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Agency in transition: The role of transnational actors in the development of the off-grid solar PV regime in Uganda

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ABSTRACT

While the sustainability transitions literature has highlighted the importance of agency in technological change, there is still limited understanding of the role of transnational actors, such as development agencies, which tend to be key drivers of energy transitions in low-income countries. This paper aims to fill this gap by investigating the role of transnational actors in the development of off-grid solar PV regime in Uganda, from the early 1980s to 2017. Specifically, we develop a typology of transnational actors and examine their roles in mobilizing the flow of knowledge, capital and technology towards shaping the country's off-grid solar PV rural electrification regime. By discussing the pivotal role of foreign actors, their underlying motives and their shifting importance over time, the paper demonstrates empirically the highly transnational nature of regime development. In doing so, we contribute to the academic literature on actor-oriented determinants in sustainability transitions, as applied to low-income countries.

1. Introduction

International efforts to provide access to modern, off-grid, clean energy services have intensified in recent years. This includes global initiatives such as Sustainable Energy for All (SE4All), Alliance for Rural Electrification (ARE), and the Global Off-Grid Lighting Association (GOGLA). Such efforts aim at achieving universal energy access (SDG7) while ensuring a reduction of greenhouse gases in line with the Paris Agreement. In most Sub-Saharan African (SSA) countries, improving access to energy is critical as national electrification rates are often below 20%. In this context, solar photovoltaic (PV) has become the principle technology to improve energy access due to its decreasing cost and increasing efficiency. This has been complemented by the widespread use of mobile phones, new flexible mobile payment systems and favorable national policies (Nygaard et al., 2016; Ockwell et al., 2018; Rolffs et al., 2015).

Accordingly, the uptake of off-grid solar PV products, such as solar home systems (SHS), has increased rapidly across SSA. In the period between 2011 and 2015, the number of so-called pico-solar PV products sold in SSA grew from less than half a million to over 11 million per annum (Panel, 2017), with nearly 1.92 million units being sold in SSA in the second half of 2017 alone (GOGLA et al., 2016). East Africa is home to the highest density of solar PV product suppliers worldwide (GOGLA et al., 2018), and in Uganda, the cumulative sale of off-grid solar products between 2014 and 2016 was around 2 million, with an annual growth of 135% (GOGLA et al., 2018). This increase in uptake of solar PV offers a significant means to improve energy access, driving the transition towards sustainable energy systems in East Africa.

It has been argued that sustainability transitions in low-income countries are greatly influenced by various transnational actors

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(TNA) and cross-border linkages (Hansen and Nygaard, 2013, 2014; Marquardt et al., 2016; Sixt et al., 2017; Tigabu et al., 2017; Truffer et al., 2015; Wieczorek et al., 2015). In the case of SSA, scholars have drawn attention to the power of global capital in "disciplining" clean energy transitions in Kenya (Byrne et al., 2018), the influence of "rising powers" in Mozambique and South Africa (Power et al., 2016) and the struggles between local actors and international development actors in Kenya's PV niche development (Byrne et al., 2018).

However, we still know very little about the specifics of *how* TNAs influence such transitions and especially, how they form relationships with local actors and become embedded in transition processes locally. In this paper, we offer an account of these processes by analyzing the role of TNAs in the development of the off-grid solar PV regime in Uganda, from the early 1980s to 2017. We develop a typology of TNAs and examine their influence on regime development through their mobilization of knowledge, capital and technology and their respective strategies and interests in doing so. The research question guiding the paper is: *How do transnational actors exert influence and operate while mobilizing key resources for sustainability transitions in low-income countries?*

In the following section, we elaborate the analytical framework for the article. In section three, we describe the research methodology, followed by section four, which presents our empirical findings. These findings are discussed in section five, followed by the conclusion in section six.

2. Analytical framework

The sustainability transitions literature focuses on analyzing how transformative change in socio-technical systems unfold (Geels, 2002, 2010; Geels and Schot, 2007). A prominent framework in this literature is the Multilevel Perspective (MLP), which offers a structure to assess how transitions unfold as interlinked processes across three analytical levels: landscape, regime, and niche (Geels, 2002; Markard et al., 2012). Niche refers to a protected space that facilitates experimentation and innovation, whereas landscape is seen as "a broad exogenous environment" (Grin et al., 2010). Regimes are conceptualized as "semi-coherent rule sets carried by different social groups, which stabilize a technological trajectory" (Fuenfschilling and Binz, 2018; Geels, 2002). Transitions entail a shift from one socio-technical regime to another, resulting from the interplay between niche developments and landscape pressures.

Scholars have pointed out that niches and regimes are not limited to specific territorial boundaries and span across multiple spatial scales (Berkhout et al., 2011; Hansen et al., 2017; Manning and Reinecke, 2016; Raven et al., 2012). As Raven et al. (2012) put it, regimes may be "transnational in physical extent, or in the economic and technological base that supports them". Smith et al. (2010) suggest that they may be influenced by global actor networks and institutional arrangements that may either strengthen or weaken them. Wieczorek (2017) and Hansen et al. (2017) note that while regimes may be influenced by transnational linkages, it is less clear how these linkages operate and function, particularly in the context of developing countries. We aim to enhance this understanding by employing the MLP framework in analyzing the process of socio-technical regime development, using a transnational perspective.

Despite MLP's emergence as a key analytical framework, it has increasingly been criticized for a lack of sensitivity to the importance of agency (Avelino and Wittmayer, 2016; Farla et al., 2012; Geels, 2011; Grin et al., 2011; Wittmayer et al., 2017). Grin et al. (2011), for example, highlight a lack of systematic understanding of multiple actors and their agency in transition processes. Similarly, Farla et al. (2012) call for a more explicit conceptualization of actor strategies and resources. Fischer and Newig (2016) suggest that actors supporting transitions can be part of multiple categories, rather than just niches and regimes performing different types of roles (Wittmayer et al., 2017). And Avelino and Wittmayer (2016) note and clarify the ambiguities associated with the conceptualization of actors, and propose a multi-actor perspective to better understand "shifting power relations in transitions". These critical voices have raised renewed interest in improving the understanding of the role of different actors and agency in sustainability transitions.

Following Budde et al. (2012) and de Haan and Rotmans (2018), we adopt a more actor-oriented perspective in transition studies, particularly in understanding the agency of TNA in influencing systems change. We draw inspiration from the "relational perspective" suggested by Raven et al. (2012), which focuses on how specific TNAs become entangled with local networks, institutions and infrastructures through global-local relations (Coenen et al., 2012; Sengers and Raven, 2015). In a similar vein, we draw on Wieczorek et al. (2015) who explores how local niche actors in the solar PV sector in India are embedded in different types of transnational linkages, distinguishing five categories of linkages: actors, knowledge, capital, technology and institutions. Our approach differs slightly from Wieczorek et al. (2015), however, as we understand actors not as an independent category of linkages, but the main node through which various resource flows, specifically knowledge, capital and technology, are mobilized (Wei, 1995). We conceptualize the flow of knowledge as comprised of the exchange of ideas, skills and competences, for example through a process of learning by importing and interacting (Lema et al., 2018; Ramanathan, 1994). The flow of capital refers to the inflow of financial resources from abroad in the form of direct project funding, official development assistance, loans, grants, and equity investments provided by development banks, charities, and commercial investors. The flow of technology refers to the cross-border transfer and diffusion of hardware artefacts, components and equipment, such as solar panels, batteries or inverters (Wieczorek et al., 2015). Further, we do not explore TNAs as niche actors or regime actors, but acknowledge that their roles cut across the analytical levels of the MLP framework.

We understand that landscape is associated with tremendous inertia at a wider ideological, political and economic scale, through such forces as globalization, privatization, neoliberalism and climate change (Geels, 2005; Geels and Schot, 2007). It operates beyond the direct influence of actors (Geels, 2005), but it "can have a major influence on the [actor] behaviours and choices" (Raven and Geels, 2010). In addition, TNAs (such as development agencies) have an influence on how such landscape forces are instantiated in particular contexts at the local level (Baker et al., 2014; Sergi et al., 2018). Instead of treating these as given, our enquiry attempts to

Table 1
Typology of transnational actor-groups.
Source: Developed by the authors based on Avelino and Wittmayer (2016), Wieczorek (2017) and de Haan and Rotmans (2018).

Actor-Groups	Examples	Characteristics	Resources likely to be mobilized
Development aid organizations	USAID, DFID, GIZ	These agencies have a country of origin and operate with the motive of representing their country's policies and politics. They exert political power and engage with influencing the politics of nations.	Capital Knowledge
Inter-governmental organizations	UNEP, UNDP, WHO, IRENA, IEA	These organizations do not have a specific country of origin but are representative of sovereign member states. They exert economic, social and political power.	Knowledge Capital Technology
Bi-lateral, multi-lateral development banks	IFC, FMO, KfW	These are institutions providing capital to developing countries and could be bi-lateral or multi-lateral. They exert certain economic and political power.	Capital
Charities, NGOs, foundations	WWF, Shell Foundation, Solar Light for Africa	These are non-profit organizations performing development and/or humanitarian work. These include: i) faith-based organizations; ii) corporate-backed foundations; and iii) charities. They enact, propagate and organize different world-cultural issues.	Knowledge
Private firms	Solar Now, Fenix Int., Barefoot Power	These are for-profit firms and social enterprises engaged with business to improve the delivery of electricity goods and service esp. targeting rural areas. They enjoy authority in terms of economic power.	Technology Knowledge
Consultancies, Advisory firms	Enclude, Open Capital Advisors	These are organizations engaged with providing consultancy and technical advisory services for rural electrification. They assert expert knowledge.	Knowledge
Global industry association	GOGLA, ARE	These are associations targeted to achieve common goals such as promoting off-grid solar. They exert the power of networking, advocacy and international clout.	Knowledge
Educational Institutes, Universities	Access2 Innovation, MIT	These are educational institutions, university consortiums engaged with projects as intermediaries or implementers etc. They exert a certain definitional authority and enjoy high social legitimacy.	Knowledge Technology

make these forces of influence more explicit by focusing on the agency of specific actors.

We build on the Multi-actor Perspective (MaP) developed by Avelino and Wittmayer (2016), in which they unpack the actor category of the "third sector" defined as an intermediary between the state, market, and community. The third sector comprises of individuals and organizations that cut across the boundaries between the three axes i.e. profit and non-profit, private and public, formal and informal. In our case, a majority of the TNAs operate in this spectrum of three axes, without strictly adhering to any one notion. Several TNAs operate in a hybrid form, through partnerships that involve a blend of private firms, foundations, NGOs and development banks, among others. Thereby, we develop a typology of "transnational actors" and expand the interpretation of TNAs beyond donor agencies, to include consultancy firms, social enterprises, philanthropic foundations and missionary organizations, among others. This typology of TNAs is presented in Table 1 along with the resources they are likely to mobilize. We also identify the actor characteristics, including the authority they may exert for being positioned within global networks. In line with de Haan and Rotmans (2018), we identify an actor as a person operating individually, or as an organization, or a collective of persons including alliances and networks. In this the underlying assumption of the typology is that the actors operate under common logics and modus operandi along the three axes, which allows us to analyze their respective interests and motives in mobilizing resources in regime building. We assess this in detail in Section 4, in order to better understand the solar PV transition process. In so doing, we do not undermine the interests and contributions of the national actors, but illustrate the multi-actor dynamics, and emphasize the influence of TNAs in sustainability transitions.

In Uganda, historically, the government and various development organizations have operated under the assumption that electrification should be achieved through grid connectivity, characterized by large utilities and centralized governance. The policies and related development activities have been aligned to this vision of electrification. This may be seen as corresponding to the dominant electrification regime at a national level. As per the National Population and Housing Census 2014 (UBOS, 2016), the total percentage of the population with access to electricity was 20.4% at the national level, of which 15.5% was connected to the electricity grid, and 4.9% to other sources, as displayed in Fig. 1 below. While the main census report does not elaborate on the "other sources", according to the interviews conducted for this paper, they comprise mostly of off-grid solar PV systems. Also, we note that these electrification rates are captured at a household level, which does not include institutions, where off-grid solutions have a wide application (e.g. in rural health centers, schools, telecom towers, churches).

Further, nearly 79% of the total population in Uganda is identified as rural (WorldBank, 2018). Of the rural population, nearly 5.1% of households are connected to the national grid, and 5.2% of households use off-grid solutions (UBOS, 2016). Based on this, we

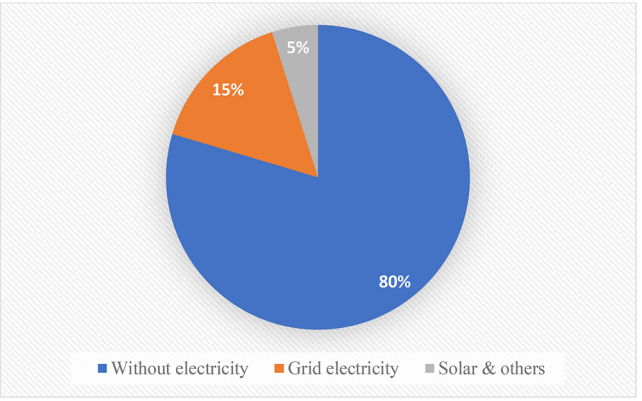

Fig. 1. National Electrification Rate in Uganda.
Source: National Population and Housing Census, 2014.

infer that there is no dominant rural electrification regime since a majority of the rural population is unelectrified. Unlike a conventional monolithic understanding of regimes in the transitions literature, we argue – in line with van Welie et al. (2018) – for an understanding that appreciates coexisting and complementary heterogeneous regimes in developing countries. Accordingly, the rural electrification regime in Uganda may refer to both electricity grid extension and the use of off-grid solar PV systems. Mini-grids that make use of solar PV may provide an example of a niche due to their nascent stage of development. Solar PV systems are currently a widely used electrification source in rural areas than its alternatives (such as the expensive diesel generators), whereas the policy focus of grid connections is mainly in urban areas and for productive use. There is a patchwork of different motivations and institutions driving the off-grid solutions rather than a dominant vision typically associated with a single electrification regime. Hence, we conceptualize the use of solar PV systems in off-grid, rural areas as a rural electrification regime on its own. And this PV regime comprises of semi-coherent rules, policies, infrastructures and discourses, which we analyze unfolding over a period of time.

3. Research methodology

Off-grid solar PV is an important technology behind the rural electrification regime in Uganda in terms of diffusion rates. Furthermore, off-grid solar PV has over time been significantly influenced by transnational actors and linkages, which range from small-scale projects by NGOs to sector-based development programs and private firms. The case of off-grid solar PV in Uganda was therefore selected as it provides a suitable empirical context to examine the role of TNA in regime building.

We used a qualitative approach based on case studies to capture historical accounts, narratives, power relationships, actor contestations and negotiations. Case study design is appropriate for process-related *how* questions, and is also sensitive to contextual details (Eisenhardt and Graebner, 2007; Yin, 2003, 2009). Moreover, a qualitative case study approach allows flexible use of data with an exploratory nature of analysis, which better captures the motives and experiences of actors and provides a deeper understanding of the mechanisms of change (Gioia et al., 2013; Graebner et al., 2012). Fig. 2 highlights the approach employed for the study.

Yin (2009) suggests using multiple data sources such as secondary material, archival records, interviews, public records etc. for case study research. For this study, we collected secondary data, reconstructed the timeline of solar PV development, and identified the key organizations, events and developments. Next, we identified the key actors based on the available information and through snow-balling technique and interviewed them. Not all actors identified could be interviewed due to access and availability

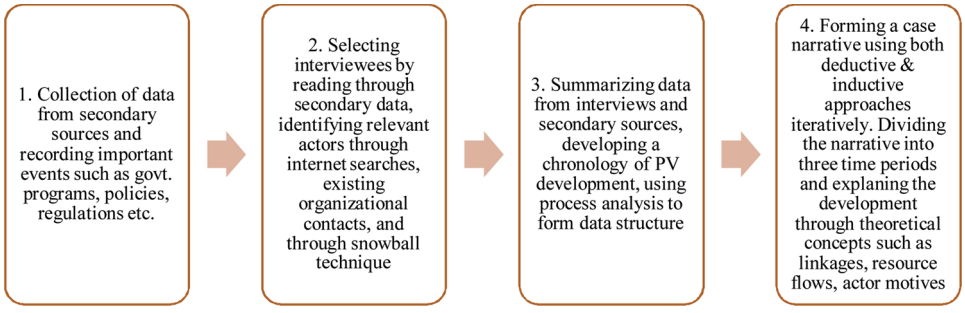

Fig. 2. An overview of research design.

constraints, especially those involved in the sector in the 1980s and 1990s, but some of the developments in that period were covered in secondary material.

The semi-structured interviews totaling thirty-one were carried out between July and December 2017 with representatives of government, private firms, development agencies, and the solar industry association, among others ***(see Appendix)***. The questions focused on understanding the involvement of interviewees in the development and diffusion of off-grid solar PV systems. We enquired about their roles in specific projects/programs, and gauged their objectives and motives such as policy goals, sectoral targets, political aspirations and philanthropic interests ***(see Appendix)***. In addition, visits were made to eight private firms operating from Kampala, and discussions were conducted with the staff at five branch offices (points of sale) at district level, and seven independent vendors/retailers across Northern and Eastern Uganda. These were aimed at gauging the market demand, pricing, distribution strategies, challenges, user interest and feedback. Subsequently, we developed a detailed chronology of events, and a database of forty-five off-grid solar PV initiatives between 1985 and 2017 involving TNAs ***(see Appendix)***, some of which are analyzed in detail in Section 4. Based on this compiled data and insights from the interviews, we divided our analysis into three time periods of PV development.

The analysis was carried out by synthesizing and summarizing data from interviews, secondary documents, and field notes. The analytical procedures focused on understanding the role of TNAs, their main motives and their activities related to mobilizing resources. For capturing the resulting outcome of their involvement with PV initiatives, we use the indicator of the total number of solar PV units installed or sold. The ways in which transnational actors influenced and mobilized resources needed to be assessed empirically. We identified the key solar PV initiatives, relevant TNAs, and undertook stages of open coding to indicate the objectives and motives associated with the initiatives. Further, empirical examples of resources mobilized were gathered by operationalizing transnational linkages in line with Wieczorek (2017). We looked for specific evidence such as foreign knowledge providers, foreign work experience, references to technical and training assistance, capacity building, references to finance and funding sources including development finance, grants from foundations, and references to technology imports, foreign technology providers etc.

Limitations of the data collected by this methodological approach, as also reflected in other such historical studies (Byrne, 2011), include unreliability (esp. sales figures of PV systems by private firms), fragmentation (e.g. due to the short-term employment of multiple consultants through the project lifecycle), inaccessibility (e.g. available only with retired officials), and sometimes unavailability (e.g. many initiatives were not recorded or documented). For many projects/programs, we relied on the memories of key informants, and wherever possible, triangulated them with/through other available evidence. It was particularly difficult to gather quantitative information such as units installed or system capacities or the funding amounts based on personal memory.

4. The role of transnational actors in the regime building process

We have divided this section into three separate phases that emerged during the research process: Phase I (1983–1996), Phase II (1997–2008) and Phase III (2009–2017). The cut-offs mark disjunctures in the regime building process, characterized by distinct breaks from the nature and pattern of developments preceding them. The narrative only presents a curated sample of initiatives from the database, those that were highlighted by local experts as key milestones, and for which sufficient data could be obtained. A snapshot of the key developments and milestones across the three phases of PV development has been presented in Fig. 3. These are detailed further in the following paragraphs.

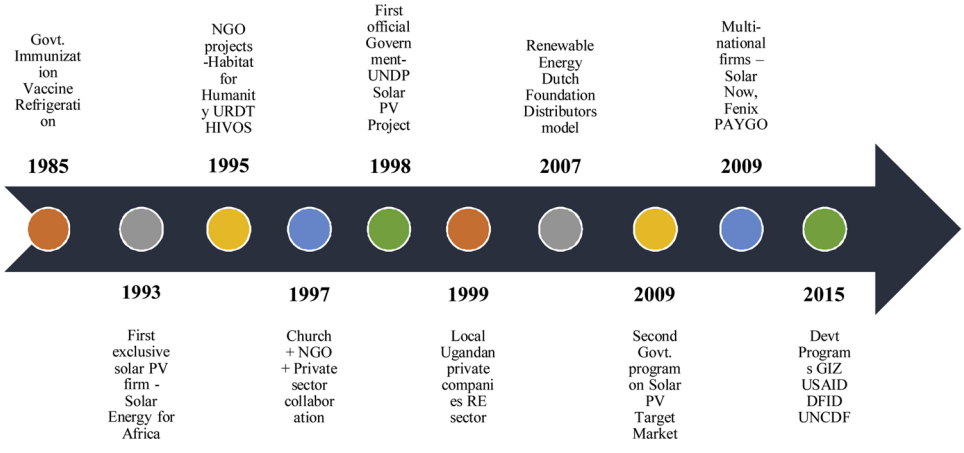

Fig. 3. Reconstructing the timeline - key developments and milestones.

4.1. Phase I (1983–1996): Small scale, scattered and unintended developments

In the 1980s, a civil war was still being fought in Uganda, following a decade of civil unrest during the 1970s. After an interruption, the Uganda National Expanded Program on Immunization (UNEPI) against diseases like tuberculosis and measles was restarted in 1983, with full operations being resumed in 1986 after the war ended and Yoweri Museveni became the President. The program was hosted by the Ministry of Health (MoH), and external expertise was brought in through two United Nations (UN) agencies: The World Health Organization (WHO) and United Nations Children's Fund (UNICEF). The UN agencies mobilized resources for the program by collaborating with numerous other organizations such as missionary hospitals, development aid/cooperation agencies (DANIDA, DFID, JICA), Rotary International, the Red Cross and Save the Children Fund (SCF) (Johnstone, 1988). Vaccines, the main tools for immunization, are fragile and sensitive to temperature changes, requiring refrigeration at 4 °C, which needed electricity. Also, while the central cold store was located in Entebbe, the vaccines had to be stored and transported throughout the country. Back then, diesel generators and kerosene were the main fuel sources used in rural areas for electrification. However, their restricted supply in the war zone slowed down the program.

To counter this, the managers at UNEPI and MoH explored solar PV as a possible solution, and SCF undertook a feasibility study on it in 1984, after which they embarked on promoting a unique solar-powered refrigeration system in Uganda. Using solar PV was thus not part of the initial program planning but was incidental and a response to local circumstances. A former manager reported that they installed fifty solar-powered refrigeration units initially[1] . Due to a lack of technical know-how in Uganda, technicians from UNEPI went to Rome for training by Pragma, an Italian company that produced solar PV cells, and a team of Italian engineers travelled to Uganda to help with the first installations in 1987 (Johnstone, 1988). The Italian Government had previously pledged a part of 100 million USD to Uganda in support of the UNEPI program. It was reckoned by program managers that though the solar PV systems were expensive, they needed little maintenance once installed and were a reliable means to store high-value vaccines in remote areas. Subsequent, solar-powered refrigerators were also procured from BP Solar (Spain) by UNICEF. By the late 1980s and early 1990s, in addition to refrigeration, solar PV also started being used for lighting in rural health centers (Eliah and Louineau, 1999). The overall uptake rate of solar PV for vaccine refrigeration within UNEPI program in Phase I was 150, which increased to around 900 systems by Phase III.

The private sector's relationship to solar PV formed during the late 1980s, when a former aircraft maintenance engineer with Kenya Airways returned to his native country Uganda and founded the company Incafex Ranches Ltd., supplying solar PV systems to rural farmers for lighting purposes[2] . Concurrently, his German friend wanted to set up a farm laboratory in Uganda to conduct experiments on tick-control and tick-borne diseases on cattle. They decided to set up the laboratory on the farm of Incafex, in central Uganda. The laboratory required electricity and a refrigerator, which prompted them to import a solar PV system from Germany, as there was no electricity grid and solar-based refrigerator was a viable option by then. Subsequently, Incafex imported another small kit-sized system comprising of a solar panel, battery and two light bulbs from Neste Advanced Power Systems (NAPS - Netherlands), with the help of a regional agent of NAPS-Kenya based in Nairobi[3] . Their use of solar PV at the farm lab generated interest among fellow farmers in the region. This in turn motivated other local firms, such as Magric Ltd. (founded by a British-Ugandan), Sun Trade and Consulting International Ltd., Agip Ltd. and Nairo Agro, to venture into importing and supplying solar PV to government projects and households on need-basis. Little is known about these local companies, though, and most have shut down their operations.

Incafex, however, continued to engage in importing and selling PV systems mainly by securing contracts for government projects and for solar lighting systems in rural health centers and schools. Later, Incafex also imported invertors from Mastervolt, based in the Netherlands. In the 1990s, the focus was on the sale of solar PV systems mainly to NGOs and government agencies. Representing Mastervolt in Uganda, the founder also attended an annual meeting of solar distributors in the Netherlands in the 1990s to connect with the larger network of distributors[4] . The strategy helped him develop contacts with equipment suppliers in Europe and strengthened ties with Mastervolt, which led to a continued collaboration through the 2000s.

Meanwhile, in the early and mid-1990s, NGOs (local and foreign) played an important role in spreading the use of solar PV in rural areas, some of which is well-documented. One such NGO was Uganda Rural Development and Training (URDT), founded by a US educated Ugandan social entrepreneur, and supported by a few American strategists engaged in creative leadership and systems thinking. URDT was established in 1987 and they started exploring solar PV for powering their office in Western Uganda in 1990, and to operate computers. URDT also offered school leavers a training program in installation of solar PV systems (Eliah and Louineau, 1999). Other NGOs that undertook similar endeavors include World Vision and Concern International. After gaining experience, URDT embarked on a solar lending program in 1995 with support from Hivos, a Dutch NGO, and a loan from the Dutch Bank Triodos. URDT played an intermediary role between the bank and the end-users. Through a cross-subsidy scheme, large system buyers subsidized the small system buyers. Hivos provided technical assistance to install and service PV systems, and funding from the Dutch TOOL Foundation enabled 15 locals to be trained in technical aspects, marketing and user awareness (Eliah and Louineau, 1999). In addition, URDT also supported four staff members to be trained by specialized PV firms in Tanzania and Kenya. Assistance in the form of capital (loans) and knowledge (technical assistance) helped the project achieve its targets, and URDT developed long-term partnerships with the Triodos Bank and Hivos[5] . Within two years, 130 systems were reportedly installed (Eliah and Louineau, 1999).

[1] Personal interview # 3.
[2] Personal interview # 4.
[3] Personal interview # 4.
[4] Personal interview # 4.
[5] Email interview # 29.

Table 2
Role of transnational actors in regime-building process Phase I: 1983–1996.

Transnational actors involved	Resources mobilized by the transnational actors	Main actor motives	Off-grid solar PV diffusion rates
WHO, UNICEF, SCF in the UNEPI program	-*Knowledge*: training provided to installers (subsequently users) by the Italian company Pragma, program management and feasibility study by SCF -*Finance*: WHO, UNICEF and a number of development banks and partners, for procuring vaccines -*Technology*: solar-powered refrigeration systems imported from Pragma, Electrolux, and BP Solar.	WHO: improving health by promoting vaccination programs UNICEF: improving the wellbeing of children SCF: equal opportunities to every child	Nearly 150 solar-powered refrigeration units were installed in this phase, and 900 installations in total till date
Incafex Ranches Ltd.	-*Knowledge*: The founder´s engineering knowledge from aircrafts, and his German friend's networks with solar PV manufacturers -*Finance*: government project contracts -*Technology*: Solar kits from Neste Advanced Power Systems, and imported invertors from Mastervolt from Netherlands	-Exploring new business opportunities	N.A.
Uganda Rural Development and Training	-*Knowledge*: technical assistance and training in installation and service of solar PV systems by HIVOS. Training of URDT staff members by Karagwe Development Association (solar training facility) in Tanzania and Energy Alternatives Africa in Kenya -*Finance*: solar lending program in 1995, with support from a Dutch NGO called HIVOS and a loan from Dutch bank Triodos. -*Technology*: solar panels, batteries and invertors from NEST-Netherlands	-To help rural communities access education and training to become self-sufficient -Altruistic motives of the co-founders	Nearly 300 solar systems were installed (different types of products in terms of Wp)
Habitat for Humanity and Solar Electric Light Fund (SELF)	-*Knowledge*: technical assistance to users for installation of PV systems -*Finance*: solar systems were 50% subsidized by the US Department of Energy bringing the local cost down to 400 USD *Technology:* solar PV systems were imported from the US through a private firm - SEFA	-Habitat: affordable housing and electricity; rebuild lives SELF: livelihood empowerment, and reducing energy poverty	Around 100 solar PV systems were installed by the two NGOs between 1995 and 1996.
Solar Energy for Africa (SEFA)	-*Knowledge*: all staff members underwent training in solar PV technology in the US; they provided technical assistance to users -*Finance*: 50% of the financing of the solar system was covered by Christian organization (SLA), and the remaining 50% was borne by the end-users. - *Technology:* imported PV systems from a number of manufacturers in China, Germany, India, Spain, US etc.	-To promote the church and Christian ideals in Uganda	N.A.

In western Uganda, two US NGOs, Habitat for Humanity and Solar Electric Light Fund offered loans to around 1500 new homeowners to purchase solar PV systems. Reportedly, around 100 solar PV systems were installed by the two NGOs between 1995 and 1996. The systems were partly (50%) subsidized by the US Department of Energy (Eliah and Louineau, 1999). The NGOs adopted a coupled approach targeting low-income families for affordable housing and electricity.

While a number of initiatives were driven by NGOs in the early to mid-1990s, the number of private (for profit) firms selling and installing solar PV systems in Uganda rose alongside to nine. Most of these were small enterprises with sales averaging 0.5–3 KWp/year (Da Silva and Kyalimpa, 2001). Many of them were involved with the sale of agricultural equipment and saw the sale of solar PV systems as a growth technology within an existing market. Others were traders marketing a range of commercial products, selling solar PV systems as off-the-shelf items similar to kerosene lanterns and transistor radios. However, only one of the firms dealt with solar PV exclusively.

Solar Energy for Africa (SEFA), founded in 1993 by a US based Ugandan, provides an example of the Ugandan firms that emerged in the 1990s. In the beginning, SEFA had three employees, but by 1994 it had expanded with subsidiaries in Tanzania, Rwanda, DR Congo and Burundi. Initially, all staff members underwent training in solar PV technology in the US. The founder continued to be based in the US, with frequent visits to East Africa. SEFA partnered with NGOs to implement PV projects in the region. One of the first projects SEFA implemented was in partnership with Habitat for Humanity in which 100 solar home systems were installed in the village of Kasese (SELF, 2019). In 1994, SEFA installed PV lighting systems in three hotels on the Kalangala island of Lake Victoria. The founder tapped into many high-profile networks in Uganda. The next project reportedly came through Salem Saleh, the brother of President Museveni, to install PV systems in a number of rural health centers. Soon, the word spread and SEFA got a project through a Member of Parliament in Western Uganda who wanted to electrify schools and villages in his constituency[6] . In this case,

[6] Personal interview # 5.

the diffusion of PV gained legitimacy due to political currency. SEFA partnered with Solar Light for Africa (SLA), a US non-profit, founded in the late 1990s by a Bishop with the initial purpose of providing light to an orphanage in Hoima. The bishop's idea was to build a partnership between Ugandan and US churches, to leverage the church in helping Ugandans access modern and clean energy (Vision, 2003). The agenda went beyond just lighting churches to bringing light to the rural communities, literally and metaphorically. In this model 50% of the financing for the solar system was covered by SLA, and the remaining 50% was borne by the end-users. The Bishop's son was an electrical engineer and provided technical support, and they also partnered with SEFA for installations. While being rooted in the diaspora network, the founder mobilized resources through national and transnational ties, and also linked it with religious agendas. Thus, Phase I evolved in a non-linear manner, through experimentation and need-based interventions. This phase is characterized by small-scale initiatives, short-term projects, and the beginnings of entrepreneurial ventures. A summary of the role of TNAs in this phase is presented in Table 2.

4.2. Phase II (1997–2008): gaining momentum / commercialization of PV

In 1993, the Govt. of Uganda (GoU) started a program of major market liberalization, financed by the World Bank (WB), which led to the break up and/or sale of numerous public enterprises, which included power sector reforms. These structural reforms aimed at economic growth were promoted by WB and the International Monetary Fund (IMF) in a number of countries, and were based on earlier experiences of the privatized electricity sectors of Chile, Argentina, UK and Norway. In Uganda, the reforms entailed unbundling of the monopoly of electricity board, privatization and liberalization of the electricity sector (Mawejje et al., 2013), and strengthening the regulatory framework. These measures were enshrined in the Electricity Act, 1999. It is important to understand the process that led to the reforms, and the role played by TNAs (esp. development banks). Late 1990s, several study teams from WB visited Uganda conducting an energy sector assessment mission in 1994, followed by a review of the renewable energy sector in 1995. The energy sector management assistance program (ESMAP) produced a sector strategy in 1996 (supported by development aid agencies and UNDP) (Bank, 1999), and another mission in 1998 for implementing the Africa Rural and Renewable Energy Initiative (AFFREI), which aimed to achieve rural electrification through the private sector. Based on these studies, WB heavily influenced the Electricity Bill, which was designed to attract private and foreign investment in the energy sector. In addition, the Norwegian Govt. and the Norwegian Agency for Development Cooperation (NORAD) provided grants (0.6 million USD) (DEMD, 1999) and played a prominent role in institutional restructuring, establishing the de-regulated energy sector, and preparing the Energy Act. WB, NORAD, UNDP, JICA, among others, were the principle architects of the restructured electricity regime.

Meanwhile, MEMD (Ministry of Energy and Mineral Development) embarked on a pilot project in June 1998, the Uganda Photovoltaic Pilot Project for Rural Electrification (UPPPRE), again aimed at promoting solar PV technology for rural electrification through the private sector. UPPPRE was a precursor to the ERT project, and a number of TNAs were involved in the design process including World Bank and UNDP. Through this project, the government sought to establish the foundation for diffusion of PV technology in rural areas for which there were no plans to extend the national electric grid. The project was selected for funding by the Global Environment Facility (GEF), which is a partnership of governments, development agencies and civil society organizations.

UPPPRE included a 1.8 million USD budget for technical assistance, and it received an additional 500,000 USD from UNDP to finance a PV credit fund and guarantee facility. The project aimed to electrify 2000 households and several community/institutional facilities. By the end of 2002, 2389 household PV systems had been installed with support from UPPPRE (Thorne and Mutesasira, 2002). The program trained technicians for system installations and maintenance, and conducted awareness campaigns. It also led to capacity building within the MEMD. UPPPRE was the first government project to initiate planned efforts to promote the use of solar PV in Uganda. It mobilized private actors and helped them form an association, namely the Uganda Renewable Energy Association (UREA), predominantly comprised of solar firms. The project also provided financial resources to UREA for networking, sensitization, and training.

However, UPPPRE suffered from delays, financial mismanagement, and lack of capacity (MEMD, 2009). There were differences of opinion and contestations among the partners, including about the timeline for payback period of PV loans by end-users. The contestations were mainly over international expertise (claimed by development partners) versus local contextual knowledge (claimed by MEMD)[7] . This was followed by a period of struggle and negotiations between development donors and the MEMD, resulting in agreements to apply a longer payback period. The new payment system allowed flexibility and inclusion of households engaged in seasonal activities (such as fishing, agriculture), without a steady income source, thereby expanding the market for PV home systems.

UPPPRE was the beginning of a decades-long program called Energy for Rural Transformation (ERT), the first phase of which (ERT-I) commenced in July 2002. Around the same time, a semi-autonomous body - the Rural Electrification Authority (REA), was set up to manage the rural electrification fund, as advised in the Electricity Act, 1999. The ERT was a multi-sectoral collaborative project with a mission to increase energy access. For the energy component in ERT-I, the objectives were to increase PV sales, improve the quality of products being imported, and ensure price reduction. MEMD and REA were responsible for implementation, with support from WB (for funding) and Private Sector Foundation Uganda. ERT-I was designed to be purely commercial, with PV companies undertaking installation, sale and marketing of the systems. Training was provided to 300 solar technicians. This strategy for building up the PV market was based on the assumption that given appropriate grants, private firms would accelerate market growth and deliver on the ERT-I targets (REA, 2010), which was in line with the mainstream privatization ideals, motivating the TNAs and shaping the larger narrative.

However, private sector penetration in rural areas remained low during 2002 to 2005, and several PV firms focused instead on the urban markets, primarily Kampala. Further, the initial phase of ERT was characterized by "uncoordinated and unclear operations and

[7] Personal interview # 1, # 12.

Table 3
Role of transnational actors in regime-building process Phase II: 1997–2008.

Transnational actors involved	Resources mobilized by the transnational actors	Main actor motives	Off-grid solar PV diffusion rates
UNDP, World Bank, CTA, private companies' involvement in the UPPPRE	-*Knowledge*: technical assistance for installation and maintenance of PV by WB consultants, trainings for cooperatives, 30 seminars/awareness campaigns held for users by private firms, advertisements in newspapers and radio/talk shows for users -*Finance*: Global Environment Facility for technical assistance and UNDP for PV credit fund and guarantee facility -*Technology*: the solar equipment was procured by the World Bank from China	- To improve electricity access by piloting solar technology -To promote privatization in service provision -Capacity building	Installation of 2389 PV systems at the household level in rural Uganda
World Bank involvement in the ERT-I program	-*Knowledge*: training of 300 technicians, developing higher solar PV standards, business support to PV firms, installation and maintenance of PV systems, user manuals, capacity building of ministerial staff involved, trainings to microfinance cooperatives, setting up solar PV testing lab -*Finance*: International Development Association, and GEF grant -*Technology*: the solar equipment was procured by the World Bank from China	- Facilitating access to energy for improving services such as health, education, water, sanitation - For promoting solar PV as a viable technology and enhancing the quality of products sold	512 solar systems installed in 127 health centers, 221 systems in medical buildings, 261 systems in medical staff houses, 20 solar water pumps, schools – nearly 1200 systems in total
Rural Energy Foundation	-*Knowledge*: training local retailers with a knack for engineering solutions to become entrepreneurs and developing a competent supply chain -*Finance*: grant fund by the DOEN foundation in Netherlands and the Dutch Ministry of Foreign Affairs for REF; financing for users via retail loans through micro-finance institutions -*Technology:* importing solar products from China, US, and Europe, assembling and installation by local technicians	- To create a network of local technicians in rural Uganda - To test the viability of a unique supply chain focused business model	57000 solar home systems and 36,000 solar lanterns

incoherent guidelines from the World Bank" (MEMD, 2009), and there was a lack of unified authority as multiple WB consultants were working over short time periods (MEMD, 2009). ERT-I also suffered delays for several reasons including the disagreements between WB and REA with regard to the project design and delivery models (REA, 2010). Such contestations between MEMD and WB/UNDP in both UPPPRE and ERT programs revealed ideological and intellectual struggles. In both cases, TNAs privileged their knowledge and agency over government insights on the local context and requirements, leading to delayed outcomes.

Meanwhile, the number of private players in the solar market began to rise. During Phase II, at least 30 key private players were operating in the market, the majority of whom were system integrators and hardware retailers (Kyezira et al., 2009). In addition, a number of small-scale traders, local retailers with over-the-counter sales, and independent distributors scattered country-wide were also responsible for significant PV penetration, for which no aggregated data exists. The market was "in a state of transition where different players were yet to find their optimum servicing levels" (Kyezira et al., 2009). More importantly, some firms had started to carve their niche by partnering with specific manufacturers (such as SolarHart-Australia), and/or by focusing on specific geographical areas (such as Kampala). Such firms developed through diverse distribution networks including partnerships with NGOs, development agencies, microfinance institutions, credit cooperative groups, and local distributors[8] . They were also instrumental in unifying the previously fragmented voice of solar industry in Uganda.

In 2007, the Rural Energy Foundation (REF), a Dutch non-profit organization, started its SolarNow program in Uganda. REF specializes in establishing and capacity building of retailer networks at the lower end of the supply chain (i.e. local retailers). REF was funded through grants from the DOEN foundation (Netherlands) and the Dutch Ministry of Foreign Affairs, in addition to several individual contributions and foundations. Typically, REF identifies retailers and distributors, trains them in PV technology, sales, and marketing, and helps them start a local business[9] . Entrepreneurs completing the training sign an agreement with REF and develop solar businesses using the SolarNow brand (Ashden, 2010). Between 2007 and 2010, SolarNow sold over 57,000 solar home systems and 36,000 solar lanterns, a far greater number of units than all previous business models combined.

Distinct from phase I, this second phase was characterized by a number of deliberate and planned solar PV programs focused on for-profit ventures, often with specific sales and distribution targets. It was the beginning of a new privatized era for the electricity sector, with the promotion of private sector investments for rural electrification becoming a government priority. There was an increased momentum and a greater supply-push from stakeholders. Commercial-scale PV operations gained traction and a number of

[8] Personal interview # 6.
[9] Personal interview # 22.

new TNAs entered the market, including development aid agencies, foreign private firms and non-profit organizations. The emphasis was on rural electrification given that nearly 90% of the total population in Uganda was rural, most of which was off-grid. A summary of the role of TNAs in this Phase is presented in Table 3.

4.3. Phase III (2009–2017): scaling up and the dominance of market forces

In continuation to ERT-I program, ERT-II was initiated in 2009 to develop the institutional framework and capacity for delivery of renewable energy services. The PV sub-component of ERT II was implemented by REA through the PV Targeted Market Approach (PVTMA), which included provisions for consumer subsidies, and incentives to suppliers and financial institutions. The target was 20,000 new SHS units by 2013[10] . ERT-II was designed by MEMD and REA, based on the experience of ERT I and UPPPRE. REA supported the firms in establishing a fee-for-service business model. For this, a combination of funds from the International Development Association (IDA, a part of the WB Group) and GEF (REA, 2010) were used to co-finance sales to households and NGOs. Nearly 20 solar PV firms participated in the PVTMA program.

The subsidy program was not entirely effective. Many PV providers did not pass on subsidies to end-users. Further, an internal audit team at REA identified several discrepancies. In 2015, Uganda's Auditor General highlighted malpractices in the implementation of the solar subsidy program including misreporting and double billing (Muwanga, 2015). Some solar firms claimed payments for non-existent installations, and some invoiced for systems donated by NGOs. The program also failed to meet its target, delivering only 14,000 connections by 2014 (MEMD, 2014). ERT-II was replete with lax bureaucracy, complicated project designs, corruption by private actors and vested interests of some, all of which undermined project success.

Meanwhile, the solar market grew rapidly with a new generation of market players (mostly foreign) – SolarNow, Fenix Int., M-Kopa, Village Power, Azuri Tech etc. New business models based on pay-as-you-go (PAYG) technology were developed, overtaking the local Ugandan companies and forcing strict competition. Capitalizing on its success discussed in Phase II, the SolarNow program was transformed in 2012 from a non-profit foundation to a commercial for-profit entity selling to SMEs and households not only in Uganda but the whole of East Africa.

Around the same time, a US based venture-backed renewable energy company, Fenix International, entered Uganda in 2011, with expertise in power electronics, product design and base-of-the-pyramid (BoP) marketing. They initially partnered with MTN Uganda (telecom stores) to sell solar systems for phone charging and lighting based on upfront cash sales targeting the BoP market[11] . By 2013, Fenix developed mechanisms for offering credit, and in 2014, launched its commercial-scale ReadyPay products, a mobile pay-enabled solar panel and smart battery system based on a lease-to-own model. ReadyPay, developed by an in-house team, was made available on a PAYG basis using MTN mobile money, a payment platform that allows subscribers to send and receive money via their cell phones. By 2017, Fenix had connected over 100,000 users through their systems[12] . Unlike SolarNow, Fenix deals with relatively small size systems, targeting low-income rural users.

In Phase III, the sales of just 4 such large solar firms in Uganda had totaled 250,000 units[13] . These new generation firms provide quality electricity supply, hardware and services, and also offer coupled credit services. Their solar system distribution branches are predominantly located in high-density areas i.e. central and eastern Uganda, with few in the northern region[14] . Some of them have a cloud-based distribution management system, allowing them to monitor real-time customer energy usage data. They have dedicated personnel engaged with training staff through customized in-house trainings. And they have staff that's able to speak dozens of local languages and dialects, allowing for far greater market penetration.

These firms typically have a regional presence and operate across East Africa in order to achieve economies of scale. Several of them rely on external funds in the form of debt financing (e.g. Azuri gets funds from ElectriFI and TRINE, M-Kopa from CDC, FMO and Norfund) (Maina, 2017; Reporter, 2018), series B financing/crowdfunding (SolarNow from Novastar Ventures and Shell Technology Ventures Fenix from GDF Suez and Scheider Electric) (Fenix, 2015; Saberi, 2017), second structured asset financing/SAFI (SolarNow from SunFunder) (SolarNow, 2016), UN's capital investment through UN Clean Development Fund (for Village Power) and a range of grant funds from USAID (Power Africa), and GIZ (EnDev). Currently, a hybrid financing structure is being witnessed with a mix of DFIs, impact funds and commercial investments. Further, there is an emergence of commercial investments as the off-grid markets are scaling up (GOGLA et al., 2018).

While Phase III has been mainly private-sector driven, a number of initiatives by development partners and multilateral banks are being implemented such as Lighting Africa Program/Campaign (IFC/World Bank), Transforming Energy Access/Energy Africa Campaign (DFID), Energizing Development (EnDev) and Scaling Off-grid Challenge for Development (SOGE). These are multi-country, multi-partner programs, and similar approaches are adopted targeting the whole of SSA and/or beyond as well. Thereby, many key initiatives may not necessarily be driven by adaptation to a local context but they display similarities and patterns with decisions triggered elsewhere, which is reflective of a more regionalized or even internationalized view of the rural electrification regime. Instead of short-term projects/subsidies etc., the development partners and charities such as Shell Foundation are adopting an "enterprise-based model" that is built on market solutions, business support, partnerships and financial sustainability.

[10] Personal interview # 15.
[11] Personal interview # 24.
[12] Personal interview # 24.
[13] Personal interview # 24, # 22, # 20.
[14] Personal interview # 20, # 24.

Table 4
Role of transnational actors in regime-building process Phase III: 1997–2008.

Transnational actors involved	Resources mobilized by the transnational actors	Main actor motives	Off-grid solar PV diffusion rates
World Bank in ERT II program	-*Knowledge*: developing an institutional framework for PV by WB, capacity building of the private firms, trainings for installation and maintenance -*Finance*: by International Development Association, and GEF grant; subsidy scheme for the consumers -*Technology*: procurement of PV systems by private firms from a number of different manufacturers in China, Europe and the US.	- To promote private sector in delivery of rural electricity services - Impetus to private firms engaged with solar PV business	In total, 14,000 PV systems installed at household level
Solar Now	-*Knowledge*: prior knowhow of Dutch entrepreneur in a renewable energy foundation (based in Netherlands) with domestic market in Uganda, technicians turned local franchises and suppliers for the firm, training of 550 technical staff engaged in sales and marketing by Solar Now -*Finance*: grant support by the Government of Netherlands -*Technology*: from a number of manufacturers, especially in China.	- To capture a business niche through focusing on the lower end of the supply chain	Nearly 30,000 units sold
Fenix International	-*Knowledge*: technology company with vast experience, based in San Francisco, with expertise in electronics, product design and marketing, trained hundreds of their staff in technical competence, sales and marketing skills, and trained users in installation and maintenance of systems -*Finance*: Grant support from the Govt. of Netherlands and commercial finance -*Technology:* the technology/ and product designs are developed by in-house engineering team, and manufactured through partnerships with factories in China.	- To develop an innovative, technology-based business model - To integrate the business with data analytics and credit scores to connect users with financial institutions	Over 100,000 systems sold
GIZ, multiple donors, and private firms involved in EnDEV program	-*Knowledge*: technical expertise provided in the form of certifying technicians, developing guidance manuals, supporting PV firms in awareness campaigns for users etc. -*Finance*: co-financed by multiple donor partners and governments such as Dutch Ministry of Foreign Affairs, Norwegian Agency for Development Cooperation, UK Department for International Development, Swiss Agency for Development and Cooperation -*Technology:* the solar PV systems are procured and managed by individual private firms with the help of results-based financing scheme by EnDev	- To develop and test a viable business model (RBF) with financial incentives at its core - To promote the delivery of renewable energy services through private sector and remove barriers	157,800 systems installed at household level, 1100 at institutional level and 1600 for small businesses

Within this rural electrification regime, we also witness the emergence of solar PV mini-grids at a scale (kWp) different from that of solar pico and home systems (Wp). The Rural Electrification Strategy and Plan (RESP 2013-22), developed by REA, prioritizes rural electrification through PV-powered mini-grids (REA, 2013). In phase III, 6 mini-grid projects were implemented in Western Uganda and the islands on Lake Victoria[15] . These were developed by private actors with support from USAID, Shell Foundation, GIZ and REA etc. While the solar mini-grids form the rural electrification niche, it is likely that in future they may be a co-existing regime, along with grid extensions and off-grid solar PV.

Thus, in this phase, the solar PV market matured and became commercially viable for the private sector to thrive. The total number of private players in 2013 were 85 (Kyezira et al., 2009). However, this doesn't include a number of small-scale traders, dealers, independent distributors, local retailers etc. which may indicate a number of roughly 300 or more. As a result, the uptake of solar PV is relatively high. Foreign firms capture a large share of the market. The presence of foreign technology, capital and skills has been driven by the market and has helped professionalize the sector. Firms that were previously distributors representing specific manufacturers have diversified and now import from a range of manufacturers, and some develop customized designs but get them manufactured in China. Further, there is an increased mobilization and consolidation of several actors, and joint advocacy for a bigger industry voice through the Solar Association (USEA). Several new partnerships and alliances have been forged, and networks formed, which is an ongoing process. The overall off-grid sales data (representative) is presented in Fig. 4 and a summary of the role of TNAs in this phase is in Table 4.

[15] Personal interview # 14.

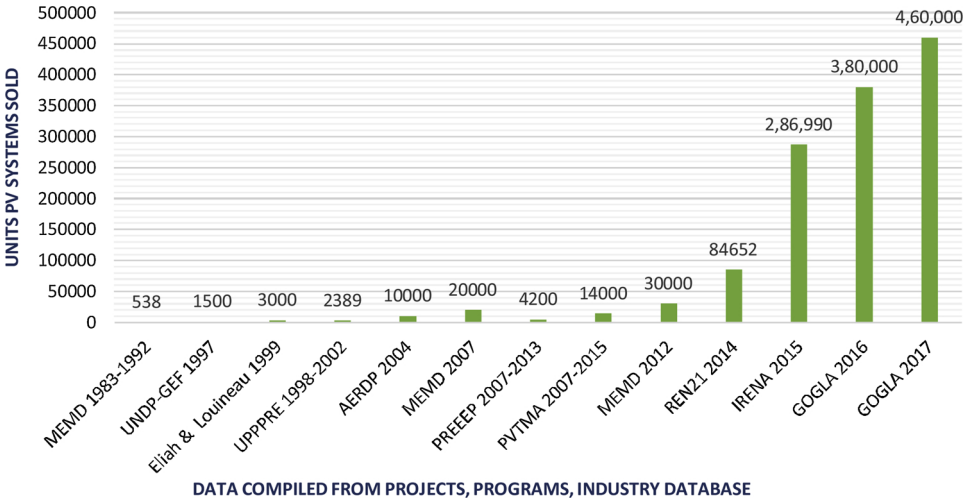

Fig. 4. Off-grid solar PV sales data (1983–2017).
Source: Author's own compilation. This has been compiled from various sources, and is not exhaustive. Some of them represent govt. programs (UPPPRE, PVTMA), and others represent data from industry association (GOGLA).

5. Discussion

In our description of the evolution of solar PV rural electrification regime in Uganda, we can see a shift from Phase I to Phase III from the traditional donor and government-supported programs to a more market-based diffusion of solar PV, as is also indicated in a report (Nygaard et al., 2016). Similarly, a shift can also be seen from traditional financing to innovative public and private financing mechanisms. After an initial period of incidental explorations in the late 1880s, a larger market was deliberately created with concerted efforts by the government through long-term programs in collaboration with development partners, with a focus on rural electrification. The government played a critical role in supporting the consolidation of private actors to encourage and support market penetration, esp. in the late 1990s. It invested in generating awareness and increasing the technical knowhow within the nation, with technical and financial support from international development partners and climate funds. It is important to note these background developments which created an enabling environment for the private-sector expansion and intensification of donor activities.

Within the private sector developments in this regard, we can also identify three different phases: First phase – late 1880s and early 1990s – local Ugandan companies experimenting with the solar sector without it being their main business interest (ex: Incafex, Magric); Second phase – late 1990s to mid-2000s – Ugandan companies/traditional business models, dealing primarily in solar pico, SHS and large systems (ex: UltraTec, Energy Systems Ltd., Konserve); Third phase – late 2000s through 2010s – Multinational companies capturing large market shares with bigger investments, business innovation, development assistance and private capital (ex: Solar Now, Fenix). Further research needs to focus on the solar market, particularly private sector experimentation and up-scaling.

Our findings also provide inputs for the shifting agency of actors in renewable energy transitions. The specific trajectory of off-grid solar PV is largely a manifestation of the changes and shifts in the development aid and financing mechanisms. Development organizations (esp. WB, NORAD, GIZ) during Phase I were involved in strategic, policymaking and advisory capacities and also provided financial support. In addition, they were closely engaged with shaping the fundamentals of the power sector in line with structural reforms and a push towards privatization and liberalization. The narratives – state failure and neo-liberal reforms – revealed that the rules of the game were soon to be determined by the market. This became the basis for how the electricity sector in Uganda is organized now, within which the multiple actors are located. The activities of the development partners have intensified but their roles have shrunk, to mainly becoming mediators and facilitators of the private-sector driven transition during Phase III, partnering, funding and promoting select private sector firms (ex: Lighting Africa, Transforming Energy Access), and advocating and lobbying for private sector voices and rights. This is also reflective of the shifting paradigms within development assistance for renewable energy (Kruckenberg, 2015). Further research needs to focus on developing more specific insights on changes in development assistance (comparing DAC vs non-DAC contributions, public vs private finance etc.) in general, and how that manifested in the energy sector, specifically solar PV.

In line with the proposed alternative "global regime" perspective that embraces multi-scalar actor networks, our findings also illustrate that regimes (and niches) are indeed much more globally embedded than previously assumed (Fuenfschilling and Binz, 2018). Our findings reaffirm that the fairly rapid diffusion of solar PV, in a context such as Uganda (and East Africa), can only be understood from an "internationalized perspective" (Binz and Anadon, 2016; Quitzow, 2015). Further, this paper demonstrates the considerable contribution that a relational perspective could make with regard to deconstructing how distinct constellation actors

and their relationships can influence socio-technical trajectories.

The paper disaggregates “transnational actors” by developing a typology beyond foreign donors and investors, and assesses the complex diversity of roles played by these actors in advancing the PV transition. The multitude of actors do not act as one unit but rather as a transnational network of independent, heterogeneous organizations driven by different sets of agendas and operating within a negotiated terrain, while exercising power of varying degrees. Agency is thus distributed rather than centrally coordinated (Manning and Reinecke, 2016) and multiple actors operate with a varied set of logics not easily captured by the simplistic notions of “profit” in relation to private companies, and “development” with regard to aid organizations. Our paper also highlights the need for a better framework of agency in transitions.

Further, our analysis indicates that TNAs tend to play a central role in mobilizing resources, exert varying degrees of influence through financing projects and providing expertise, and enjoy a superior position in global networks. This allows them higher bargaining power with the opportunity to advocate and support their preferred solutions. They gain legitimacy due to their embeddedness and siting within the wider global network instead of specific actor characteristics as such. Given this, we also observe distinctions in the definitional authority exerted by the “rational” or “neutral” third sector actors vis-à-vis the state and private sector actors. The trajectory of transition is constantly shaped and framed amidst the negotiations and tensions between the interplay of global and local actors in myriad forms. However, through a number of cases discussed in the empirical section, it is evident that TNAs frequently privilege their knowledge and agency over that of the national actors.

The case of Uganda also reveals similarities to the Kenyan and Tanzanian cases (Byrne, 2011) and we observe several linkages between Ugandan actors and those in Kenya and Tanzania (such as SELF, WB, UN organizations and many private sector firms). A striking similarity among these East African countries is in the pattern of involvement of donors, charities and NGOs in the early period and increasing private sector activity over time, with foreign firms building the momentum and continued involvement of donor agencies. This suggests that solar PV development in the broader East African region may be considered as essentially a transnational phenomenon i.e. shaped by mainly transnational actors and cross-border resource flows. Perhaps this warrants a wider study about the roles of transnational actors in energy transitions across the national borders of East African nations.

6. Conclusion

This paper had set out to answer the following research question: *How do transnational actors exert influence and operate while mobilizing key resources for sustainability transitions in low-income countries?* So far, theoretical frameworks and empirical analyses have had a limited focus on the role of TNA, and their respective motives and agendas. This exploratory paper develops a typology of transnational actors, expands the heuristic framework of Multi-actor Perspective (MaP), and demonstrates the workings of it in an under-researched empirical context. It breaks away from the simplified aggregations of niche, regime and landscape actors, and identifies a number of actors that intervene at each of the levels. Thereby, it illustrates how specific actor groups and constellations of TAs influence the PV-based rural electrification regime, while being positioned and operating at multiple scales. This paper complements existing research work on global socio-technical regimes (Fuenfschilling and Binz, 2017) and contributes to the existing discourse on agency and power in transition studies (Avelino and Wittmayer, 2016; Wittmayer et al., 2017).

Appendix. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.eist.2019.02.001.

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