevant degree or Higher National Diploma with 2 years of solar installation experience.

---

[9] Diectly copied from: http://energyzedworld.com/index.php/2016/03/23/how-to-become-a-licensed-solar-pv-technician-in-kenya/ (accessed 26/01/19)

Once you have the above qualifications;

1. Register through the Energy Regulatory Commission's Website (erc.go.ke). Attach copies of your academic and professional certificates.
2. Thereafter, you will be invited for a written exam. If you pass this exams (the pass mark is 50%) , you will be invited for an oral interview. Once you are successful in the orals, you will get your license.
3. For TI, an application fee of Ksh.250, 500 and 750 is payable for class T1, T2 and T3 respectively.

A lot of Solar PV training is also offered through government regulated institutions. Approximately 16 tertiary institutions across Kenya offer training in Solar PV. ERC only recognizes training courses offered in institutions accredited by the National Industrial Training Authority (www.nita.go.ke). Applicants without basic knowledge in electrical engineering must first undergo training in these institutions before applying for the ERC exams."