Piecing together the fragments:
The case of solar PV niche in Uganda (1985-2015)

1. Introduction

The international efforts to provide modern clean energy services has escalated in the recent years particularly leading up to global initiatives/platforms such as the "Sustainable Energy for All", "Alliance for Rural Electrification, and "Global Off-Grid Lighting Association". The challenges of energy access are two-pronged: achieving universal energy access through a clean and just transition, but also ensuring reduction of the greenhouse gases, in the context of Paris Agreement. In some Sub-Saharan African (SSA) countries (e.g. Uganda, Malawi), this challenge is heightened as the electrification rates are less than 20% (IEA, 2015). Solar PV technology had been introduced as an alternate solution and off-grid solar PV products such as solar home systems (SHS), pico-solar have penetrated the markets. Nearly 1.87 million units (50% of global total) of solar products were sold in SSA, only in the second half of 2016 [20] . In the period 2011-15, the number of pico-solar products sold in SSA grew from less than half a million to over 11 million[1].

East African markets are home to the highest density of suppliers esp. Kenya, Tanzania, Uganda, Ethiopia [21] . While Kenya and Tanzania were among the early focus-markets for off-grid systems (OGS), countries such as Uganda and Ethiopia are the mature second-gen markets with substantial progress and high penetration of OGS. The past three-years cumulative sales of OGS in Uganda is 2 million, an annual growth of 135% between 2014-16 [21] . The intensification of solar PV circulation has been mainly attributed to the widespread use of mobile phones, upscaling of businesses through flexible mobile-pay technology (PAYG), favorable regulatory environment, availability of cheap Chinese products, and the suppliers taking advantage of price and efficiency of the core technology [43] . Further, a shift has been witnessed from the traditional donor and govt-supported programs to a more market-based diffusion of solar PV [25; 43] .

A rapidly emerging field of sustainability transitions is focused on analyzing how transformative change in socio-technical systems (such as energy) come about [17] . This is mainly attributed to significant technological changes (new innovations), emergence of new markets, increased pressures on the existing electricity regime, interests of the actors (who steer it or set the terms), and also favorable economics [47; 58] . Sustainability transitions of socio-technical systems i.e. changes towards more sustainable modes of production and consumption are complex, ambiguous and uncertain [33] . Scholars have been studying these mechanisms by applying the core analytical frameworks as the multi-level perspective (MLP), strategic niche management (SNM), and technological innovation systems (TIS), among others.

In the recent years, the field has branched in many directions to capture the complexity and multi-dimensionality of sustainability transitions. However, the lack of sensitivity to actor-oriented perspectives within transition research had limited its scope of analysis [18] . This has been reiterated in a number of studies including Grin et al. (2011) that highlight a lack of systematic understanding of multiple actors and their distributed agency in the transition process, and Farla et al. (2012) who called for a more explicit conceptualization of actor strategies and resources. In response, agency and actor-oriented studies have received increasing attention across various geographical contexts and transitions are being increasingly recognized as comprising of dynamic and ever-evolving multi-actor processes. Some of the recent works on this theme include: analyzing actor-network strategies [39] , actor expectations [4] , interplay of actors and institutions [16] , and changing actor roles in transition [71] .

Solar PV diffusion in East Africa is essentially a transnational phenomenon i.e. developed through transnational actors and resources. In other words, while the market developments around solar PV technology are contained within specific country contexts, a number of non-national actors are influencing and negotiating the terrain of

[1] African Progress Panel, 2017

market diffusion. These include a number of transnational actors such as inter-governmental organizations, development banks, aid agencies, private firms etc. and transnational movement and flow of capital, knowledge, skills, and technology [70] . The transnational processes are non-linear and complex, and unlike global, they are enmeshed within a nation but also contains social and symbolic ties that cut across the borders of that nation. Thereby, transnational includes the national and focuses on analyzing how broader social processes and entities influence and shape the national/sub-national territorial spaces [31] . In the solar PV context in East Africa, the flows of actors, knowledge, technology, and finance are neither only from the developed western nations to the low-income countries, nor are they only from the Global south either. Instead, the flows are multi-directional and cyclical in nature, comprising of a combination of actors and entities with dispersed agency, operating through a negotiated terrain and exercising power of different degrees.

In this paper, we investigate the transnational actors and flows acting upon and shaping the solar PV niche in the context of Uganda. We do so by analyzing the history of solar PV transition since the 1980s, by paying close attention to a number of significant projects/programs implemented. We identify the need for more holistic representation of actors, esp. transnational and a more nuanced analysis of the transnational forces acting within newer empirical contexts, esp. in low-income countries, which have relatively been under-represented within the transitions research. We find that transnational actors and linkages are particularly pertinent in the context of low and middle-income economies, in which innovation dynamics are to a large extent driven by forces including foreign investments, multi-national companies, global value chains, and through technology transfer. In the following section, we elaborate on the theoretical framework i.e. how transnational is understood or appropriated within the transitions literature and also the within the larger social sciences literature and developing a conceptualization.

2. Theoretical Framework

2.1. Transnational Outlook in Social Sciences

Faist (2010) defines the term transnational as "sustained cross-border ties, events, and processes across the borders of several nation states, (in which) both non-state agents and states participate". Transnationalism has received increasing attention within the social sciences literature, esp. due to increased significance of global interconnectedness (Beck, 2000; Tomasci, 2001). With globalization, international trade, and escalation of international migration, the centrality of nation-state has waned [68] . The conventional understanding of transnational was linked to the movement of immigrants, within the anthropological tradition [51] . However, the concept has been extended to a number of studies as transnational […] "communities, capital flows, trade, corporations, inter-governmental agencies, supply chains and markets, politics, social networks, migrations, identities" [66] .

When applied to a solar technological niche, the concept of transnational helps to explain how the local niche of a nation state is enmeshed within the larger transnational forces and relations across multiple scales. It thereby opens up possibilities for understanding the complex ties between actors and networks across nations, and the movement, flow, and circulation of knowledge and capital that have a nation of origin but are no longer limited to it. Here, we are in agreement with Waldinger et al. (2004) who suggest that a transnational process or entity belongs to things and connections between "here" and "there", and thereby it is characterized by a certain in-between-ness and fluidity, and in the making. The solar PV market development comprises of a network of actors and institutions - not all of which are national. The network has subtly discerned yet shared values with regard to clean technologies and universal electrification. The actor roles and dynamics are not rigid but evolving and fluid.

2.2. Transnational Perspective in Transition Studies Literature

The most fundamental framework in the sustainability transitions literature is the Multilevel Perspective (MLP), which analyzes how socio-technical transitions entail complex interlinked processes across three levels: landscape, regime, and niche [17] , and how the socio-technical systems be made more 'sustainable' [33] . MLP is developed in a European context, with increasing applicability in the Global South. Recent works in the literature, esp. on the geography of transitions, have attempted to challenge the traditional MLP framework, and arrive at different conceptualizations of the three levels [48] . Drawing on the fields of economic and human geography, the researchers have identified the need to transcend the transition field's strong tendency to favor the national scale for analysis [23; 69] . A spatial perspective on niche development means "moving away from the national as the default level of analysis without dismissing the importance of national governments and other actors operating at the national level" [6; 54] . As a result, the roles of transnational relationships, global forces, sub-national processes and actors are being identified as important to shaping the socio-technical transitions [62] .

An emerging stream of research is the transnational pursuit of transition processes, including the non-national embeddedness of the niches and regimes, particularly in the low and middle-income country contexts[2] [24; 32] . Wieczorek et al. (2015) illustrate the existence of *transnational linkages* as resources for niche development. Shove et al. (2014) conceptualize *transnational transition*s in terms of how mechanical cooling has been appropriated differently – at different times and rates – outside of the US, thereby broadening the geographical canvas of transitions. Sengers et al. (2015) emphasize the importance of a transnational view on transition processes and develop a *spatial perspective*, using the case of bus rapid transit system as a socio-technical niche proliferating globally. Manning et al. (2016) seek to better understand the governance processes of sustainability transitions in transnational domains by illustrating the role of *transnational standard-setters* in the coffee sector. The latter three studies adopt a spatial-approach by following an object outside of the national borders of its origins (i.e. bus rapid transport system or air conditioning system or sustainable coffee production practices) and conceptualize transnational transitions as a complex array of multi-site, multi-nation, multi-actor processes. While we do not adopt such an explicitly spatial approach, we do however acknowledge and investigate the critical role played by the transnational actors and resources in shaping the solar PV transitions in Uganda.

Further, studies have also analyzed technological change beyond the national scale through global production networks, global value chains, international technology transfer, in the contexts of Ghana and China [22; 42] . However, the type of transnational influences in these contexts, and how they operate have been less clear (with a few exceptions). Even these exceptions either focus only on specific actor groups that have played an influential role in technological development such as foreign investors [42] , foreign donors [35; 36; 56; 61] , and/or focus on specific NGO-funded projects (in case of van Welie et al. (2017)). There is a limited representation of transnational actors, and limited understanding of the complexities involved in navigating through multiple roles, of operating within weak institutional systems, and of the overall transnational nature of niche development.

2.3. Conceptualizing Transnational Actors and Resources

In transition studies literature, actors in transition have been conceptualized in many ways – as 'policymakers', 'consumers', 'firm owners' [13] , 'frontrunners' [50] , 'policy entrepreneurs' [3] ; 'intermediaries' (Hargreaves et al., 2013), and as 'system-builders' [44] . Avelino et al. (2016) highlight the conceptual weakness in the transitions literature: i) in its usage of the category "civil society" for everything that is non-market and non-government; and ii) in its vagueness in the reference to actors and their level of aggregation. Further, they note a conceptual ambiguity with regard to the way "actors" have been understood – as specific individuals, as individual organizations and/or as specific categories of actors, and/or all of them. Avelino et al. (2016) develop a Multi-actor Perspective (MaP), in which they distinguish four actor categories – state, market, community and the third sector – along the three axes: informal – formal; profit – non-profit; public – private. The "Third Sector" is defined as an

[2] Here, we follow the definition of low income and middle-income countries as per the World Bank.

intermediary sector comprising of individuals/organizations that cross the boundaries between profit and non-profit, private and public, formal and information. They include phenomena such as 'not-for-profit' social enterprises, and cooperative organizations (Avelino et al., 2016).

However, Avelino et al. discuss these actors in contexts which pre-dominantly comprise of national actors. Hence, the need for better conceptualization in non-OECD contexts, which comprise of pre-dominantly transnational actors. Further, de Haan et al. (2018) proposed a theoretical framework for actors in transformative change. They adopt a fluid interpretation of the actors driving the transition (in line with the arenas of development framework, see Jørgensen (2012)), and not bound by the rigid levels of MLP. Thus, each actor may assume different roles and affiliations (across niche and regime), similar to the concept of 'boundary spanners' [57] . Further, they develop a typology of transformative actors: frontrunners, connectors, topplers and supporters, and alliances: initiatives, networks and movements. This framework has yet to be empirically validated. While this is not in the scope of our paper, we however include a brief discussion of the framework using our empirical case. In a similar vein, while some studies deal with non-national or external actors, there is a lack of explicit conceptualization of the transnational actors and resources. Wieczorek et al., (2015) de-construct the notion of transnational linkages, provide descriptive mapping, and an analysis of the patterns witnessed in case of solar pv in India. However, the paper falls short of analyzing how these linkages influence the outcomes of the projects, and/or the relative importance of the transnational vs the national linkages. We attempt to fill this gap in our paper.

This paper builds on the above contributions and expands the interpretation of "transnational actors" beyond only foreign donors and investors, and captures/analyses a host of other transnational actors as well such as development banks, consultancy firms, social enterprises, corporates, educational institutions, missionary organizations etc. 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. Agency in promoting technological change is thus distributed rather than centrally coordinated [32] and the multiple actors operate with a varied set of logics not easily captured by simplistic notions of 'profit' in relation to private companies and 'development' with regard to aid agencies. Thereby, this paper aims to transcend the simplistic framing of transnational actors and their activities. It attempts to develop an understanding of their interests, motivations and agendas, in order to better analyze the solar PV transition process. In so doing, it does not undermine the interests/position of the national actors, but illustrates the multi-actor dynamics, and emphasizes the influence of the transnational actor-ties. Our research question is: *How do transnational actors influence and operate with regard to mobilizing key resources for sustainable transitions in low-income countries?*

We distinguish and include a diverse set of transnational actors, using solar PV as a case in point. We develop a typology of transnational actors, adapting and building on a few of the existing works. In line with Avelino et al. (2016) and de Haan et al. (2018), we identify actor as a person or entity operating individually (hereby referred to as *individual actors*), or as an organization, or a collective of persons including alliances, networks (hereby referred to as *organizational actors*). In addition, the individual actors within organizations/alliances also play a significant front role and thereby assume importance in some cases. We identify them as *individual actors within organizations*. The transnational individual actors include researchers, independent consultants, independent experts, and volunteers etc. However, based on our understanding of the empirical context, we recognize that the organizational actors are more pertinent, and thereby identify eight (8) different types, as depicted in Table #, along with the resources they mobilize (discussed later in this section).

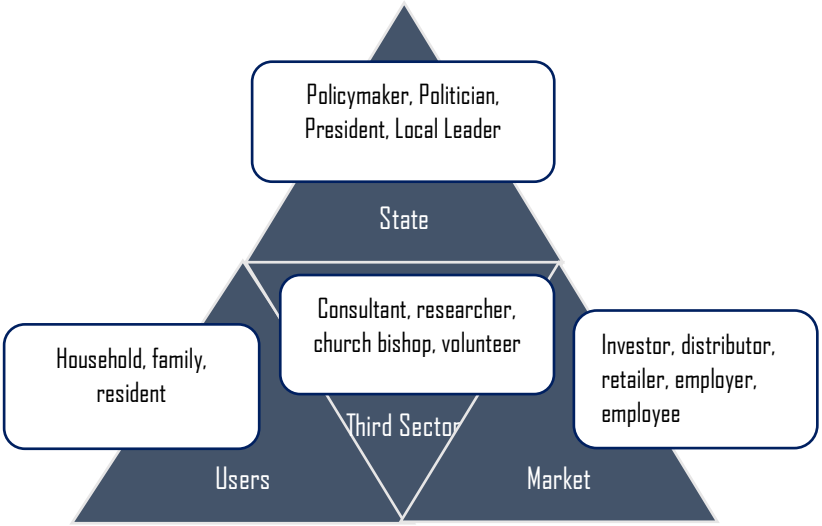
Table #: Type of Transnational Actors and Resources

Actor-Groups	**Characteristics**	**Organizational Actors**	**Resources**
Development aid agencies	These agencies have a country of origin and are representative of their country´s policies and politics.	USAID, DFID, GIZ	Capital, Knowledge
Inter-governmental organizations	These organizations do not have a specific country of origin but are representative of sovereign member states.	UNDP, UNEP, World Bank, WHO	Knowledge Capital
Bi-lateral/multi-lateral development banks	These are institutions providing funding support to emerging countries and could be bi-lateral or multi-lateral	IFU, FMO, KfW, ADB, AfDB, EIB	Capital

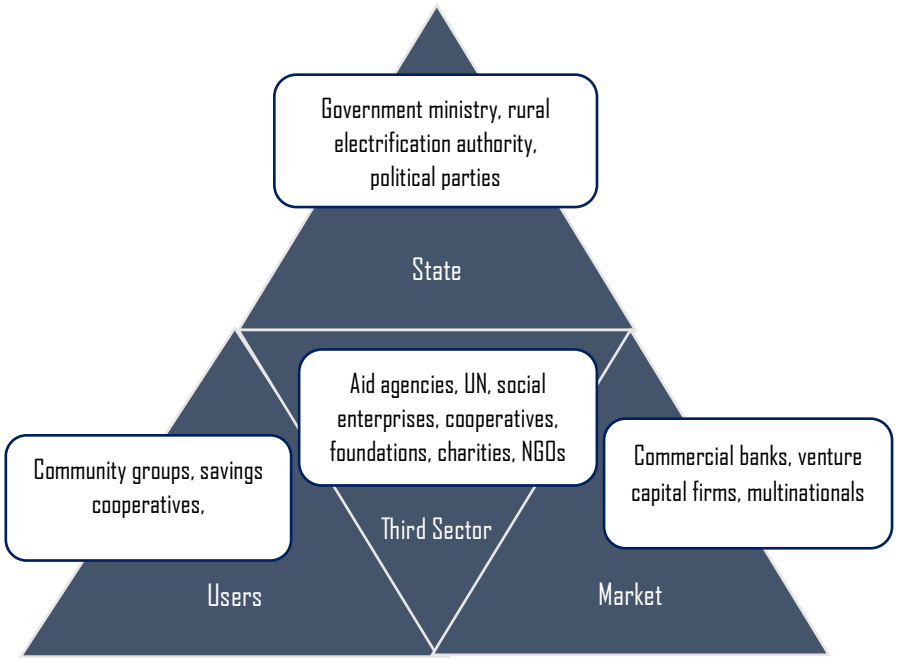
Non-profit, charities, cooperatives, NGO, foundations	These are non-profit organizations performing different types of development work and assistance. These include: i) faith-based organizations; ii) corporate-backed foundations; iii) charity-based organizations;	E4I, FRES, REF, NRECA, WWF, SLA, LWF, Shell Foundation	Knowledge
Corporate business/firms	These are for-profit firms and social enterprises engaged with business activities to improve the delivery of electricity goods/service esp. in rural areas.	Solar Now, Fenix, Barefoot Power, M-Kopa, Village Power	Technology Knowledge
Consultancy/Advisory firms	These are for-profit organizations engaged with providing various kinds of consultancy and technical advisory services.	Enclude, Open Capital Advisors	Knowledge
Global alliances/ industry associations/ advocacy networks	These are alliances, networks, associations formed by like-minded organizations, or member states or industry associations towards achieving certain common goals	SE4ALL, ARE, GOGLA, IRENA, IEA, GEF, EAPN	Knowledge, Capital
Educational Institutes / Universities	These are educational institutions, university consortiums working with other partners, engaged with projects world-wide.	Access2Innovation, MIT, Humboldt State University	Knowledge

Developed by the authors

We work with the adapted Welfare Mix Model and include the four actor categories (Avelino et al., 2016). We concur with defining the third sector as the "in-between" space crossing the boundaries of profit-nonprofit, formal-informal, and public-private. We adapted the model by: i) including a host of transnational actors; ii) including a wider interpretation of market actors i.e. even those along the solar value chain such as trader, distributor, retailer; and iii) categorizing individual and organizational actors in an empirical context. Most transnational actors are located in the in-between space and operate across a spectrum of different logics.



Figure#: Individual actors



Figure#: Organizational actors

Following Budde et al (2012) and Haan and Rotmans (2018), we see a need to conceptualize the levels in the MLP in a more actor-oriented manner. For example, the landscape concept is typically seen as something that is floating 'in the air' as a background/context variable, such as 'globalization' for example. But, what we commonly understand as 'globalization' is a process that fundamentally involves specific actors, particularly multinational companies, deeply engaged in expanding the integration of economic activity on a global scale: it is through their activities that globalization evolves. This globalization process is enabled by another landscape concept: 'privatization', which in some emerging economies is a process that is significantly influenced by specific actors, such as the World Bank and other development aid agencies, promoting this agenda. Hence, what we understand as 'structural conditions' also involves actors and agency. Similarly, regimes are typically stabilized by specific incumbents that through their activities and practices seek to reinforce status quo. At the niche level, specific agents operate in various experiments and networks. Hence, in this paper we will be studying the *practices* of specific landscape *actors*, regime *actors* and niche *actors*, including their strategies, activities, and resources.

The landscape actors include: development aid agencies, development banks, non-profit organizations, and consultancy firms. The regime actors entail: government ministry, rural electrification authority, electricity utilities, independent power producers etc. and the niche actors: firms, NGOs, social enterprises, government ministry, development aid agencies. Though we draw a distinction between the three types of actors, it is to be noted that there are overlaps among actors across the different levels, and that they are acting within an arena. Hence, instead of fixating the actors and spaces across each of the levels, we are interested in investigating the fluidity of actors and spaces, and the way they navigate, esp. in contexts where niches and regimes co-exist. This is marked by vested interests, entrepreneurial gains, market development, political pressures, financial flows, institutional change etc.

In the existing work, transnational linkages have been typified into five categories i.e. actors, knowledge, capital, technology and institutions [70] . We propose an analytical distinction with regard to one of the categories: i.e. actors. We believe actors are not just one of the linkages but are all encompassing i.e. they are the nodes through which resources are mobilized. These resources include knowledge (skills), capital (finance), and technology (products/services). Knowledge enables the adoption, diffusion and implementation of technologies. Knowledge spillovers involve an exchange of ideas, transfer of skills and capacities through formal and informal mechanisms including: i) technical trainings (hard skills); ii) trainings imparted on project management, system installations and maintenance; iii) awareness and sensitization on new technology and its usage (soft skills); iv) brochures, and flyers (codified knowledge); v) know-how shared through interactions and dialogue via workshops, seminars etc. (tacit knowledge). Capital refers to the flow of financial capital in the form of R&D funding, private equity, venture capital, technical cooperation grants, official development assistance by governments, and loans, grants, and equity

investments by development banks, debt and equity investments by commercial banks, and crowdfunding at series A and series B stages. Technology-related flows refer to "cross-border diffusion of equipment, products and technological artefacts". They take place through the means of trade (legal and illegal), and sourcing of equipment from key manufacturing zones worldwide, in standardized or customized design formats. Technologies are not neutral - they shape certain geographical ties, are appropriated by specific actors, and embody social practices. However, the spread of knowledge, ideas, values, skills, technologies and capital may come with assumptions based on specific political paradigms, for instance, neo-liberal ideas on how to efficiently organize or develop new markets (Hall, 1989). Hence, it is important to scrutinize the intent and motives of the transnational flows mediated through actors, and their implications in low-income country contexts.

3. Methodology

3.1. Scope of the Study

The main objectives of the paper are three-pronged: i) to offer a detailed account of the history of solar pv market; ii) to document and analyze the multiple initiatives/projects on solar pv and their outcomes; and iii) to analyze the critical actors (national and transnational) driving the market development and the transition. We use the case of solar PV as our technology in focus to study transitions. In Uganda, PV technology is deployed across 3 scales: off-grid (solar home systems, solar Pico), mini-grids (isolated independent grid-based systems) and grid/utility scale (connected to the national grid). We consider these 3 scales as parallel niches as they entail different set of actors. While the data has been collected across all 3 scales, we choose to focus on the off-grid solar systems in this paper: i) as one type/scale helps to delineate the analysis process; and ii) as off-grid solar has gained maximum traction in Uganda, while the other two are relatively nascent. While the transnational forces are operating across all the three scales, we limit our study to only those relevant to the off-grid systems.

Within off-grid solar systems, there are a diverse range of projects/programs implemented with varying applications (including lighting, refrigeration, water heating). In the transitions literature, these initiatives have been conceptualized as sustainability experiments (Sengers et al., 2016). Sustainability experiments are defined as "planned initiatives" embodying a "highly novel socio-technical configuration" in order to achieve "substantial sustainability gains" (Berkhout et al. 2010). While the initiatives discussed in this paper do broadly relate to the concept of sustainability experiments, however we have a few reservations with the terminology: i) this has a prominent focus on consensus and shared-vision, whereas in several initiatives the visions/motivations of the actors are very different; ii) it would be difficult to qualify all of them as leading to "substantial sustainability gains"; and iii) this working definition offers limited interpretation of the diversity and breadth of initiatives taking place on the ground including unplanned or unintended developments. In addition, as Sengers et al. (2016) rightly note, the role of business in experimentation has received limited attention esp. for sectors which have moved beyond the early phases of niche creation (ex: new business models, new ways of creating shared values). In this paper, we also include business models and/or novel ways of business operations. Hence our unit of analysis entail: i) deliberate and intended programs/projects; ii) accidental and unintended developments; and iii) new business models, operations.

3.2. Methodological Approach

We devised a longitudinal case study approach to delve deeper into the market developments in a single country case. Qualitative research was employed in order to undertake a nuanced analysis of the history, and to capture the multi-actor dynamics and resource flows. The data collection approach involved developing a historical narrative of solar pv and a chronology of all significant initiatives and constructing a database of solar pv sustainability experiments. The overarching narrative was constructed based on in-depth interviews with solar PV experts and also based on the secondary data sources. These include: i) historical reports published by the Ministry of Energy accessed through their resource center; ii) published research papers; iii) reports in the grey literature; iv) media articles; vi) reports accessed through government websites; and vii) power point presentations used in seminars/workshops. We used multiple sources to triangulate the information gathered.

The database of all experiments (40) was developed on the basis of personal interviews and web-based information on solar PV. Data was collected for initiatives in the period 1980-2017. Key informant interviews were conducted with 30 interviewees between July-December, 2017. The interviewees comprised of: government officials, private firms, development partners, solar association members, rural electrification agency, regulatory authority, and civil society organizations. The interviewees were identified through a snowballing method and multiple online searches were undertaken to ensure that all the key individuals and organizations have been included in this study. The data analysis was carried out by summarizing data from interviews, field notes, documents from secondary sources and by triangulating and juxtaposing details from these multiple sources. An inductive or 'bottom up' approach was adopted based on the analysis of the empirical material, synthesizing the themes and thematic observations, and identifying the patterns through the emerging narratives, and validating the findings.

4. Analysis of Solar PV in Uganda

The solar PV market development historically has been charted in this section, focusing on the specific projects and the actors and resources. Based on our understanding of the type of initiatives and actors of solar PV, we have segregated the trajectory into three distinct phases: Phase-I (1983-1996), Phase-II (1997-2008) and Phase-III (2009-2017). The cut-off timeline marks a disjuncture, a distinct break from the nature and pattern of developments preceding it. For e.g. while Phase I is characterized by unintended developments, and initiatives by the non-governmental organizations predominantly, Phase II is characterized by deliberate long-term government programs, and developments in the PV market, and Phase III by pro-active upscaling of private firms and market diffusion. Further, the authors have curated a sample of sustainability experiments for analysis based on certain reasons. First, the sample has been curated with the intention to represent and be representative of the diverse set of initiatives documented in the list. Second, this includes initiatives which were highlighted by various experts as being pertinent. Lastly, the sample was also selected on the basis of adequacy of the data available on the specific initiatives. For a detailed list of sustainability experiments, please refer to *Annex I.*

4.1. Phase I (1983-1996): Setting the Stage / Limited Uptake

In the 1980s, a civil war was still being fought in Uganda, in continuation to a decade-long civil unrest during the 1970s. After an interruption during this period, the Uganda national expanded program on immunization (UNEPI) had re-started in 1983, and the full program operations resumed in 1986, after the war had ended and Yoweri Museveni became the President of Uganda. The program was hosted by the Ministry of Health-MoH (Uganda), and jointly supported by the *UN agencies- WHO and UNICEF*. It was aimed at vaccinating children against a number of infectious diseases including TB and measles. The UN agencies mobilized resources for the program in the form of funds (capital), skilled health workers (skill/knowledge), supply of vaccines and related equipment (technology), and publicity about the program (awareness). Soon after, Save the Children Fund (SCF), an *international non-governmental organization*, was invited to join on board in 1984 to help the Ministry of Health to manage the program [27] . Vaccines, the main tool for immunization, are fragile, sensitive to temperature and must be kept at 4° C during storage and transportation. While the central cold store was at Entebbe, the vaccines had to be transported throughout the country. Diesel and kerosene-based fuel source was primarily relied on. However, restricted supply of diesel in the war zone, and limited low-quality kerosene, slowed down the program[3].

As an alternative, solar pv was explored and SCF undertook a feasibility study for solar PV in 1984, after which the program embarked on a unique solar-powered cold chain in Uganda. Using solar pv was thus not deliberate and planned as part of the program design but was incidental and purely based on the circumstances. It was reported that the project partners agreed to install an initial network of first 50 solar-powered refrigeration units. Due to a lack of technical know-how in the country, technicians from UNEPI reportedly went to Rome for training by PRAGMA, an Italian company that produces PV cells, and a team of Italian engineers travelled to Uganda to help with the first

[3] Personal Interview – Mr. Moses Murengezi

installations in 1987 [27] . It is relevant to note that the Italian Government had previously pledged almost $100 million to 26 African states (including Uganda), in support of the EPI program. It was reckoned that though the solar panels were expensive, it was cheap to run and needed little maintenance once installed.

With the initial success of solar-powered refrigerators, many more were imported/installed. Later on, solar pv products were also procured from BP Solar (Spain) by UNICEF. In addition to refrigeration, solar pv started to be used in the late 80s and 90s for lighting in the health centres (HC II and III) for operation theatre/maternity ward at night, and at a small-scale for water pumping and heating. Examples include a health unit equipped with a 1.6 kWp solar pump unit, another equipped with 10 lighting systems, and a PV pump of 1.5kWp [10] . The overall uptake rate of solar pv within the EPI program was limited i.e. approx. 4% in late 80s, 8-10% in the early 2000s, mainly due to high costs[4]. As of 2016, the share of solar-powered vaccine refrigerators is 20%, while the two other major sources are gas and electricity. Other barriers for solar include: i) product failures; ii) difficulty in getting spare parts, making it more expensive; and iii) thefts of solar panels from the health centers.

While the EPI program incidentally started using solar PV, the beginnings of the private sector foray into solar pv also was rather similar – incidental, based on the immediate need and circumstances. In the late 1980s, a former aircraft maintenance engineer with Kenya Airways, Henry Nganwa, returned back to his native Uganda, and founded Incafex Ranches Ltd., focusing on commercial farming and ranching. Around the same time, a German contact/friend in Uganda wanted to set up a farm-lab to conduct experiments on tick-control and tick-borne diseases on cattle. They set it up on the farm of Incafex, in central Uganda [41] . However, they required electricity for the lab, and a refrigerator. In late 80s, less than 5% of the country was electrified, which mainly included the capital city-Kampala. It was this specific need for alternative, micro, off-grid solution which prompted him to explore solar pv and import pv systems from Germany.

After two years, the colleague left, but Henry, having a knack for engineering, retained some of the solar contacts established by his friend and forayed peripherally into the solar pv business. The farm lab and use of solar pv generated a lot of curiosity among fellow farmers in the region. The first systems he imported were small kit-sized system comprising of a solar panel, battery and 2 light bulbs from Neste Advanced Power Systems (NAPS - Finland), with the help of a regional agent of NAPS-Kenya based in Nairobi. Other firms which ventured into solar include Magric (U) Ltd., Sun Trade and Consulting International (U) Ltd., Agip (U) Ltd., and Nairo Agro (solar drying)[5]. Little is known about them, with most having shut down their operations. Incafex, however, continued to engage with solar pv as a side project. It entered the market, when there was no market for solar. It could sustain initially mainly by securing contracts for government projects such as the immunization program, and they installed solar lighting systems in health centres, and schools. Later, he also imported invertors from Mastervolt (Netherlands). In the 90s, the focus was on cash sales of pv systems mainly to NGOs and government agencies and working as a contractor/partner to government projects. Representing Mastervolt in Uganda, Henry also attended an annual meeting of solar distributors in Netherlands in the 90s to connect with the larger network of distributors. The collaboration helped him develop contacts with equipment suppliers in Europe. and strengthened ties with Mastervolt, which led to a continued collaboration through the decade of 2000s [41] .

Other less documented initiatives of solar pv usage in the 80s include: i) installation of 35 KWp systems at 39 remote locations for telecommunications and signaling by the Uganda Railway Corporation, with support from the EU and Govt of France; ii) installation of 30 KWp systems at 35 remote telecommunication sites by Uganda Posts and Telecommunications, with funding from the World Bank. These initiatives were reportedly carried out independently with little information exchange or coordination with the local stakeholders [64] .
The period of 1980s for solar pv was mainly marked by independent small-scale explorations, incidental encounters, experiments, and only nascent beginnings of what would become a solar industry. The niche, however was not being shaped by niche actors with a deliberate focus on creating a protected space or by a strategic supply-based intervention. Instead, it was bottom-up, demand-driven with an effort to adapt to micro-solutions. In the early and mid-90s, the non-governmental organizations played an important role in spreading the use of solar in the rural

[4] Personal interview – Ms. Pamela Zanika, Technical Manager, UNEPI
[5] Based on personal interviews

sector along with an emerging private sector. Several parallel small-scale initiatives took place across different localized sites, some of which were not well-documented, but a few were.

One such initiative was by *Uganda Rural Development and Training* (URDT), a local NGO established in the 1987. URDT began as a small collective in mid-80s in Western Uganda by Dr. Mwalimu Musheshe[6], Silvana F. Veltkamp[7] and Ephrem Rutaboba[8], who were colleagues working in Uganda, with ties to the U.S., and a shared interest to transform rural development. They termed their endeavor as "the Uganda Project". Around that time, in a parallel world in the U.S, a group of scientists and strategists were developing the principles and concepts of creative leadership, systems thinking that can stimulate social change. These were Peter Senge[9], Robert Fritz[10], and Joel Yanowitz[11]. Peter Senge met Dr. Musheshe at an event in the U.S. and later joined him in developing the Uganda project [53] , and Silvana mobilized Robert to support them in using the creative process and structural dynamics in their project [15] , which soon transformed into URDT. It's interesting to note how such serendipitous encounters across different contexts/nations lead to new ideas. And through such cross-pollination of ideas, they developed programs to make the rural villagers more self-sufficient, creative and independent. URDT's motto was ""awakening the sleeping genius within each of us". They introduced appropriate "village technologies" for sustainable agriculture, such as organic farming, composting, mulching, and crop rotation [15] . URDT was a product of collective thoughtful creative process and involved long-term churning of ideas by actors across multiple spatial sites. It can be seen as a natural progression that URDT explored solar pv as an appropriate technology. They started by powering their facility with solar PV in Western Uganda in 1990, esp. for operating computers for trainings and educational programs. URDT offered school leavers training program in welding, building and also solar installation [10] . Around that time, other NGOs such as World Vision and Concern International (in central Uganda) were also using PV systems as part of their project activities.

After gaining experience, URDT embarked on a solar lending program in 1995, with support from a Dutch NGO HIVOS and a loan from Dutch Bank Triodos, through a contact Dr. Musheshe had established. URDT played an intermediary role between the bank and the end-users. Within two years, 130 systems were reportedly installed, of which 30 systems of 51 Wp (with four fluorescent lights of 8 watts each for $1300) and 100 Minikit Naps 22Wp (with 2-8 watt lights with a small DC-DC converter for $300) [10] . Through this cross-subsidy scheme, large system buyers subsidized the small system buyers. Loan repayment was spread over 6-24 months but the repayment rate (~70%) was lower than anticipated. HIVOS and another Dutch-based foundation provided technical assistance by training select locals to install and service the systems, and train the end-users in maintaining their systems [10] . In addition, URDT had also sent 4 staff members to be trained in Tanzania and also Kenya from Mark Hankins (ASD)[12]. URDT's and Dr. Musheshe's vision of strengthening the grassroots got him international partners and acclaim. The assistance in the form of capital (loan), knowledge (technical assistance) helped the project to achieve its outcomes. URDT developed long-term partnerships with the Triodos Foundation and the Bank. The project received start-up capital, training and skills through transnational ties.

In western Uganda (not too far from URDT), a U.S. based NGO, *Habitat for Humanity* helped 1500 residents finance and build durable homes. They worked in conjunction with *Solar Electric Light Fund*, another U.S. based non-profit organization. Habitat for Humanity made loans available for new homeowners to purchase solar PV systems. 100 systems were installed between September 1995 and November 1996. 32Wp 3 light systems were 50% subsidized by the US Department of Energy bringing the local cost down to $400 [10] . The home loans were to be

[6] He is a veteran social entrepreneur, leader, and an Ashoka fellow. His native country is Uganda. He obtained MSc and PhD degrees in Development and Environmental Management from Maine, US

[7] She is an American, raised in Italy, went on to work with the UN FAO in Rome and Beirut, and co-founded the Africa Food and Peace Foundation, which informed the Uganda Food and Peace Project.

[8] A civil engineer and a social entrepreneur. His native country is Uganda.

[9] Peter Senge is an American systems scientist, a senior lecturer at MIT, and an author of several books including *The Fifth Discipline: The Art and Practice of the Learning Organization*.

[10] Robert Fritz is an American author, and management consultant. He is known for development of structural dynamics, the study of how structural relationships impact behavior from individuals to organizations.

[11] Joel is a co-founder and vice president of Innovation Associates, also a former Board Member and a long-term partner of URDT

[12] Email communication with Dr. Musheshe

financed over a three-year period. Seemingly, the demand proved to be high for the solar systems and many homeowners accelerated their payment schedule to qualify for a PV loan. The loan repayment rates were however disappointing. It was reported that many of the PV systems were installed in remote locations difficult to access for loan officers[10] . And a number of PV owners also declined to pay for systems that have not worked properly or at all for some time. The NGOs adopted a coupled approach targeting low-income families for affordable housing and electricity. But despite availability of capital and technology, it was only a partly successful project, as the NGOs did not account for maintenance/repairs of the systems, neither did they pass on the knowledge to the end-users.

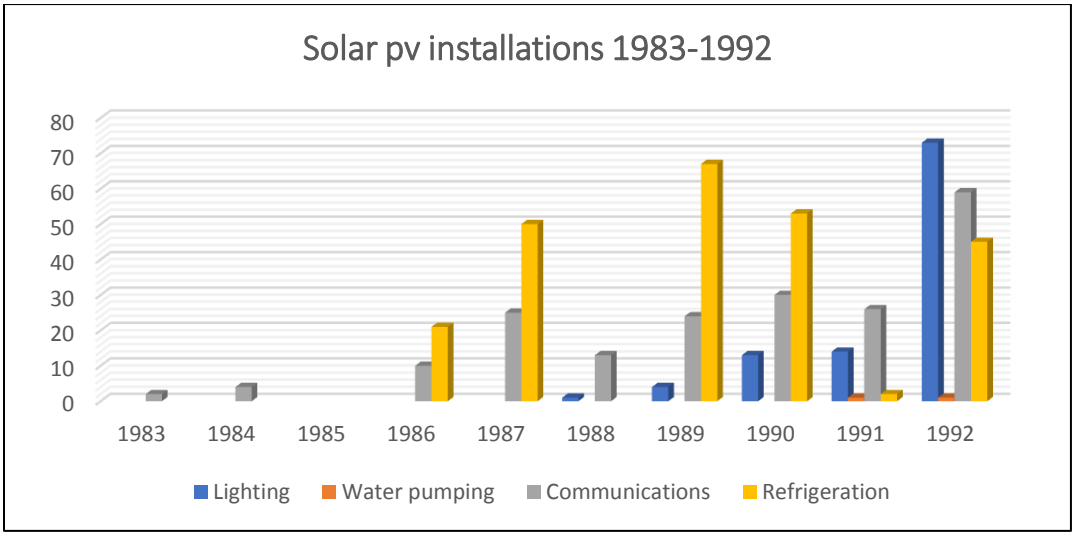
While a number of initiatives were driven by NGOs in the early to mid-90s, the number of private sector firms selling and installing PV systems in Uganda rose to nine (9). The PV suppliers include: Solar Energy for Africa (SEFA), Magric (U) Ltd., Sun Trade and Consulting International Co. Ltd., Incafex Solar, Agip (U) Ltd., Energie System Technik, Afro-Kai, Wilken Telecommunications Ltd. and Entech (Africa) Ltd. Most of these were small enterprises with sales averaging 0.5-3 KWp/year [7] . Many of these were involved with the sale of agricultural equipment and saw PV as a related technology for which the market may expand. Others were traders marketing a range of commercial products, selling PV systems as off-the-shelf items similar to kerosene lanterns and transistor radios. However, only one of the firms exclusively dealt with solar pv, the first solar pv firm in Uganda.

Solar Energy for Africa (SEFA) was founded by John Ssemanda, a U.S.-based Ugandan[13]. SEFA-USA led to regional subsidiaries in Tanzania, Rwanda, DR Congo, Burundi and also Uganda in 1994. After having spent 20 years in the US, John was reportedly dismayed by the situation in Uganda, and esp. the lack of electrification. Along with 3 other colleagues, SEFA in Uganda started off its operations. All the 4 team members undertook trainings in solar energy technology in the US. John continued to be based in the US, with frequent visits to East Africa[14]. SEFA partnered with NGOs to implement solar pv projects. One of the first projects they implemented was in partnership with Habitat for Humanity in which 100 homes were electrified in the village of Kasese [52] . In 1994, SEFA installed PV lighting in 3 hotels on the Kalangala island of Lake Victoria[15]. John was engaged with marketing and tapped into many high-profile networks in Uganda. The next project reportedly came through Gen. Salem Saleh, brother of President Museveni, for installation of solar systems in the health centres[16]. Soon, the word spread and SEFA got a project through the Member of Parliament in Western Uganda who wanted to electrify schools and villages in his constituency. SEFA partnered with Solar Light for Africa (SLA), U.S. based non-profit organization, founded in the late 90s by Bishop Hathaway with the initial purpose of providing light to an orphanage in Hoima, Uganda. Bishop's idea was to build a partnership between Ugandan and U.S. churches to promote the role of the church in helping the Ugandans access energy [67] . The idea grew beyond just lighting churches but also bringing light to the rural communities, literally and metaphorically. The model was that 50% of the financing of the solar system was covered by SLA, and the remaining 50% was borne by the end-users. Bishop's son Hathaway Jr. was an electrical engineer and provided technical support and also partnered with John, SEFA. President Museveni's wife became the patron for SLA and supported the cause. While being rooted in the diaspora network, John mobilized resources through national and transnational ties and partnerships.

In the late 90s, several Chinese investors/products started to penetrate into the solar market[17]. These include solar panels, solar pico, solar lamps, home systems and were responsible for bringing the prices relatively low. Before 2000, the cheapest SHS available in the market was a Chinese plug and play 4 W which could be purchased for around 100$. A 20 W SHS could be purchased for around US $350 and one 100 W could vary from $1000 to $1500 [7] . The manufacturers include: Mastervolt (Netherlands), Trace (Spanish), Sundaya (Indonesia/China), Labcraft (UK), Triple Junction, Morningstar (US), Solarex (US) etc. In this way, the first decade (mid-80s to mid-90s) of the solar pv technology diffusion and market adoption had begun. A number of transnational actors (NGOs, Church - identified as non-profit organizations in our typology), national actors with transnational ties (social entrepreneurs,

[13] John Ssemanda received his Master's degree in Theology in 1977 and a second Master's in Social and Economic Anthropology in 1979, both from the U.S. From 1980 to 1992, he was in Washington D.C. where he was a successful entrepreneur and owned several small grocery and liquor stores.
[14] Although we couldn't personally interview John, we could however interview his colleague, Joseph, who is currently the Technical Manager at SEFA.
[15] Interview with Founder of the Sesse Beach Hotel, Lake Victoria
[16] Interview with the Technical Manager of Solar Energy for Africa
[17] ibid

private firms) played a critical role in using solar pv. This phase of solar PV evolved in a non-linear, organic way, through need-based interventions, unlike a deliberate effort to promote solar PV, which we observe more towards the latter part, and much more in the next phase of development. To translate the progress in terms of numbers, we refer to a survey conducted by the Division of New and Renewable Source of Energy /Ministry of Energy in 1993 for the African Energy Program. As depicted in the figure below, they reveal that there was a total of 538 pv installations between 1983 and 1992, of which refrigeration and communications were among the main applications with 238 and 193 systems respectively, followed by 105 units for lighting [63] . Another report [64] cites the figure to be approximately 1500 PV installations by 1997, and yet another quotes 3000 PV systems installed by 1999 [10] .



Source: Division of NRSE, Department of Energy, Ministry of Natural Resources

4.2. Phase II (1997-2008): Gaining Momentum / Commercialization of PV

Unlike the previous phase, deliberate planned solar pv programs were initiated in this phase. There was an increased momentum and a greater supply-push from stakeholders. The commercial-scale pv operations gained traction and a number of new transnational actors entered the market esp. development aid agencies, private firms and non-profit organizations. This period was also the beginning of a new privatized era for the electricity sector and promoting private sector investments for rural electrification was of high priority. The emphasis was on rural electrification because in 1990s nearly 90% of the total population in Uganda was rural.

In 1993, the Govt. of Uganda (GoU) with support from the World Bank (WB) undertook major reforms that led to divesture of many public enterprises. This led to the power sector reforms[18] i.e. unbundling of the monopoly electricity board in Uganda, privatization and liberalization of the electricity sector [37] , and strengthening of the regulatory framework, which formed the basis for the Electricity Act, 1999. It is important to understand the process that led to the reforms, and the role played by transnational actors (esp. development banks). In the 90s, several study teams from the WB had visited Uganda - energy sector assessment mission in 1994, review of the renewable energy sector in 1995, and energy sector management assistance program (ESMAP) mission to develop the sector strategy in 1996 (supported by development aid agencies and UNDP) [11] , and another mission in 1998 for implementing the Africa Rural and Renewable Energy Initiative (AFFREI). AFFREI aimed to achieve rural electrification through private sector - as part of which a decade-long program was shaped - Energy for Rural Transformation (ERT). Based on these studies, WB contributed to the Electricity Bill in support of private investments. In addition to WB, the Norwegian Govt. and the Norwegian Agency for Development Cooperation

[18] The power sector reforms were promoted by the World Bank and the IMF, and were based on the earlier successes of the privatized electricity sectors of Chile, Argentina, UK, Wales and Norway

(NORAD) provided grants (5.6 million NOK) [9] and played a significant role in institutional restructuring, establishing the de-regulated energy sector, and preparing the Energy Act. Japan International Cooperation Agency (JICA) carried out a design study on the rural electrification project in response to the request made by the Govt. of Uganda. WB, NORAD, UNDP, JICA, among many other such "landscape actors", restructured the electricity regime, with support from the national government. A number of individual actors within these organizations were responsible for interpreting and practically implementing the tenets of privatization and liberalization. However, many of these landscape actors were also niche actors in terms of mobilizing financial resources, knowledge and technology for specific programs, which is elaborated in the following section.

Ministry of Natural Resources (which was later Ministry of Energy and Mineral Development-MEMD) embarked on a pilot project in June 1998, the Uganda Photovoltaic Pilot Project for Rural Electrification (UPPPRE), with an objective to promote use of solar PV for rural electrification through the private sector. UPPPRE was a precursor to the ERT project, and a number of transnational actors 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 areas which will not be accessed by the national electric grid. The project was selected for funding by Global Environment Facility (GEF), a partnership of governments, implementing agencies and civil society organizations. UNDP is one of the implementing agencies of GEF.

The project was to the tune of 1.8 million US$ for technical assistance, and it received an additional 500,000$ from UNDP for PV credit fund and guarantee facility. The project targeted electrifying 2000 households and several community/institutional facilities. Its objective was to overcome the financial, social, and institutional barriers that existed to the dissemination of the technology in Uganda. At the end of 2002, 2389 PV systems were installed [60] . The project established two levels of financing-vendor financing and consumer financing (involving 1 commercial bank and 6 village banks). The six solar PV companies benefitted most from this program include: SEFA, Energy Systems Ltd., Uga Solar Ltd., Lwanga Electrical, Uganda Electronics and Incafex. The project trained technicians for system installations, maintenance and conducted awareness campaigns. The project also collaborated with NGOs at the district level for dissemination through seminars. About 30 seminars were held and 800 people participated in 6 districts. These efforts were augmented by advertisements in newspapers, and various radio advertisements and talk shows etc. This resulted in a flow of enquiries at project offices and the private sector renewable energy association registered more than 1000 enquiries in 2002. The project also led to capacity building within the MEMD - two technical members of staff were initially seconded to the project, a third member was added later, and a credit monitoring officer was also hired. The project also trained 5 students from the Faculty of Technology at Makerere University. This also led to a cooperation program between Makerere and Florida Solar Energy Centre, USA to train students from Makerere with a Distance Learning Centre [9] .

UNDP engaged international consultants including CTA (Technical Centre for Agriculture and Rural Cooperation, an international institution) for selecting cooperative banks, and for training and capacity building of the stakeholders involved. UPPPRE was the first government project to initiate deliberate planned efforts to promote the use of solar PV. It mobilized private actors from the beginning and helped them establish an industry representative and a self-sustaining body in the Uganda Renewable Energy Association (UREA). The project also provided financial resources to UREA (pre-dominantly comprised of solar firms) for networking, sensitization, and training.

Despite a number of successes, the project suffered from delays, financial mismanagement, and lack of capacity with the project management unit etc. Early on into the project, there were differences of opinion among the partners, including the payback period of PV loan by end-users. MEMD suggested a period of 2 years, whereas the development partners suggested less than 6 months. This was followed by a period of struggle and negotiation. Subsequently a longer payback period was opted. This payment system allowed flexibility and inclusion of even those households engaged with seasonal activities (such as fishing, agriculture), without a steady income source[19]. While the project was steered by MEMD, the actors were not only local, but also comprised of development partners, consultants, and university.

[19] Interview with Former Commissioner, Ministry of Energy and Mineral Development

This project was the beginning to a long-term ERT program, the first phase of which commenced on July, 2002. Around the same time, a semi-autonomous body- Rural Electrification Authority (REA) was formed to manage the rural electrification fund. ERT was a multi-sectoral collaborative project, with a mission to improve energy access. For the energy component, MEMD and REA were responsible for implementation, with support from WB and Private Sector Foundation Unit (PSFU). Regarding solar pv, the target outcomes of ERT Phase I were: i) increased sales of solar pv household and institutional systems (health centers, schools etc.); and ii) price reduction in solar PV market, improvements in quality. Standard solar pv packages were developed/designed for various sizes medical buildings and staff houses for Health Centre (HC). 8 HC IV, 68 HC III, and 79 HC II received solar pv systems. Nearly 220 medical buildings and 261 staff houses were equipped with solar pv lighting. A grant of $65000 was provided to the Uganda National Bureau of Standards (UNBS) to adopt and gazette solar pv standards. Approximately $1,100,000 was provided to 20 solar vendors to operate system dealerships [38] . In addition, technical assistance was provided by WB to train 300 solar technicians. The mechanism was designed to be purely commercial, with PV companies undertaking installation, sale and marketing of the systems. The Private Sector Foundation Uganda (PSFU) through the Business Development Scheme provided business support and sales-based performance grants to PV firms. This strategy for solar pv market development was based solely on the assumption that given appropriate grants, private firms would accelerate market growth and realize ERT targets [49] . This was in line with the privatization/liberalization ideals motivating the transnational actors and shaping the larger narrative for these programs.

However, the private sector penetration remained low during this period, and several PV firms focused instead on the urban markets, based in Kampala. Further, the initial phase of ERT was characterized by "uncoordinated and unclear operations and incoherent guidelines from WB" and there was a lack of unified authority, instead a constant flow of consultants over short time periods [38] . ERT-I also suffered delays due to several reasons including disagreements between WB and REA with regard to: i) the delivery models (PV credit financing); and ii) solar PV design packages. In case of latter, WB and team wanted to determine the final design which the government teams (esp. MoH) contested as not being suitable for all the health centers. This issue remained unresolved for nearly two years during which the MoH failed to undertake its tasks [49] . Further, grant money often comes with conditions such as elaborate reporting requirements, extensive paperwork/records, which occupied MEMD staff. The contestations between MEMD and WB/UNDP in case of UPPPRE and ERT programs signify ideological and intellectual struggles. In both cases, the transnational actors privileged their knowledge and agency over and above govt.'s insights on the local context and requirements, leading to delayed outcomes.

Other barriers for uptake of solar PV included: i) high interest rates charged by MFIs (2.5-4%) discouraging credit-based schemes; ii) low awareness on solar pv usage and suspicion about products; iii) high credit risks and lack of re-sale value; iv) thefts of solar panels; v) lack of institutional framework and market system; and v) poor quality and reputation of PV systems. The project ended in 2009 and based on its shortcomings, key points were noted to be incorporated in the ERT Phase II program including subsidy to the end-user, guarantees to FIs, and sensitization.

While the government and the development partners were engaged with long-term rural electrification programs, the number of private players in the solar market were steadily on the rise. There were three distinct categories of firms operating in the market: i) distributors – they are typically foreign firms representing either specific manufacturers or a range of manufacturers from Europe, China, US etc.; ii) system integrators – they form a majority of the local solar companies in Uganda combining trade with small importers. The bulk of their products are procured from locally-based distributors in Kampala and target large system installations; and iii) dealers and installers – they are rural based but loosely connected to the firms in the city [30] . Their biggest target market is the stand-alone solar systems (Pico and SHS). By this period, at least 30 key private players were operating in the market, majority of which were system integrators and dealers. In addition, a number of small-scale traders, local shops with over-the-counter sales, independent distributors scattered country-wide were also responsible for significant PV penetration. The market was "in a state of transition where different players were yet to find their optimum servicing levels within the market" [30] . More importantly, some firms had started to carve their niche by partnering with specific manufacturers, and/or by focusing on specific areas of solar market.

In 1999, Ultra Tec Ltd. was established by an Indian-Ugandan family-Abhay and Rita Shah, which went onto become a major supplier of SolarHart water heaters (S.W.Hart and Co Ltd. of Australia) in Uganda[20]. Shah had previously worked as the Manager Solar in Wilkens Telecom Uganda, which was the only agent for distributing SolarHart water heaters in Uganda, when it first started its solar operations in 1992-93. UltraTec also represented Outback (USA) for invertors/chargers as the sole distributor in East and Central Africa. They mainly specialize in installation, maintenance and design of rooftop PV systems, solar water heating systems, backup systems etc. UltraTec also conducts power analysis/energy audits for industries to improve their energy usage and efficiency. Their clientele at present comprises of commercial establishments such as industries, hotels etc. in urban areas such as Kampala. However, in the early 2000s, they sold institutional systems and household solar systems through a diverse distribution network including partnerships with international NGOs, development aid agencies (GIZ), micro-finance institutions (MFIs), credit cooperative groups at village-level (SACCOs), and local distributors[21].

Abhay Shah is considered a veteran in the solar industry in Uganda, and UltraTec has enjoyed the reputation of being a technically competent and a reliable firm. The high competition in the solar market in the late 2000s however compelled several firms, including UltraTec, to consolidate, re-strategize and even downsize. Another expert in the solar industry, Abdeel Kyezira, joined the Konserve Consult Ltd. when it was founded in 2002, after working for several years in Nairobi with the African Solar Designs (ASD). Konserve is a renewable energy company and provides consultancy/advisory services. Kyezira has been instrumental in mobilizing the solar industry voice as a co-founder of UREA in the early 2000s and as the Chairman of Uganda Solar Energy Association (USEA) later in the 2010s[22]. These private firms recognized and took advantage of the increased demand for solar PV in the urban areas, unlike the government programs. This is likely due to higher affordability among the users, a greater need for electricity, and the inconsistency of grid power. While the firms operated commercially, there was a continued reliance on grant funds/projects (such as The Shell Foundation and GIZ) and transnational partnerships.

However, during this period, the Govt. (regime actor) applied import duties and sales taxes sporadically. Prior to 1992, taxes on imported PV systems were at 58%. In 1992, they were removed but reinstated in 1992-93 at 32%. They were eliminated again during 1994-95. In 1996, the govt established a nation-wide VAT of 17% on the sale of all goods and services[23]. In 2000, the solar panels and SHS were tax free except for VAT. However, batteries, DC-lamps, and other components bought separately were still required to pay duties and taxes [7] .

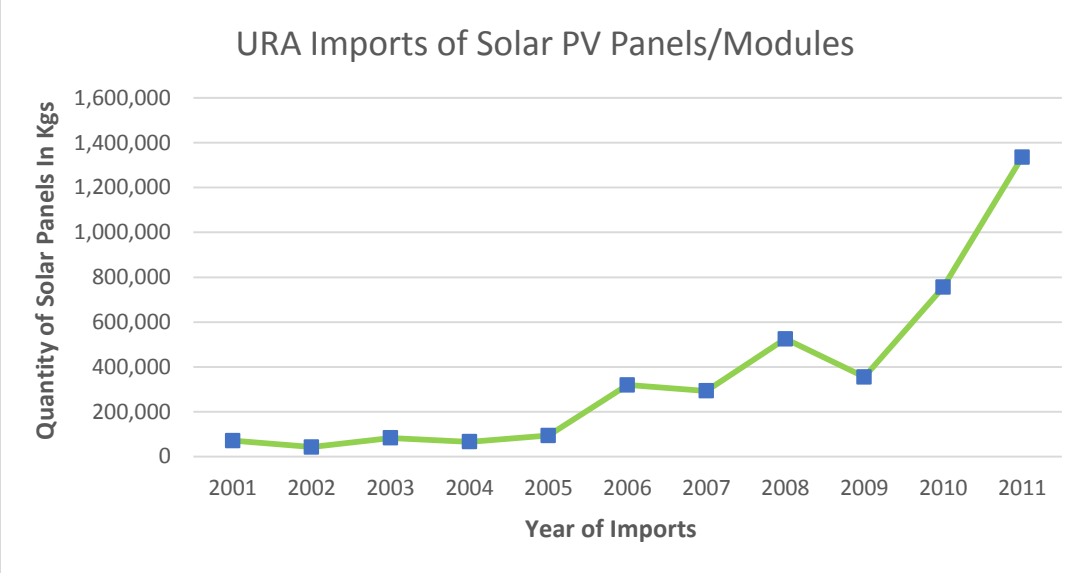
In 2007, rural energy foundation (REF), a Dutch non-profit organization, started their *SolarNow program* in Uganda. REF specializes in establishing and building capacity of retailer networks at the lower end of the supply chain for affordable renewable energy solutions. It recognized the critical role played by the local solar entrepreneurs in making PV accessible in 9 countries in SSA. REF has been grant funded by 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 skills, and helps them start-up and expand local business. Entrepreneurs completing the training, sign an agreement with REF and develop solar business using the `SolarNow´ brand[24]. The SHS promoted by REF use PV modules from 11 to 50 Wp rating. The SolarNow retailers used to sell 11-20 Wp SHS for about $250-440, and a 21-50 Wp SHS for $360-630. The end-users pay the full price as upfront cash mostly. Alternatively, REF encourages MFIs to make finance available for the end-users. In 2010, as part of a pilot project in which 4 MFIs are taking part, REF guaranteed 50% of the customer/retailer loans, which lowered the upfront costs and the users/retailers subsequently repaid within the timeline of 12-24 months. REF imports the solar products from China, US, and Europe, and these are assembled and installed by local technicians.

Unlike the earlier interventions of non-profit organizations, REF focused on the lower end of the solar pv chain, i.e. local businesses, technicians and retailers in order to penetrate deeper into rural Uganda. In addition, specific attention was paid not only to provide warranty on PV products but also on after sales services via a service contract with the end-users. REF initiated large-scale country-wide marketing campaigns to raise awareness of solar

[20] Interview with Abdeel Kyezira
[21] Interview with Idit, Marketing Manager, UltraTec
[22] Interview with Abdeel Kyezira
[23] UPPPRE Project Document, 1997
[24] https://www.ashden.org/winners/rural-energy-foundation-now-solar-now#continue

products, and also widely publicized the ´SolarNow´ brand, including all retail shops selling products using the brand. Between 2007 and 2010, SolarNow sold over 57000 solar home systems and 36000 solar lanterns. It was one of the most successful large-scale solar programs with a unique approach, which also managed to penetrate deeper into the rural areas, driven by transnational actors.

To translate the progress into numbers for this phase, the figure below portrays the data collated by Uganda Revenue Authority (URA) for imports of solar panels from 2001 to 2011. URA records the total weight of panels imported instead of units. This indicates that Phase II witnessed a relatively stable yet slow growth, especially when viewed in comparison to Phase III. However, during Phase II, only SolarNow program alone sold up to 93000 solar units (including SHS and Pico), unlike Phase I with approx. 1000 installations. Therefore, significant progress was witnessed in Phase II.



Quantity of solar panels imported by Uganda between 2001-11 (URA customs, January 2014)

4.3. Phase III (2009-2017): Taking Off / Upscaling

In this period, the solar PV market matured and became commercially viable for the private sector to thrive. The total number of private players in one study were reported to be nearly 85 [29] , whereas nearly 75 firms were registered members of the private sector solar association[25]. However, this doesn't include a number of small-scale traders, dealers, independent distributors, local retailers etc. which may indicate of number of nearly 300 or more[26]. As a result, the maximum uptake and use of solar PV can be witnessed in this period. The private players, esp. foreign firms capture relatively large shares of the market. The market gets further fragmented and the three distinct categories described in the previous phase do not hold entirely. Firms that are distributors representing specific manufacturers, diversify and import from a range of manufacturers, and some also develop customized designs but manufacture them through a third-party in China, some of the system integrators are also distributors, so on and so forth. In addition, a number of manufacturers operate in Uganda selling their products through kiosks, shops, NGOs, these include: Greenlight Planet, d.light, Sunking, Barefoot Power etc. Further, there is an increased mobilization and consolidation of several organizational actors, and joint advocacy for a bigger industry voice[27]. Different partnerships are forged, and networks formed. The number of initiatives multiply in this period.

[25] Interview with USEA Secretary, Robinah
[26] Interview with Abdeel Kyezira, Chairman UNREEEA and MD, Konserve Consult Ltd.
[27] USEA Stakeholder Meeting in collaboration with GOGLA to deliberate on the tax policy on solar products in Uganda and EAC, October 2016

In continuation to the 6-years long ERT Phase I program, Phase II was initiated in 2009 to develop the institutional framework and capacity for delivery of rural/renewable energy services in a sustainable way. ERT II included components of both grid extensions as well as off-grid (for households and institutional PV). The PV sub-component was to be implemented by REA through the PV Targeted Market Approach (PVTMA) which included provisions for consumer subsidies/credit to stimulate demand and incentives to suppliers and FIs, and the target was 20,000 PV connections by 2013. This was designed/proposed by MEMD and REA, based on the experiences of ERT I and UPPPRE. REA supported the firms in establishing a fee-for-service business model. For this, a combination of International Development Association (IDA, WB Group) and GEF funds[28] were used to co-finance sales to households and NGOs. The subsidy program for PVTMA entailed that when a system was installed, 100 meters or more from the closest low voltage line, the system was eligible for $4 per watt peak, upto a 500-watt peak system for commercial and institutional uses. For home systems, the subsidy was $5.5/Wp, up to a max of a 50Wp system [46] . For this, REA eligible solar pv enterprises (REES) were selected through an open bidding process. The consumer subsidy was channeled through FIs for transparency. The subsidy was paid per installation and was disbursed to the solar PV company after installation/sales. Nearly 20 solar PV companies participated in the PVTMA program. End-user audits for the program were conducted by external auditors to approve payment of consumer subsidies. The auditors were competent individuals contracted on call basis by REA.

However, the subsidy program was not entirely effective. It was witnessed that many PV providers did not pass on subsidies to end-users, suggesting that the customers could afford the systems at the market rate. This might mean that the program didn't reach the bottom of the pyramid customers, who cannot afford the system without a subsidy. Further, random checks conducted by an internal audit team of REA identified several discrepancies between the external auditor's report in 2014 and their observations on ground – in some cases, the systems and the users couldn't be located, and in some there were inconsistencies with the watt peak reporting, the size of system[29]. The program was stalled for some time. In the financial assessment of REA's ERT program in December 2015, the Auditor General of Uganda highlighted the malpractices in the implementation of the solar subsidy program including mis-reporting, and double billing [40] . Some solar companies invoiced REA for home systems at a rate apt for commercial systems, some claimed for non-existent installations, and some invoiced solar systems that were donated by NGOs. In addition, many users paid for after-sales services even during the warranty period. The external auditors supposedly connived with the private companies. The program also failed short of meeting its target, it had only 14000 connections by 2014[30]. The program ended in 2016, giving way to ERT Phase III. The Phase II involved less direct intervention by transnational actors, except for financial support from WB and GEF. The program was shaped and implemented by REA, with support from MEMD, and a number of other local actors (private firms, FIs, NGOs, users etc.), and led to a model case of lax bureaucracy, complicated project designs, corruption, and where vested interests of some, deranged the entire program from meeting its goals.

While the govt. programs gradually progressed, the solar market grew rapidly with new generation market players – SolarNow, Fenix Int., M-Kopa, Village Power, Azuri Tech etc. and new business models based on pay-as-you-go (PAYG) technology, overtaking the local Ugandan companies and forcing strict competition. Based on its success, the SolarNow program (discussed in Phase II) was transformed from a non-profit foundation to a commercial for-profit entity selling solar systems to SMEs and households in East Africa. SolarNow, was established in Uganda in 2011, led by Willem Nolens (former Managing Director of REF), a Dutch entrepreneur with a vast experience in microfinance and renewables in SSA. They had established a network of local dealers, retailers, technicians across the country through their program, which they continued to work with as a private company. In 2012, the firm decided to buy out the dealers as franchises. In 2013, the franchises were bought and turned into SolarNow local branches with permanent employees, taking control over the entire supply chain[31]. As of 2017, SolarNow has 47 branches and 650 permanent staff, of which 550 staff are engaged with sales and marketing (revenue generation)[32].

[28] PVTMA Operational Guidelines, 2010, MEMD, Uganda
[29] Interview with Joan, ERT Manager, REA
[30] ERT Project Summer, 2014, p.32, MEMD, Uganda
[31] Interview with Douglas Dullo, Sales Head- Uganda, SolarNow
[32] ibid

SolarNow operates in the large systems segment i.e. 50W to 250W size, and targets relatively high-income users in rural areas i.e. entrepreneurs, small businesses and the commercial farmers.

A venture-backed renewable energy company, Fenix International, based in San Francisco CA entered Uganda in 2011, with expertise in power electronics, product design and base-of-the-pyramid marketing. They initially partnered with MTN Uganda (telecom/airtime stores), to sell solar systems of 10W to 17W size for phone charging and lighting. This was based on upfront cash model. In 2013, Fenix developed technologies for offering finance/credit and in 2014, launched its commercial-scale ReadyPay products[33]. ReadyPay Solar is a mobile pay-enabled solar panel and smart battery system, based on a lease-to-own model. The ReadyPay, developed by an in-house team based in Silicon Valley SF, 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[34]. ReadyPay enables users to make flexible payments (instead of full upfront cost towards the system) to charge their phones and lights, radios and TVs.

Around that time, other such payment platforms had become available such as by M-Kopa, which had established itself as the world's largest pay-as-you-go company based in Nairobi, Kenya, which entered the solar market in Uganda in mid-2013. And as of 2016, M-Kopa has sold over 70,000 systems to households in Uganda. The innovation in Fenix's payment system is in its lock-out technology i.e. if users fail to pay, the system automatically locks out. Fenix has also developed a unique credit-scoring system for each of their users. As of 2017, Fenix has connected over 100,000 users through their systems. Unlike SolarNow, Fenix deals with relatively small size systems 10W to 34W, targeting low-income rural users. Among the other new entrants based on pay-go systems include Village Power and Azuri Technologies. Azuri is headquartered in the UK and has a presence in 5 countries (including Uganda) in SSA. The users pay a small one-off installation fee for their system and get integrated mobile money service to top-up their unit through codes received via text message. Village Power (VP), headquartered in Switzerland, is led by Thomas Huth, who has been engaged with supporting and founding start-ups for over a decade. VP began its operations in Uganda in 2014, and later expanded to several branch offices country-wide (12 branches) with support from EnDev Program of GIZ. VP offers a range of solar home systems, from 10W to 1000W output power and 10Wp to 400Wp solar panels. As of 2016, VP has provided energy service to 50,000 customers[35]. In this phase, the sales of just 4 large solar firms in Uganda had totaled 250,000 units.

These are the new generation firms with a vision to provide quality electricity good/service and also offer coupled finance/credit services to their users. They offer flexible payment systems through mobile pay-platforms (PAYG) with financing periods between 6 and 36 months, and some also have cloud-based distribution management system allowing firms to monitor real-time customer status/energy usage data. They have dedicated personnel engaged with training staff through customized in-house training programs, and academies. The trainings include: i) know-how about products; ii) marketing and brand promotion skills; iii) installation, maintenance and repair skills; iv) general trainings on HR, Accounts etc. In terms of distribution strategy, while SolarNow, Fenix and VP operate through physical branches and permanent sales staff, others such as M-Kopa, Azuri Tech mainly operate through local partners, entrepreneurs, distributors, and sales agents.[36] The distribution branches are located predominantly in high-density areas i.e. Central Uganda (the capital city Kampala is located), with few service centres in Eastern and Northern regions. Fenix also has a dedicated call center team based in Kampala, with staff speaking in 28 languages to provide after-sales services, attend to customer queries, and promote their brand. 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 (from ElectriFI and TRINE for Azuri Technologies, from CDC, Stanbic, FMO for M-Kopa), series B financing/crowdfunding (from Novastar Ventures and Shell Technology Ventures for SolarNow, from GDF Suez and Scheider Electric for Fenix Intl), second structured asset financing/SAFI (from SunFunder for SolarNow), 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

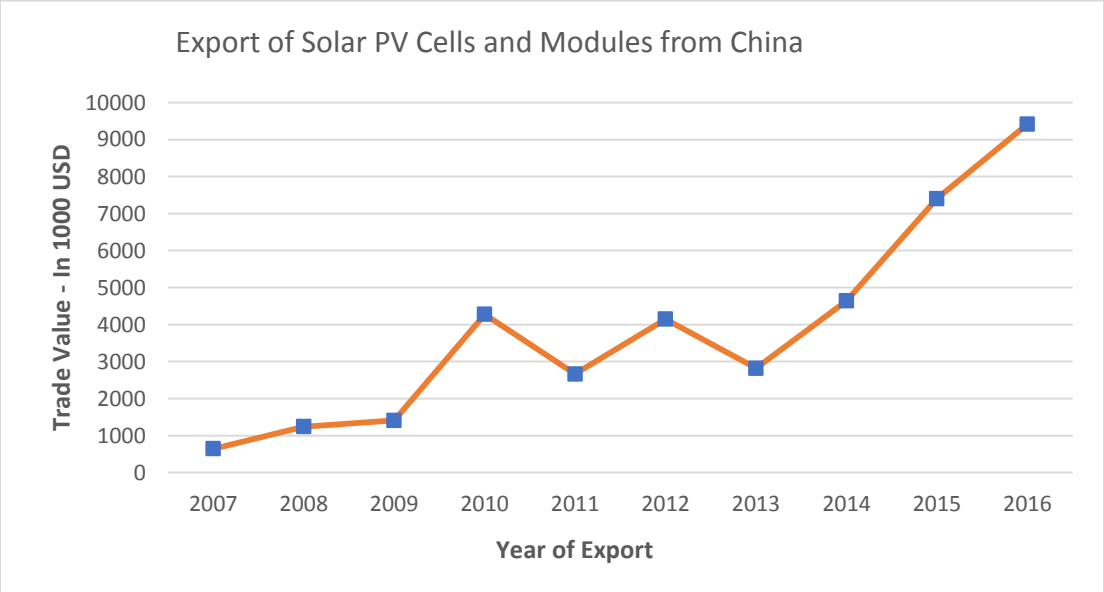
[33] Interview with Christopher Emmott, Product Manager, Fenix International
[34] www.fenixintl.com
[35] www.village-power.africa.com
[36] Interview with Lilian Country Head, Village Power

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 [21] .

A range of such transnational organizational actors including private firms, venture capital firms, development banks, and commercial banks have played a critical role in mobilizing technology, financial resources and skills. While these are among the largest firms operating in the solar market, a number of other relatively small scale local Ugandan firms (such as Solar Energy Uganda, All in Trade) have also been operating with traditional business models and limited access to financial resources. Firms such as Barefoot Power (Australian origins) have also operated through traditional means by engaging with local NGOs, CBOs, SACCOs, church associations, and local government bodies. This was witnessed through their Light Up A Village program initiated in Uganda in 2012, which aimed to improve energy access through Pico PV market penetration, and with the help of a revolving fund managed locally. The implementing agencies for this include: WWF-Uganda, Caritas Uganda, UNICEF and Coca Cola Ltd. The system installations and trainings were undertaken by Barefoot Power, whereas the local partners were responsible for mobilizing the users and local financial institutions. This model is heavily reliant on partnerships with local institutions and communities, along with national and transnational actors. During the 18-month trial period (2012-13) in Uganda, LUAV provided lighting and mobile charging services to over 3000 households. Subsequently, this was replicated in South Sudan, Rwanda and Kenya in 2014.

While Phase III of solar PV development was mainly private-sector driven, a number of initiatives by development aid agencies, and international non-profit organizations/foundations, are being implemented, many of which in collaboration with the private sector. Energizing Development (EnDev) is an energy access partnership, co-financed by EU. In Uganda, the project supported 11 solar firms since 2009 in the dissemination and Pico PV for households, institutions and SMEs. EnDev supported the firms in implementing end-user financing schemes, establishment of decentralized sales points, and implementation of awareness campaigns. Through the private firms, EnDev provided energy for lighting/electrical appliances to 157,800 users, 1100 institutions and 1600 small business [19] . The total budget was €12,250,000 and this includes off-grid access, grid-extensions and cookstoves.

In terms of the progress during Phase III, the figure below depicts the Chinese exports of solar PV cells and modules to Uganda during 2007-2016. There is a significant climb in the latter half. This is only a part of the trade in solar products, as a number of products are also imported from Europe, USA, India etc. Further, a number of solar Pico products also arrive through illegal trade routes which do not get accounted in the official figures.



5. Discussion

As noted earlier, the paper provides a history of how solar pv market has evolved in Uganda through different stages, the key actors that have dominated the terrain, their motivations and strategies, and the outcomes of various initiatives. The transnational actors and resources flows undoubtedly played a significant and pertinent part in reshaping contexts, building domestic capabilities, sharing technical know-how and in the overall solar pv transition, as illustrated through multiple projects/programs/alliances. The transnational actors are diverse, representing multiple nations, contexts, interests, values, and political paradigms. In addition, a number of national actors particularly in the mid-late 80s and early 90s benefitted immensely through transnational ties (formal and informal), and resources. In addition to doing justice to the representation of transnational actors and resource flows, our paper indicates a number of other findings, discussed in this section.

In agreement with some of the recent works [2] , our study indicates that niche is not necessarily only associated with a local scale, and this transition to solar energy is a regional East African phenomenon, although we chose to focus on only one of the countries for in-depth insights. However, a number of other studies capture the transition processes and market developments in Kenya and Tanzania [5; 26; 45] . Several inter-governmental organizations, development aid agencies, development banks, NGOs etc. are operating in the solar PV market space across the East African region, with a set of distinct and overlapping agendas. Hence, the solar transition comprises of multi-actor processes and many of them are operating through a shared network of ideas and values. Further, individual actors across organizations (UN, USAID, GIZ etc.) work on a contract-basis and engage with these countries over a period of 3 to 5 years, they gather unique lessons across different contexts. While it is relatively easy to identify the organizational actors, the drivers and the flow of resources, however it is difficult to identify the flows of ideas, thoughts, soft skills which are fluid, dispersed and operating through untraceable origins. As such, we recognize this process as actor constellations with different modus operandi but interacting within a relational and shared space of socio-technical transition.

In this paper, we question the interpretation of landscape level and landscape factors and re-conceptualize these broader ‘exogenous’ phenomenon as being ‘endogenous’ to the socio-technical system, acting through certain actors and agency. The broader/exogenous structures (such as privatization and globalization) are embedded and practiced through the actors which are operating within the niche and regime space, thereby internalizing these processes. Also, the forces of globalization within the sustainable energy segment include: global alliances and partnerships (SE4ALL, Global Tracking Framework, SREP) and global funds (Climate Investment Funds, Global Environment Facility), which also function through transnational networks and in conjunction with niche and regime actors. Processes occurring at the transnational or global level have been largely considered as exogenous to the innovation system [59] and/or as part of the system´s environment but not of the system itself [34] . But the analysis in emerging economies would be flawed if the transnational dimensions were excluded.

In addition, we observe the shifting agency of actors in transition. The development aid agencies (esp. World Bank, NORAD, GIZ) during Phase I were involved in a strategic, policy and advisory capacity and also provided financial support. In addition, they were closely engaged with shaping the fundamentals of the power sector through reforms in line with the post-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 is organized in Uganda within which the multiple actors are located. The development partners are like agents of their government-policies and ideologies, which are implemented and appropriated by them in other contexts. Whereas this role of the development aid agencies to some extent has shrunk, to mainly becoming mediators/facilitators to the private-sector driven transition during Phase III - funding and promoting select private sector firms, advocating and lobbying for private sector voice and rights.

With regard to the solar market, after a period of incidental encounters in the late 80s, the initial market was deliberately created with concerted efforts by the government through pilot projects and long-term programs, in collaboration with development partners. The govt. played a critical role in supporting the consolidation of private actors in the late-90s, to encourage and support market penetration. They invested in generating awareness and increasing the technical knowhow within the national context. It is important to note these background

developments which created the enabling environment for the private-sector driven transition in the latter stages. We also identify three critical phases of the solar PV based on private sector developments: i) Late 80s and early 90s – local Ugandan companies with the energy sector not being the main focus (Incafex, Magric); Second phase – late 90s and early-mid 2000s - Ugandan companies/traditional finance models, dealing in solar pico, SHS and large systems, targeting urban users (UltraTec, Konserve, Ital Trade); Third phase - late 2000s and 2010s – Multinational companies capturing large market shares with bigger investments, capital, and innovation. (Solar Now, Fenix, Village Power, M-Kopa). While the private sector solar association was self-contained in the first 2 phases of the transition, however, in the third phase the solar association gets captured by a range of wider foreign interests and stronger lobbying and advocacy by organizations such as USAID/Power Africa, Energy Africa/DFID, and GOGLA, which led to amplifying voices, widespread publicity and positioning, but also influenced the problem framing.

Throughout the PV transition, there was no clear roadmap or centralized authority guiding or driving the process. It is a culmination of a fragmented set of actors, widespread initiatives, and diverse yet common interests. The multiple actors have varying notions and are guided by different socio-political narratives. Solar is "a renewable energy source", "an enabler", provides "power to life and rural communities", and it is "a portable source", "affordable"; and is useful "for lighting", and "for productive use". Overall, solar PV accounts for 4-5% out of the total 20% electrification rate in Uganda at present. Off-grid has had low acceptance esp. among policy makers and political leaders because of the overpowering grid-mindset. There are differentiated priorities of the government – there's a continued focus on hydropower-based grid electricity to prepare the economy for industrialization/ industrial parks, and there's an increasing emphasis on bagasse, geothermal, and nuclear power (roadmap being prepared), all of which are considered to be baseload sources as opposed to intermittent. While off-grid solar pv is still considered as a temporary source/solution despite its uptake, mini-grids have gained more traction and acceptability within the political milieu and are being recognized as an alternative to grid for connecting with remote rural locations and particularly for income-generation activities and for boosting the economy.

ANNEX – I: Database of Sustainability experiments (40)

Phase I (1985-1996) - 9	**Phase II (1997-2008) - 10**	**Phase III (2009-2017) - 21**
UNEPI Program/MOH: solar vaccine refrigeration	UNDP-GEF UPPPRE Project	ERT II Project (PVTMA)
Commonwealth Science Council Project on Solar Drying	ERT I Project supported by the World Bank	FRES Uganda: small-scale PV company
URDT– Dutch HIVOS Project	UltraTec Firm – distributor and system integrator	Solar Now Uganda: PAYG firm
Habitat for Humanity and Solar Electric Light Fund (US)	Davis & Shirtliff Water-Solar Nexus	Village Energy (Network of Technicians and Academy)
Incafex and Magric – Private firms	Rural Energy Foundation (Dutch) SolarNow Program	Barefoot Power Light Up a Village Program
Solar Energy Uganda/Solar Energy for Africa – First PV firm	Shell Foundation - Uganda Energy Fund	EnDEV Project GIZ Uganda – Solar SHS and Pico PV
SEFA in partnership with Solar Light Churches for Africa	PREEP GIZ Project: promoting renewable energy projects	Fenix International/ ReadyPay (PAYG)
Uganda Railway Corporation – EU Project on Telecommunications	JEEP-Nordic Folkecenter: Solar project	Solar Sisters Inc.: empowering women as entrepreneurs
Uganda Posts and Telecommunication – WB Project	Promotion of solar water heating-MEMD and Govt. of Ireland	Village Power "Lighting Lwango Project"
	Greenlight Planet, Sunking, d.light – manufacturers of PV	CREEC Presidential Initiative Project: solar lamps initiative
		CREEC Solar Energy Kiosk Project
		Let There Be Light International collaborated with KACCAD
		Scaling-up rural electrification: EU funded and supported by WWF-Uganda / FRES Uganda
		Africa-EU Renewable Energy Cooperation Program (RECP)
		ERT III Project: collaborating with Lighting Africa
		Transforming Energy Access: Shell Foundation, Innovate UK, DFID
		UNCDF Clean Start Program: – NORAD, SIDA, Austrian Agency etc
		Milking the Sun and Harvesting the Sun Solar Now, Barefoot Power, funded by the Dutch Government
		Scaling off-grid energy (SAGE) – USAID/Power Africa, DFID/Energy Africa and The Shell Foundation
		UNICEF MobiStation Initiative – 'Digital school in a box'
		Solar Suitcases Project – We Care Solar

Compiled based on personal interviews and grey literature

References

[1] Avelino, F., & Wittmayer, J. M. (2016). Shifting power relations in sustainability transitions: a multi-actor perspective. *Journal of Environmental Policy & Planning, 18*(5), 628-649.

[2] Binz, C., & Diaz Anadon, L. (2016). *Transplanting clean-tech paths from elsewhere: The emergence of the Chinese solar PV industry*. Retrieved from

[3] Brown, R. R., Farrelly, M. A., & Loorbach, D. A. (2013). Actors working the institutions in sustainability transitions: The case of Melbourne's stormwater management. *Global Environmental Change, 23*(4), 701-718.

[4] Budde, B., Alkemade, F., & Weber, K. M. (2012). Expectations as a key to understanding actor strategies in the field of fuel cell and hydrogen vehicles. *Technological Forecasting and Social Change, 79*(6), 1072-1083.

[5] Byrne, R. P. (2011). *Learning drivers: rural electrification regime building in Kenya and Tanzania.* University of Sussex,

[6] Coenen, L., Benneworth, P., & Truffer, B. (2012). Toward a spatial perspective on sustainability transitions. *Research policy, 41*(6), 968-979.

[7] Da Silva, I. P., & Kyalimpa, E. (2001). *Photovoltaic Industry in Uganda: Local Manufacturers of PV Components and Imported Products - Efficiencies and National Standards*. Paper presented at the Domestic Use of Energy Conference Cape Town, South Africa.

[8] de Haan, F. J., & Rotmans, J. (2018). A proposed theoretical framework for actors in transformative change. *Technological Forecasting and Social Change*.

[9] DEMD. (1999). *Report of the Directorate of Energy and Mineral Development for the year 1998*. Uganda: Ministry of Energy and Mineral Development.

[10] Eliah, E., & Louineau, J.-P. (1999). Here comes the sun – The hope of rural electrification in Uganda relies on solar energy. *Gate Technology and Development, No.1 - Small Scale Fisheries. GTZ*

[11] ESMAP. (1999). *Rural Electrification Strategy Study: Uganda*. The World Bank. Washington, DC.

[12] Faist, T. (2010). Towards transnational studies: World theories, transnationalisation and changing institutions. *Journal of Ethnic and Migration Studies, 36*(10), 1665-1687.

[13] Farla, J., Alkemade, F., & Suurs, R. A. (2010). Analysis of barriers in the transition toward sustainable mobility in the Netherlands. *Technological Forecasting and Social Change, 77*(8), 1260-1269.

[14] Farla, J., Markard, J., Raven, R., & Coenen, L. (2012). Sustainability transitions in the making: A closer look at actors, strategies and resources. *Technological Forecasting and Social Change, 79*(6), 991-998.

[15] Fritz, R. Uganda Rural Development and Training Programme: A Winner in Bill & Melinda Gates Foundation/Changemakers International Online Community. Retrieved from http://shermanbuck.com/fritz/uganda-development-training-program-winner.html

[16] Fuenfschilling, L., & Truffer, B. (2016). The interplay of institutions, actors and technologies in socio-technical systems—An analysis of transformations in the Australian urban water sector. *Technological Forecasting and Social Change, 103*, 298-312.

[17] Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research policy, 31*(8-9), 1257-1274.

[18] Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions, 1*(1), 24-40.

[19] GIZ. (2017). Energising Development Partnership EnDev - Country Project Uganda. Retrieved from https://endev.info/images/7/75/Factsheet_EnDev_Uganda_EN.pdf

[20] GOGLA, Global, L., & Berenschot. (2016). *Global Off-grid Solar Market Report: Semi-Annual Sales and Impact Data for July-December 2016*. Retrieved from

https://www.gogla.org/sites/default/files/recource_docs/final_sales-and-impact-report_h22016_full_public.pdf
[21] GOGLA, Global, L., ESMAP, & Advisors, D. (2018). Off-Grid Solar Market Trends Report
[22] Gosens, J., & Lu, Y. (2014). Prospects for global market expansion of China's wind turbine manufacturing industry. *Energy Policy, 67*, 301-318.
[23] Hansen, T., & Coenen, L. (2015). The geography of sustainability transitions: Review, synthesis and reflections on an emergent research field. *Environmental Innovation and Societal Transitions, 17*, 92-109.
[24] Hansen, U. E., Nygaard, I., Romijn, H., Wieczorek, A., Kamp, L. M., & Klerkx, L. (2017). Sustainability transitions in developing countries: Stocktaking, new contributions and a research agenda. In: Elsevier.
[25] Hansen, U. E., Pedersen, M. B., & Nygaard, I. (2014). Review of Solar PV market development in East Africa. *UNEP Risø Centre, Technical University of Denmark: Kongens Lyngby, Denmark*.
[26] Jacobsson, R. (2013). *The diffusion of solar PV technology using TIS perspective-a case study of Rwanda.* PhD Thesis. VU University Amsterdam,
[27] Johnstone, M. (1988). A shot in the arm for Third World health. *New Scientist*(1614), 4.
[28] Jørgensen, U. (2012). Mapping and navigating transitions—The multi-level perspective compared with arenas of development. *Research policy, 41*(6), 996-1010.
[29] Kakooza, M., Bagumisa, E., Dold, F., Wassler, S., & Kossakowski, P. (2014). *Solar Market Development Study in Uganda*. Retrieved from Uganda:
[30] Kyezira, A., Hankins, M., Saini, A., & Kirai, P. (2009). *Target Market Analysis - Uganda's Solar Energy Marker*. Retrieved from Germany:
[31] Levitt, P., & Khagram, S. (2008). Constructing transnational studies. In *Rethinking transnationalism* (pp. 33-51): Routledge.
[32] Manning, S., & Reinecke, J. (2016). A modular governance architecture in-the-making: How transnational standard-setters govern sustainability transitions. *Research policy, 45*(3), 618-633.
[33] Markard, J., Raven, R., & Truffer, B. (2012). Sustainability transitions: An emerging field of research and its prospects. *Research policy, 41*(6), 955-967.
[34] Markard, J., & Truffer, B. (2008). Actor-oriented analysis of innovation systems: exploring micro–meso level linkages in the case of stationary fuel cells. *Technology Analysis & Strategic Management, 20*(4), 443-464.
[35] Marquardt, J. (2015). How transition management can inform development aid. *Environmental Innovation and Societal Transitions, 14*, 182-185.
[36] Marquardt, J., Steinbacher, K., & Schreurs, M. (2016). Driving force or forced transition?: The role of development cooperation in promoting energy transitions in the Philippines and Morocco. *Journal of Cleaner Production, 128*, 22-33.
[37] Mawejje, J., Munyambonera, E., & Bategeka, L. (2013). Powering ahead: the reform of the electricity sector in Uganda. *Energy and Environment Research, 3*(2), 126.
[38] MEMD. (2009). *ERT Phase I Implementation Completion Report*. Kampala, Uganda.
[39] Musiolik, J. (2012). *Innovation system building: on the role of actors, networks and resources. The case of stationary fuel cells in Germany*: Utrecht University.
[40] Muwanga, J. F. S. (2015). *Report of the Auditor Journal On the Financial Statements of Energy for Rural Transformation Project (ERT II) and GEF Trust Fund Grant Agreement Implemented by Rural Electrification Agency*. Kampala, Uganda.
[41] Nganwa, H. (2017, September) *Personal Interview*
[42] Nygaard, I., & Bolwig, S. (2017). The rise and fall of foreign private investment in the jatropha biofuel value chain in Ghana. *Environmental Science & Policy*.

[43] Nygaard, I., Hansen, U. E., & Larsen, T. H. (2016). The emerging market for pico-scale solar PV systems in Sub-Saharan Africa: From donor-supported niches toward market-based rural electrification.
[44] Ockwell, D., & Byrne, R. (2016). Improving technology transfer through national systems of innovation: climate relevant innovation-system builders (CRIBs). *Climate Policy, 16*(7), 836-854.
[45] Ondraczek, J. (2013). The sun rises in the east (of Africa): A comparison of the development and status of solar energy markets in Kenya and Tanzania. *Energy Policy, 56*, 407-417.
[46] Piggins, M. (2014). *Powering Rural Transformation: Solar PV in Rural Uganda*. Independent Study Projects (ISP) Collection.
[47] Raven, R. (2007). Niche accumulation and hybridisation strategies in transition processes towards a sustainable energy system: An assessment of differences and pitfalls. *Energy Policy, 35*(4), 2390-2400.
[48] Raven, R., Schot, J., & Berkhout, F. (2012). Space and scale in socio-technical transitions. *Environmental Innovation and Societal Transitions, 4*, 63-78.
[49] REA. (2010). *PV Target Market Approach (PVTMA) Operational Guidelines - ERT II Project*. Uganda.
[50] Rotmans, J., & Loorbach, D. (2010). Towards a better understanding of transitions and their governance. A systemic and reflexive approach. *Transitions to sustainable development. New directions in the study of long term transformative change*, 105-198.
[51] Schiller, N. G., Basch, L., & Blanc-Szanton, C. (1992). Transnationalism: A new analytic framework for understanding migration. *Annals of the New York academy of sciences, 645*(1), 1-24.
[52] SELF. Uganda: History. Retrieved from https://www.self.org/archive-uganda/
[53] Senge, P. (2015). The Solutions in our Midst. *Oxford Leadership*.
[54] Sengers, F., & Raven, R. (2015). Toward a spatial perspective on niche development: The case of Bus Rapid Transit. *Environmental Innovation and Societal Transitions, 17*, 166-182.
[55] Shove, E., Walker, G., & Brown, S. (2014). Transnational transitions: the diffusion and integration of mechanical cooling. *Urban Studies, 51*(7), 1506-1519.
[56] Sixt, G. N., Klerkx, L., & Griffin, T. S. (2017). Transitions in water harvesting practices in Jordan's rainfed agricultural systems: Systemic problems and blocking mechanisms in an emerging technological innovation system. *Environmental Science & Policy*.
[57] Smink, M., Negro, S. O., Niesten, E., & Hekkert, M. P. (2015). How mismatching institutional logics hinder niche–regime interaction and how boundary spanners intervene. *Technological Forecasting and Social Change, 100*, 225-237.
[58] Smith, A., Voß, J.-P., & Grin, J. (2010). Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research policy, 39*(4), 435-448.
[59] Suurs, R. A., & Hekkert, M. P. (2009). Cumulative causation in the formation of a technological innovation system: The case of biofuels in the Netherlands. *Technological Forecasting and Social Change, 76*(8), 1003-1020.
[60] Thorne, S., & Mutesasira, L. (2002). *Terminal Evaluation Report UPPPRE* Retrieved from Kampala, Uganda:
[61] Tigabu, A., Berkhout, F., & van Beukering, P. (2017). Development aid and the diffusion of technology: Improved cookstoves in Kenya and Rwanda. *Energy Policy, 102*, 593-601.
[62] Truffer, B., Murphy, J. T., & Raven, R. (2015). The geography of sustainability transitions: Contours of an emerging theme. In: Elsevier.
[63] Turyahikayo, G. R., Hatanga, E. S., Otiti, T., & Kebirungi, P. (1995). *Renewable Energy Technologies Dissemination: Case Study on Uganda*. Report. Ministry of Energy and Mineral Development.
[64] UNDP-GEF. (1999). *Uganda Photovoltaic Pilot Project for Rural Electrification - Project Document*. Uganda.

[65] van Welie, M., & Romijn, H. (2017). NGOs fostering transitions towards sustainable urban sanitation in low-income countries.
[66] Vertovec, S. (1999). Conceiving and researching transnationalism. *Ethnic and racial studies, 22*(2), 447-462.
[67] Vision. (2003, October 29). Hathaway's solar dream for Uganda. *New Vision*.
[68] Waldinger, R., & Fitzgerald, D. (2004). Transnationalism in question. *American journal of sociology, 109*(5), 1177-1195.
[69] Wieczorek, A. J., Hekkert, M. P., Coenen, L., & Harmsen, R. (2015). Broadening the national focus in technological innovation system analysis: The case of offshore wind. *Environmental Innovation and Societal Transitions, 14*, 128-148.
[70] Wieczorek, A. J., Raven, R., & Berkhout, F. (2015). Transnational linkages in sustainability experiments: A typology and the case of solar photovoltaic energy in India. *Environmental Innovation and Societal Transitions, 17*, 149-165.
[71] Wittmayer, J. M., Avelino, F., van Steenbergen, F., & Loorbach, D. (2017). Actor roles in transition: Insights from sociological perspectives. *Environmental Innovation and Societal Transitions, 24*, 45-56.