Robert Kranefeld

Beyond the grid

Post-network energy provision in Rwanda

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Contents

List of Figures

List of Tables

List of Appendix

Abbreviations

AC	alternating-current
AfDB	African Development Bank
ANT	Actor-network theory
AVCA	African Private Equity and Venture Capital Association
BDS	Business Development Support
CEO	Chief Executive Officer
CIF	Climate Investment Funds
DC	direct-current
EC	European Commission
EDCL	Energy Development Corporation Ltd.
EnDev	Energising Development
ESMAP	Energy Sector Management Assistance Program
EU	European Union
EUCL	Energy Utility Corporation Limited
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (German International Cooperation)
GO	Governmental Organisation
GoR	Government of Rwanda
GVEP	Global Village Energy Partnership
h	hour
ICT	Information and Communication Technologies
ICT4D	Information and Communication Technologies for Development
IEA	International Energy Agency
IMF	International Monetary Fund
IREARPPP	Increase rural energy access in Rwanda through PPP
km	kilometres
kW	kilo Watt
kWh	kilo Watt hours
kWh/a	kilo Watthours per year
LED	Light-Emitting Diode
lmhrs	lumen hours
LTS	Large Technical Systems
M4P	Making Markets Work for the Poor
MDGs	Millennium Development Goals
MINECOFIN	Ministry of Finance and Economics
MININFRA	Ministry of Planning and of Infrastructure
MW	Mega Watt
NDBP	National Domestic Biogas Program
NGO	Non-Governmental Organisations

OECD	Organisation for Economic Co-operation and Development
PAYG	Pay-as-you-go
PV	Photovoltaic
PPP	Public-Private-Partnership
PSF	Private Sector Federation
PV	photovoltaic
RBF	results-based-financing
RDB	Rwandan Development Board
REG	Rwandan Energy Group
RURA	Rwanda Utilities Regulatory Authority
RWF	Rwanda Franc
SDGs	Sustainable Development Goals
SE4ALL	Sustainable Energy for All-Initiative
SHS	solar-home-system
SNV	Netherlands Development Organisation
SREP	Scaling Up Renewable Energy in Low Income Countries Program
STA	Socio-Technical Agencement
STS	Science and Technology Studies
SWH	Solar-water-heater
T	tier
TV	Television
UN	United Nations
USAID	United States Agency for International Development
USB	Universal Serial Bus
USD	US Dollar
V	Voltage
VC4A	Venture Capital 4 Africa
W	Wattage (Watt)
WB	World Bank
WEO	World Energy Outlook
Wh	Watthours
Wh/d	Watthours per day

1 Before the grid

» *Personally, I don't think that charities in Africa really work. I think it just holds the people down longer than it should. I think the only way to build Africa is to build for-profit businesses that create opportunities and jobs for the people locally. That's why with Akon Lighting Africa we decided to take a for-profit approach. Ultimately, it's providing empowerment to local people so they can start developing their own economies. (Akon, US-Senegalese Music Artist and Co-Founder of Akon Lighting Africa, cited in Surtees 2015)* «

In industrialised countries, electric energy is typically provided through large centralised power grids, and thus designating a public task. However, in many parts of the world the national grid only partly covers the territorial space. According to the World Energy Outlook (WEO), the electrification rate of 32% for sub-Saharan Africa countries is the lowest in the world. This represents 634 million people, and thus half of the world's population without electricity (International Energy Agency 2015b). But during the last years there has been an increased attention to those mostly rural areas in the Global South beyond the centralised grid, especially with respect to improved possibilities of solar power systems (Saldinger 2015). A diverse set of actors is involved in related energy projects, including local start-ups as well as foreign companies, non-governmental organisations (NGOs), governmental organisations (GOs), international donors and funds such as USAID, EU or GIZ and even celebrities as Akon. Despite this heterogeneous compilation, more and more private companies commit themselves to the implementation of such off-grid energy provision at the household level and try to design for-profit business models, similar to the Akon Lighting Africa campaign. Furthermore, single devices or bigger mini-grids run by hydro-power or even solar power that have the capacity to connect an entire village contribute to energy provision beyond the grid. All in all the various initiatives and programmes bring a lot of movement into the fields of energy provision and require opening new perspectives on the relation between society and energy.

This study is based on research for my master thesis in Rwanda, which I conducted in 2015. The national context of Rwanda serves as a case study to elaborate on the making of these different forms of energy connectivity beyond the central grid. Rwanda has set up an ambitious rural electrification programme aiming at 70 % energy access of the total population by 2017. The Government of Rwanda (GoR) wants to triple its electricity generation from the 160 MW in 2015 to 563 MW by financial year 2017/18 (East African Business Week 2015). Though, this very ambitious target was missed, electrification reached 208.36 MW in July 2017 (Tumwebaze 2017). A great part, namely, 48 % of this electrification should come through on-grid enlargements and is fostered

by various medium- and large scale energy projects. For instance, in 2015 the GoR inaugurated a large photovoltaic-panel power field, which resembles the shape of the African continent and which has a capacity of 8,5 MW (Smith 2015). Furthermore, it is about to exploit methane gas in Lake Kivu at the border to the Democratic Republic of Congo (DRC) and Burundi. Owing to the volcanic activities in the region the methane stock is continuously growing and presents a serious natural threat to the local population, but it has also an expected potential to generate 700 MW of electrical power and in May 2016 the first 26 MW power plant was provided with gas (Rosen 2016). However, for those parts of the country that remain outside of the centralized grid, off-grid energy systems, either by hydro or solar, provide an alternative for reaching the national target.

Energy hasn't been of much interest in social theory. However, it is closely connected to many topics as it provides necessary background infrastructure for many processes and social phenomena, and hence it makes up a bridging topic. Studies in the field of »energy geographies« describe a shift from former studies of »energy geography« (or »Geography of energy«), which took a predominant resource and economic management and positivist perspective towards a more diverse perspective of socio-spatial relations between physical energy flows and social energy demands (Calvert 2015, Huber 2015, Pasqualetti & Brown 2014). Huber sees the role of Energy Geography as follows:

> »Developments in critical social theory suggest energy should no longer be seen as a mere ›object‹ of empirical analysis. We need to grapple with the role of energy in fuelling the very stuff of social theory – modernity, democracy, capitalism, and ideas of freedom. If geography is to participate in these debates, it is critical for us to theorize the broad role of energy in the social production of space. While geopolitics, urbanization, and consumption might be obvious terrains from which to begin this project, there are countless other geographical registers through which to theorize the role of energy (e.g., globalization, agglomeration, and territoriality).« (Huber 2015: 335)

Still, most studies on decentralised energy come either from a user perspective and try to identify needs and challenges of consumers or focus on management and regulation aspects for implementing such energy systems. With this study I want to combine a theoretical-conceptual stance on energy and society with a concrete empirical study on the marketization of decentralised energy systems in Rwanda to contribute to the still small field of »geographies of energy«.

Thus, I broadly take a Science and Technology Studies-perspective (STS) and conceive of energy provision as a complex socio-technical ›agencement‹ (STA) (see Definition) (Çalışkan & Callon 2010). These are not purely technical, but comprise many different

elements, which are human as well as non-human, material, textual or even normative and cultural. The transition from one dominant form of energy provision to various alternatives therefore includes different dimensions and depends on specific socio-spatial contexts. Energy systems are framed within systems of spatial practices, performed by a variety of involved actors, like consumers, local suppliers, international for-profit companies, international development donors as well as national and regional authorities (Rutherford & Coutard 2014). As such power systems are always cause and effect of socio-technical change (Hughes 1983).

Definition **Socio-technical agencement (STA)**

The term ›agencement‹ goes back to Deleuze and Guattari and combines the words ›arrangement‹ and ›agency‹. A STA is a »combination of heterogeneous elements that have been adjusted to one another [...], endowed with the capacity to act in different ways, depending on their configuration«. (Çalışkan & Callon 2010: 9)

Empirically, this research was guided by the methodological concepts of grounded theory and ethnographic research. During a preparatory field trip of four weeks to Kigali, the capital of Rwanda, I conducted interviews with different actors that were involved in the energy provision beyond the grid. Based on the interview transcripts, I did a qualitative inductive analysis to elaborate how rural spaces in Rwanda beyond the grid are provided with energy. This global question was guided by three sub questions:

- What are implications for the spatial implementation of different technologies of energy provision, which similarly include energy generation, distribution and usage, in the specific socio-political context of energy beyond the grid?
- How do energy entrepreneurs engage in the provision of energy and how do they organize their activities?
- How do the different actors involved in the provision of energy interact with each other and how do they build the pre-conditions for a market-oriented energy provision?

The entire work unfolds in 7 chapters. This introductory part is followed by a theoretical discussion of the relation between energy and society in a historical perspective. It pays special attention to the role of development programmes on energy infrastructure in the Global South (chapter 2). Chapter 3 presents the methodological approach and the broader epistemological framework, which is oriented towards post-colonial theories. It finishes with a critical reflection on my positionality and its impacts for the later results.

Chapter 4, 5 and 6 eventually present the findings of the research in relation to the guiding questions mentioned above, respectively. Owing to my theoretical perspective, I regard energy provision likewise as a socio-technical agencement, which is made up

of many interrelating elements. For the analysis I demarcate three core elements and break them up into tiny bits and pieces to analyse single aspects that all influence and affect energy provision beyond the grid. Therefore, chapter 4 delineates the technological possibilities and social implications of decentralised power systems. Chapter 5 depicts one of the main actors for this provision, namely, private companies. These, also-called, energy entrepreneurs develop sophisticated business models for addressing the economic bottom-of-the pyramid with their products. The last main chapter includes even more actors apart from customer and supplier and analyses the marketization of energy provision and includes the particular political dimensions of Rwanda (chapter 6). Finally, chapter 7 discusses global and interrelating aspects of the formerly segregated elements.

2 Energy in transition

This chapter gives an overview of recent discussions on the energy, society and development nexus and puts particular focus on transitions from large centralised fully connected systems to small post-network forms of infrastructure. First, I provide a general overview on my theoretical framework with a focus on literature about transition and post-network developments particularly from a STS perspective. Then, I give a historical review on different paradigms concerning energy and development and exemplary present recent studies and concepts in this field.

2.1 The very substance of our society

Energy, according to Encyclopædia Britannica (2016) a subfield of physics, is in its simplest definition the capacity to do work. Technically seen it can manifest in many different forms. It can be transformed into heat, like mechanical energy to run machines, into energy of electromagnetical radiation such as visible light, into chemical energy contained for instance in fossil fuels, into nuclear energy or electrical energy. The last is best suited for transmitting energy over distances but very bad for saving it (Encyclopædia Britannica 2016). However, energy is more than a physical parameter inscribed in laws of physics; it is elementary to human life and surrounds constantly everyone unconsciously. But why does energy matter and why should social sciences care about it? Bruno Latour (1993) and others show that thinking of nature, including energy, and human culture as two separate worlds is an old myth of modernity. »Energy especially shows what we can call the ›hubris of the modern‹. The human and physical/material worlds are utterly intertwined and the dichotomy between the two is a construct that mystifies understanding of the problem of energy« (Urry 2014: 7). As a starting point for this work, I argue that reflections on energy and electrification concern »the very substance of our societies« (Latour 1993: 4), which demands crisscrossing »the divide that separates exact knowledge and the exercise of power« (Latour 1993: 3). In general, energy is necessary for all kinds of technology. Even though I put the main focus on electrical technologies or artefacts that either generate electricity or make use of it, I also include other dimensions, particularly the social, of energy and power. I conceive of artefacts as socio-technical, which means they are not only skilful products made by humans but in turn transform human-beings, too.

To exemplify, engineering companies develop an input-output device. It generates electrical light out of solar radiation to electrify basic appliances such as LED-lights and a radio: a so-called solar-home-system. Once installed, such a technical artefact may shift hours of wake and sleep or alter places of labour, thereby it influences and changes human behaviour. But, beyond such obvious and orderly happening situa-

tions, human and non-human may cause and affect each other even more severely in situations of failures and blackouts. It is indeed moments of technical failure that exemplify best immediate results of social and technical interplays.

2.1.1 Scales of energy

Shove & Walker similarly reinterpret the physical definition of energy and take a practice oriented perspective by asking, »what is energy for?« (Shove & Walker 2014) in the sense of, what »work« and social practices does energy enable us to? Hence, they look at practices and material arrangements concerning forms of energy and question research approaches that mainly focus on energy supply. Thereby they assume that there is always a constant or even rising demand for energy. What people actually do in their daily lives would highly depend on specific conjunctions of technologies (wires, light bulbs, radios) that have become obvious and unquestioned, but in turn, these technological systems have been built and transformed according to daily needs and to enable more practices (Shove & Walker 2014: 49). Apart from a micro-scale perspective on individual users, one could take a meso-scale perspective on the relation of energy systems and societies or even a macro-scale view on global energy patterns.

The first, micro-scale view, comprises »mature technological system« (Edwards 2003: 185), like a national energy grid, which - although societies as a matter of course fundamentally depend on it - remains unnoticed as long as it is well-functioning[1]. Again, the dependency only becomes obvious when the grid fails. Furthermore, society and technology co-constitute infrastructures, which do not only consist »of hardware, but also of legal, corporate, and political-economic elements« (Edwards 2003: 199) and therefore are not only socially shaped but social through and through (Edwards 2003: 199). Electricity is typically considered as critical infrastructure (see Definition), defined as »the basic facilities, services, and installations needed for the functioning of a community or society« (American Heritage Dictionary, cited in Edwards 2003: 187). A crucial element of the definition is the maintenance of a continuous flow of goods and services, which is indispensable for the functioning of contemporary societies. The probably most prominent attention to the role of large technical systems (LTS) and their interlinkage with society was paid by Thomas Hughes in his work on »networks of power« (1983).

Definition Critical Infrastructures

The EU defines it as: »an asset, system or part thereof located in Member States that is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people,

[1] It is important to mention that this definition lacks a western bias, as the image of infrastructure as »invisible, smooth-functioning background ›works‹« is an ideal that does not manifest globally (Edwards 2003: 187).

and the disruption or destruction of which would have a significant impact on a Member State as a result of the failure to maintain those functions« (European Commission (EC) 08.12.2008).

Hughes describes the long historical process of the emergence of electric power systems in Western society from 1880 to 1930, which he regards as the greatest construction project of the previous century, comparable to the development of railway systems in 19th century[2]. He conceives of networks as cultural artefacts that involve certain basic technical components and connections. However, these are interwoven with many fields of human activity such as science, economy, political practices and organizational arrangements and hence socio-technical. He concludes that power systems, similar to any other technology, can show temporal and spatial variations from one society to another, and as such, »are both causes and effects of social change« (Hughes 1983: 2). More generally, he defines socio-technical systems as related components interconnected by a structure and often centrally controlled, though there might be differences between vertical, horizontal or hierarchical systems. The control part usually sets the limits of the system, the direction towards the achievement of goals and decides how these can be best realised. For him, interconnectedness is particularly crucial, because the change of one component would impact the whole system (Hughes 1983: 5). Similar to other LTS-studies, he takes an evolutionary perspective and demonstrates the path-dependency of electrical systems. A primary diffusion stage with a set of actors developing new technological possibilities is followed by a stage of chaotic competition over standards, customers and investors. Finally diverse approaches consolidate and converge to a unified standard and create a relatively stable system, like a public utility. In addition, Edwards delineates a forth phase of deregulation of state protected infrastructure services in favour of free markets (Edwards 2003: 199f.).

The evolution of electrical systems starting with Thomas Edison's direct-current (DC) system in the 1870/80s to mainly interconnected systems of national grids was therefore far from linear and not determined by technological progress. According to Hughes, the momentum for electric supply systems including the development of main high-voltage transport lines was in the 1920s, the post-World War I era. These large technical systems manifested either in an evolutionary or planned way. The former, evolutionary systems referred to regional power systems that developed heterogeneously over long periods. Engineers, politicians and managers of one region collaborated and created an economic mix by interconnecting different kinds of energy sources. The latter, planned systems, were established out of complex master plans designed for

[2] McDonald delineates similar developments for South Africa and other southern African countries, where he draws parallels between the ongoing rush to build electricity lines and the erasing of colonial railway systems during the ›scramble for Africa‹ in the 19th century (McDonald 2009, xvi).

greater regions and connected many different utilities and facilities that had formerly evolved independently and which often preserved their legal identities (Hughes 1983: 324f.). These were major political as well as economical projects to relocate and re-territorialize formerly isolated ›islands of power‹ into national and continental grid systems (Bridge et al. 2013: 336). Hughes' concept of technical system serves as crucial starting-point for this study. However, it likewise presents a counter-narrative since the problem of my work concerns energy beyond centralised electrical grids. Nevertheless I adopt his network approach and similarly conceive energy beyond the grid, including isolated systems, as sociotechnical hybrids and networks.

Turning to a global scale, one can state that the way »societies are ›energized‹ is crucial for how they work« (Urry 2014: 5). Similar to the mutual influence of individual practices and technologies, societies are highly interlinked with global patterns of energy generation and consumption, which Urry describes for Western societies as a »carbon-metabolic profligacy« (Urry 2014: 6). The rising levels of fossil fuels are connected with increased levels of social complexity and increased patterns of communication, consumption and habitation. Mitchell (2011) refers to this energy-society-nexus as »carbon democracy«, while Nobel-prize winner Paul Crutzen invented the term »Anthropocene« to describe a new geological period which would have succeeded the Holocene (Urry 2014: 10). They all raise the argument that modern life and all its achievements have become collectively dependent on the expropriation of an ending resource, namely, carbon fuels and especially oil. Today's »global energy dilemmas« (Bradshaw 2013) are linked to the Enlightenment view that a human world can be mastered and that progress provides the ability to exploit and dominate a separate nature (Urry 2014: 7). I will come back to the ideals of modernisation and its influences on Development in the next chapter.

To conclude on the different scalar perspectives on energy, they should neither be seen separately nor suggest any hierarchical order. Instead, Edwards suggests a »mutual orientation« (2003) on scales that considers the interplay of micro-scale users with meso-scale institutions and macro-scale larger technological systems and political economies. These different scales are inseparably intertwined and cannot be reflected upon individually. Nevertheless, I am empirically mainly looking from a micro-perspective on practices of individual entrepreneurs and smaller institutions without claiming that this is the only scale that matters, though.

2.1.2 Towards post-network energy infrastructure

In response to the energy dilemma, new ways of thinking such as post-carbon, de-growth and post-network theories (Alstone et al. 2015, Bulkeley et al. 2011, Coutard & Rutherford 2014, Schulz & Bailey 2014) emerged that in different ways challenge the dominant view of Modernity and present ways for energy transition (Araújo 2014,

Dodson 2014, Moss 2014, Newell & Mulvaney 2013, Rutherford & Coutard 2014, Shove & Walker 2007, Shove et al. 2014, Shove & Walker 2010, Coenen et al. 2012). The transition literature, broadly speaking, argues for »radical, systemic and managed change towards ›more sustainable‹ or ›more effective‹ patterns of provision and use of energy« (Rutherford & Coutard 2014: 1354). However, this should not be confused with current mainstream attempts of ›smart growth‹ or ›green growth‹. ›Green growth‹ focuses on more efficient use of resources but remains largely within conventional, growth-centred capitalism. Approaches of de-growth instead try to find ways for ›prosperity without growth‹ that strive for sustainable lifestyles and economic systems, while at the same time emphasising distributive justice of wealth (Schulz & Bailey 2014).

Rutherford & Coutard delineate three particular elements for their analysis on transitions and socio-technical change: First, a transversal view on energy materialities that combines contexts, infrastructures and practices, second, a relational perspective to deal with connections between near and far places and, third, a view on socio-technical change as always being political and contested (Rutherford & Coutard 2014: 1362). The transition and post-network literature mostly engages with urban landscapes (in the Global North), arguing that most people live in cities and therefore social change would always be related to cities. Nevertheless, they admit that the provision of energy on an urban scale only works via networks that connect the city to big power plants and the hinterland (Rutherford & Coutard 2014: 1369).

The post-network approach is a critique on the ›networked city‹ paradigm in Europe that is based on the principle of linear flows with resources coming into urban consumption centres, where they are transformed and then returned as waste to the hinterland (Coutard & Rutherford 2011: 109). Albeit the completely different spatial contexts of networked cities in Europe and my case study of Rwanda, I want to reflect on a typology Coutard & Rutherford developed of various forms of post-networked connectivity, as presented in Tab. 1.

Tab. 1: A typology of post-networked pathways to low carbon transition

		Organisation	
		Delinking, unlinking (local authority)	New forms of linking (local autonomy)
Decision	Collective, local scale of decision	*A. Off-grid*	*B. Loop closing*
	Individualized (or quasi-individualized) scale of decision	*C. Beyond net*	*D. Feed-in to grid*

Source: Coutard & Rutherford 2011: 112

Off-grid (A) presents the most radical form of post-network as a whole community bypasses the centralised grid and lives on local autarchy. In contrast, communities that are technically self-sufficient but are situated within political boundaries of an existing network (such as a city) can promote a circular metabolism. Then all resources, as much as possible, are produced, reused and recycled within a closed loop (B). Living beyond or before the collective net (C) refers to spaces at the edge of cities that, for the time being, rely on alternative and individualized forms of service provision but that might be included in a future net. Finally, individual power producers can be connected to the centralised grid through feed-in systems (D), which supports a splintering of the supply system (Coutard & Rutherford 2011: 111 ff.).

2.2 Energy and development

At the moment, a diverse set of actors is engaging in the field of energy provision, starting with small projects from NGOs, specific national support schemes to global multilateral programmes and frameworks. However, before dealing with these current players and programmes on energy, I want to take a historical perspective on the origin and the influence of development programmes on energy provision. The contribution of national and international private and public actors alike in the field of energy in the Global South underwent at least two major paradigm shifts that were closely related to questions of development and infrastructure. In the following section I refer to insights from post-development studies to elaborate on a short critical genealogical perspective on the conception of energy and development.

2.2.1 Development and modernisation

First of all, for conceptualising ›development‹ I follow Hart (2010) by differentiating between small *d* and capital *D ›D/development‹*. The first is defined as a worldwide long-term process of socio-economic change enabled through the spread of colonialism and capitalism. (Capital *D*) ›Development‹ in turn refers to the post World War II »Development Age« (Rist & Camiller 2014: 71) initiated through international donors and aid programmes. In this section I focus on (capital *D*) ›Development‹ and energy, whereas Hughes historical analysis would be an example for a (small d) ›development‹ perspective on energy.

The fourth point of President Truman's Inauguration speech can be seen as the entry point in the Development Age (Rist & Camiller 2014: 71):

> »Fourth, we must embark on a bold new program for making the benefits of our scientific advances and industrial progress available for the improvement and growth of underdeveloped areas.« (Truman '49)

In this opening paragraph, two vital elements are introduced: First, the making of an ›underdeveloped‹ world as a synonym for ›economically backward‹ areas (Rist & Camiller 2014: 71). The term ›underdeveloped‹ suggested a linear succession of capitalist stages, where one part of the world still finds itself at an ›original‹ stage of history that the other part – the ›developed‹ world – has passed long ago and accordingly sets itself in the final stage (Frank 1966: 5). Second, it expresses the faith in scientific advances and progress as the markers of civilisation. »Technology, it was believed, would not only amplify material progress, it would also confer upon it a sense of direction and significance« (Escobar 1995: 36). Hence, the transfer of modern science and technology became a major component of Development.

Highly important and influential for Development was Rostow's conception of a five folded Development ladder, which he delineates in the beginning of his non-communist manifesto on the stages of growth:

> »It is possible to identify all societies, in their economic dimensions, as lying within one of five categories: the traditional society, the preconditions for take-off, the take-off, the drive to maturity, and the age of high mass-consumption.« (Rostow 1960: 4)

Post-development theorists (Escobar 1995, McMichael 2008, Rist & Camiller 2014, Sachs 1992, Hoogvelt 2001) criticise his conception for several reasons that I won't discuss in detail, but just name briefly. It would be western centric in taking western capitalist development as a blue print for all societies by ignoring different spatial and temporal contexts that make it impossible for every society to develop exactly the same way. During western capitalist development there has been no other part of the world dominating world politics and deciding on the distribution of labour and resources. To act upon the maxim of accumulation and consumption gives development an open-end as it is always possible to accumulate and consume more and finally it ignores all the casualties of capitalist mass-consumption, in form of natural deterioration, labour conditions or inequalities (Rist & Camiller 2014: 98). To conclude, modernisation, institutionalised in belief in western Development, follows the idea of developing into one particular form of modernity through technical progress and economic growth (Khan 2003: 332). These points are far from comprehensive and fortunately some current Development concepts go beyond this conception. But, interestingly enough the general assumption of a linear form of development that the objects of Development metaphorically need to climb up, somehow, on a kind of five-folded ladder still persists. The field of energy, in this regard, remains no exception.

2.2.2 Paradigm shifts on energy provision within Development

Philip McMichael (2008) names two different paradigms that dominated the development age: The early Post-war era of the ›development project‹ (1940s-1970s) under post-colonial state-regulated markets and the later ›globalisation project‹ (1970s-onwards) under self-regulating markets.

Central for the development project were the establishment of strong national development states encouraged by decolonisation throughout the Global South. Albeit different political systems and configurations of social forces in different countries, the new development states were built on similar ideals encouraged by foreign aid: state planning dominated over market-orientation, centralized administrations were installed inspired by former colonial forms of governance and growth of bureaucracy favoured planning and state elites (McMichael 2008: 34ff.). Part of such politics were large public investments in the field of energy, like dams or high-voltage grids, and infrastructure like establishing public airways to demonstrate the power and autonomy of the newly formed states. On the example of Egypt, Timothy Mitchell (2002) delineates how US development aid was either spent directly in the United States or on large manufacturing projects such as energy systems managed by large American companies like *Bechtel Overseas* or *General Electric*. This means that in neither case money for investments was transferred to the Egyptians, but remained in the US. On top of that, the Egyptian government needed to pay local implementation costs for commodities imported from the US for many of these projects. This created an enormous amount of debt for the Egyptian government and a high dependence on American imports and technology (Mitchell 2002: 238ff.). The World Bank supported these large-scale and capital-intensive projects and encouraged borrower countries to engage in such ›productive‹ instead of ›social‹ investments. This led both to western technology transfer and a lasting institutional presence of the World Bank in the Global South (McMichael 2008: 60).

Side note **The Rwandan development state**

Mamdani (2001) names Rwanda »an authoritarian development state« with a »National Council for Development that strictly controlled and lead its population« (Mamdani 2001: 144f.). Until the 1980s it had an impressive development record concerning public debt or rates of growth and for social indicators on mortality, medication and education (Mamdani 2001: 145). Energy generation during that timed relied almost completely on hydro power coming from the two biggest dams Ntaruka, installed in 1959 still under Belgian-colonial rule, and Mukungwa, installed in 1982, with an installed capacity of ca. 12 MW each (Safari 2010: 526).

The second paradigm according to McMichael was the »globalisation project«, which succeeded the »development project« with the dominant idea of market rule on a global scale. Though, Development and the setting of national goals remained of high im-

portance, the focus shifted more towards the positioning and competing within a global market (McMichael 2008: 150). There is no special event that marked a sharp rupture from »Developmentalism« to »Globalism«, however, the Oil crisis in the 1970s and the end of the Bretton-Woods-System in 1973 were important events that influenced that shift in Development. Bi- and Multilateral loans were reduced while the share of private banks in financing projects in the Global South increased drastically. During the financial crisis in the 1980s, export revenues went down and for consolidation of the many increasingly indebted states in Africa and Latin America, »global managerialism [emerged], in which the world economy was managed through coordinated, rule-based procedures - the debt regime« (McMichael 2008: 128). Part of the financial crisis in the affected states were the privatisation of capital intensive large-scale infrastructure projects and related state enterprises as well as a general downsizing of the big bureaucratic state apparatus. Concerning energy, this comprised restructuring and unbundling of a former national energy or infrastructure utility into separate companies, responsible for instance for grid-extension, energy generation, transmission or distribution. Moreover, this opened the opportunity for partial or complete privatisations of the separated companies in a next step (I refer to the unbundling in Rwanda in chapter 6).

Tab. 2: Three paradigms of energy access and development

	Donor gift paradigm (1970s–1990s)	**Market creation paradigm (1990s and 2000s)**	**New ›sustainable programme paradigm‹ (2010s–?)**
Actors	One, usually a government or just one development donor	Multiple government agencies and/or multilateral donors	Multiple public, private, and community stakeholders
Primary goal	Technology diffusion	Market and economic viability	Environmental and social sustainability
Focus	Equipment, often single systems	Multiple fuels (e.g. ›electricity‹ or ›fuelwood‹)	Energy services, income generation, institutional and social needs
Standardization	Little standardization between projects	Some standardization	Harmonized with certificates, testing regimes, and national standards
Implementation	One-time disbursement	Project evaluation at beginning and end	Continuous evaluation and monitoring
After-sales service and maintenance	Limited	Moderate	Extensive
Ownership	Given away	Sold to consumers	Cost-sharing and in-kind community contributions
Awareness raising	Technical demonstrations	Demonstrations of business models	Demonstrations of business, financing, institutional, and social models

Source: Sovacool (2015: 49)

Coming from an applied political economy perspective, Benjamin Sovacool (2015) identifies three paradigm shifts concerning energy and development (see Tab. 2.) International organisations and donors would act either as gift donor, market enabler or promoter for sustainability. Though McMichael (in line with other post-development theorists) and Sovacool generally identify similar paradigms, interestingly they differ strongly in their timeframes. Sovacool only starts his analysis with the »donor-gift paradigm« in a time when McMichael already identifies a liberalisation shift and a stronger managerialism through the »debt regime« (McMichael 2008: 128), led by the Bretton Woods institutions World Bank (WB) and International Monetary Fund (IMF). Sovacool, in contrast, identifies a new »sustainable paradigm« with regard to sustainable development approaches promoted by many development agencies, which is generally in line with former paradigms. The underlying message is that the new paradigm combines the lessons learnt of the two former extremes to establish an inclusive and more comprehensive approach – the ideal win-win situation that harmonises economic, social and environmental concerns. In the next section I delineate these current initiatives and approaches on energy that correspond to the »sustainable paradigm«.

2.2.3 Modernization 2.0? Energy poverty and modern energy

In September 2015 the United Nations (UN) passed the Agenda 2030, including 17 newly formulated Sustainable Development Goals (SDGs) as the succeeding framework of the Millennium Development Goals (MDGs). The latter comprise a greater total number of goals and subgoals and define more ambitious targets. However, the most striking difference is that they address and take into account all states in the world and not only in the Global South. Among these new SDGs is Goal 7:

> »Ensure access to affordable, reliable, sustainable and modern energy for all.«

with the addition under 7.b:

> »By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support.« (United Nations 2015: 19)

Prior to the new Agenda, former UN Secretary General Ban Ki-Moon presented the common global framework of UN and WB, the Sustainable Energy for All-Initiative (SE4ALL) in 2011. The initiative and goal 7 of the SDGs are similar in targeting an increase in energy access, renewable energies and energy efficiency (Sustainable Energy for All 2012). Energy, it seems, is back on the international agenda. Albeit once so prominent in the development project it was of minor importance during the last dec-

ade considering that it was not included in the previous Millennium Development Goals. However, two aspects remain open: First, what counts as energy access and second, what is ›modern‹ energy at all? The International Energy Agency (IEA) claims that there is »no universally-agreed and universally-adopted definition of modern energy access« (International Energy Agency 2015b: 3), hence every organization develops its own definition and metrics. In the following, I present two prominent methodologies for energy access, namely, the above cited IEA, an international organisation with 29 member states almost solely from the Global North and secondly, the Energy Sector Management Assistance Program (ESMAP), a global, multi-donor technical assistance trust fund administered by the World Bank, which e.g. supports SE4ALL.

The IEA presents annually figures on energy access in its World Energy Outlook (WEO) gathered from and redistributed by global organisations such as WB, USAID, Organisation for Economic Co-operation and Development (OECD) and several UN agencies (see Tab. 3). Access to modern energy, according to IEA, is lowest in Sub-Saharan African countries whereas almost at 100 % for countries in North Africa, China and so called »transition economies« as well as OECD countries. Rwanda has a relatively low electrification rate, especially in rural areas with about 5 %. With respect to changes over the last years, the rate of energy access, both in urban and rural areas, has remained stable and the total amount of people without electricity has even slightly decreased. But, in line with a growing total population, the total amount of people without energy access in Sub-Saharan African countries shows an opposing trend as it has increased about 8 % (from 585 million in 2009 to 634 in 2013) (International Energy Agency 2011, 2015a).

Tab. 3: Electricity access on household level for regional aggregates in 2013

Region	Population without electricity **(millions)**	National **electrification rate (%)**	Urban **electrification rate (%)**	Rural **electrification rate (%)**
Africa	635	43%	68%	26%
North Africa	1	99%	100%	99%
Sub-Saharan Africa	634	32%	59%	17%
Rwanda	*9*	*21%*	*67%*	*5%*
Developing Asia[3]	526	86%	96%	78%
China	1	100%	100%	100%
India	237	81%	96%	74%

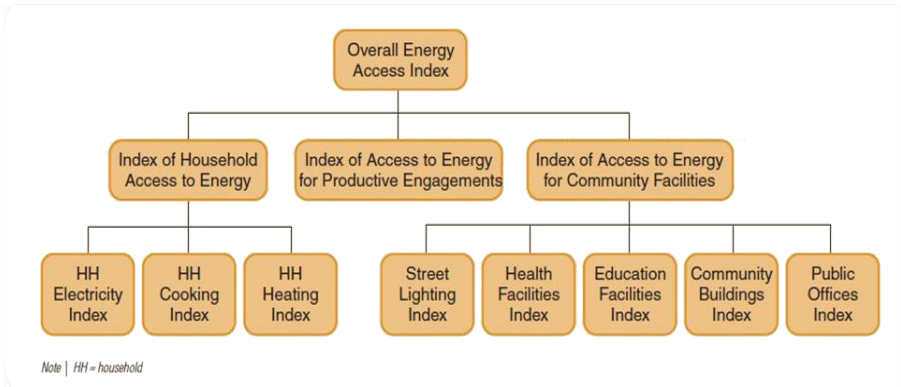
[3] Comprises all Asian countries except for those listed as »Middle East« and »Transition Economies«.

Latin America	22	95%	98%	85%
Middle East	17	92%	98%	79%
Transition economies & OECD	1	100%	100%	100%
World	1,201	83%	95%	70%

Source: International Energy Agency 2015a

Although the IEA reflects on the difficulties of giving a proper definition, in their WEO reports they define access to modern energy as »a household having reliable and affordable access to clean cooking facilities and to a minimum level of electricity consumption which is increasing over time«. In addition to this broad definition, they come up with a quantitative one that sets an initial threshold level of electricity consumption of 250 kWh for rural and 500 kWh for urban households of five persons per year[4]. This could, according to the WEO, provide for the use of a fan, a mobile phone and two compact fluorescent light bulbs per day in rural areas (International Energy Agency 2015b: 3).

Fig. 1: Hierarchy of Energy Access Indices



Source: Bhatia & Angelou 2015: 3

In contrast, ESMAP provides a very comprehensive framework for defining and measuring energy access that goes beyond binary metrics. First launched in July 2015, it is currently used for establishing a global baseline survey that helps to further track changes and monitor the success of energy initiatives. It considers three different so-called energy locales: household, community and productive engagements that again

4 In comparison, the average 5 person household in Germany in 2016 consumes 5.500 kWh/a (without electric water heater) (Kampagnenbüro der Stromsparinitiative 2016).

consist of further sub criteria such as cooking, electricity and heating on the household level, of which I only refer to electricity (see Fig. 1). In addition, each sub criterion is made up of five-folded-tier (!) matrix with specific attributes. For the household electricity level they consider:

- Access to Electricity Supply (see Tab. 4):
  (including 7 parameters: (i) capacity, (ii) duration (including daily supply and evening supply), (iii) reliability, (iv) quality, (v) affordability, (vi) legality, and (vii) health and safety)

- Access to Electricity Services (see Tab. 5)
  (qualitative use of appliances as light, phone, television)

- Electricity Consumption (see Tab. 6)
  (measured in kWh/a or Wh/d per person)

In general, ESMAP makes an interesting point in differentiating between supply, consumption and used services, as they break up the assumption that a certain capacity of electrical supply determines a specific outcome of energy practices. Besides, it is remarkable that the applied methodology uses quantitative data for Tab. 6 and qualitative categories in Tab. 5, whereas the analysis for supply consists of a mixed quantitative-qualitative approach, which on top of that is much more complex than the other two ones. Still, it seems as if energy capacity, measured in KWh presents the predominant attribute, while other attributes don't even contain a description for every tier.

The whole framework is designed in sharp contrast to former metrics such as the IEA's, because it considers more than the household level and includes nuances between full access and no access at all. This allows pondering upon technologies of supply such as off-grid stand-alone and mini-grid systems. Regarding stand-alone, a fractional measurement between tier 0 and 1 is included to emphasise the use of lighting and phone charging as critical first applications. Tier 1 of electricity supply (Tab. 4) assumes that a five person household would at least need light of 1000 lmhrs, which could be provided for instance by three 1 W LED spotlights running for 4 hours. In this scenario they would consume 12 Wh of electric energy a day. The framework further reflects that there can be differences between the three categories for one household, such as poor electricity supply (low capacity or reliability) but availability of relatively high power appliances ,or the other way round, an inability to afford appliances despite relatively good supply (Bhatia & Angelou 2015: 4 ff.) (for the full matrix see App. 1, p. 133).

Tab. 4: Shortened multi-tier Matrix for Access to Household Electricity Supply

Attribute		T 0	T 1	T 2	T 3	T 4	T 5
1. Capacity	Power		Very low min 3 W	Low min 50 W	Medium min 200 W	High min 800 W	Very high min 2 kW
	AND Daily Capacity		min 12 Wh	min 200 Wh	min 1 kWh	min 3,4 kWh	min 8,2 kWh
	OR Services		Lighting of 1,000 lmhrs per day and phone charging	Electrical lighting, air circulation, television, and phone charging are possible			
2. Duration	Hours per day		min 4 h	min 4 h	min 8 h	min 16 h	min 23 h
	Hours per evening		min 1 h	min 2 h	min 3 h	min 4 h	min 4h
3. Reliability						Max 14 disruptions per week	Max 3 disruptions per week of total duration < 2 hours

Source: Adapted from Bhatia & Angelou 2015: 6

Tab. 5: Multi-tier Matrix for Access to Household Electricity Services

	T 0	T 1	T 2	T 3	T 4	T 5
Tier criteria	Not applicable	Task lighting, phone charging, radio	General lighting, television, refrigerator, fan (if needed)	Tier 2 AND Any medium- power appliances	Tier 3 AND Any high-power appliances	Tier 4 AND Any very high-power appliances

Source: Adopted from Bhatia & Angelou 2015: 6

Tab. 6: Multi-tier Matrix for Electricity Consumption

Time frame	T 0	T 1	T 2	T 3	T 4	T 5
Annual consumption levels, in kilowatt-hours (kWh)	<4.5	≥4.5	≥73	≥365	≥1,250	≥3,000
Daily consumption levels, in watt-hours (Wh)	<12	≥12	≥200	≥1,000	≥3,425	≥8,219

Source: Adapted from Bhatia & Angelou 2015: 6

Turning away from metrics, providing energy access is often discussed as a contribution to end energy poverty (Bazilian et al. 2014: 219). A diverse set of methodologies tries to define energy poverty quantitatively similar to access, by calculating thresholds

(see for example Nussbaumer et al. 2012). One of the most prominent figures on energy poverty comes from the IEA and states that »an estimated 1.2 billion people – 17% of the global population – remain without electricity« (International Energy Agency 2015b: 3), which is based on their energy access threshold for households (see Tab. 3, page 25). This approach is very much similar to measuring (extreme) poverty as having less than 1.25 USD per day, which is used in the SDGs (Goal 1). Such figures are very powerful in transmitting short and impressing messages that go into Development policies and determine (sustainable) goals, regardless of the triviality of its definition. Needless to say, the binary threshold is highly debateable as it creates a homogeneous picture of an ›underdeveloped‹ world with wide-ranging identical needs, for instance floor fans.

Further, in many definitions there is a linkage between energy access/poverty and modern energy. In the WEO report it is said that expanding access to modern energy services at the household level would be one aspect of overcoming energy poverty (International Energy Agency et al. 2010). In this sense the dedicatory definition of energy poverty becomes the relational antipode of modern energy. Bazilian et al. for example define energy poverty as »the lack of access to affordable and high quality energy services« (Bazilian et al. 2014: 217). In comparison, lighting, heating, refrigeration, cooking and transportation are named as modern energy services that would be a »key prerequisite to a decent quality of life« (Bazilian et al. 2014: 217). Similar examples from development programmes emphasise that modern energy would improve living conditions, extend study hours and hours of operations, provide better health, and contribute to better and more efficient income opportunities (Barnes et al. 2015: 57). To conclude, definitions on modern energy and poverty are based on explicit modernisation thinking. This can at best be exemplified in the so-called energy ladder (see Tab. 7 for household use):

Tab. 7: The energy ladder for household energy use

Energy service	Developing countries			Developed countries
	Low-income households	Middle-income households	High-income households	
Cooking	Wood (incl. wood chips, straw, shrubs, grasses, and bark), charcoal, agricultural residues, dung	Wood, agricultural residues, coal, kerosene, biogas	Wood, kerosene, biogas, liquefied petroleum gas, natural gas, electricity	Electricity, natural gas
Lighting	Candles, kerosene (sometimes none)	Kerosene, electricity	Electricity	Electricity
Space heating	Wood, agricultural residues, dung (often none)	Wood, agricultural residues	Wood, coal, electricity	Oil, natural gas, electricity
Other appliances	None	Electricity, batteries	Electricity	Electricity

Source: Sovacool 2015: 25

In its explanation it is said, that

> »the idea implies that the primary types of energy used in rural areas or developing countries can be arranged on a ›ladder‹ with the ›simplest‹ or most ›traditional‹ fuels and sources, such as animal power, candles, and wood, at the bottom and the more ›advanced‹ or ›modern‹ fuels such as electricity or refined gasoline at the top. The ladder is often described in terms of efficiencies, with the more efficient fuels or sources higher on the ladder. For example, kerosene is three to five times more efficient than wood for cooking, and liquefied petroleum gas is five to ten times more efficient than crop residues and dung.« (Sovacool 2015: 24)

The ladder creates a kind of benchmarking, with energy services as used in the developed world on top and thus at the highest stage. The lowest development stage is somehow related to naturalistic products such as wood, agricultural residues or dung, while ›developed‹ relates to efficiency and electric technologies.

All in all, there is a vast field of applied studies, extension manuals or feasibility-studies that focus on concrete projects of decentralised energy. Especially within the last five years the number of publications in this field has increased, though applied studies seem to dominate over research papers. Many case studies focus on renewable energy systems for off-grid electrification, like a special issue of *energy for sustainable development* on »off-grid electrification in developing countries« (Bhattacharyya 2011), on village solar power in Kenya (Ulsrud et al. 2015), mini-grids in Uganda (Eder et al. 2015) or payment systems for solar-home-systems in South Africa and Kenya (Lemaire 2011, Rolffs et al. 2015), biomass energy in Sub-Saharan Africa (Dasappa 2011) as well as case studies from other regions, like off-grid electrification in Cuba (Cherni & Hill 2009) or in Bangladesh (Bhattacharyya 2013). Another focus lies on the relation of grid and decentralised technologies, as in Kenya (Zeyringer et al. 2015) or in a whole series on »electric capitalism« with examples on electricity and capital accumulation in (South) Africa (McDonald 2009). Finally, many applied management perspectives emerged on the energy and development nexus (Toth 2012), dealing with infrastructure, rural electrification and development (Cook 2011), decentralised energy in developing countries (Schäfer et al. 2011), renewable energy in sub-Saharan Africa (Hancock 2015), implementing mini-grids (Franz et al. 2014), or explicitly with the SE4All-Initiative (Thorne & Felten 2015).

To conclude, from a Development perspective access to energy means overcoming energy poverty, which refers to living on ›simple‹ energy services and supply. By climbing the ›energy ladder‹, developing countries should access modern energy, which in the long-run would mean energy forms and sources as used in the developed

world. Yet the significance of ›modern energy‹ remains quite empty and leaves wide scope for interpretations. In general, discourses on energy of international (Development) organizations stay strongly within modernisation thinking, following the assumption that technical progress makes it possible to develop into the stage of modernity (Khan 2003: 332). Timothy Mitchell (2000) fundamentally questions the underlying time-space conception of modernity (or even post-modernity) of being a historical time that has already been reached or even passed and as spatially associated with the West (or Global North), which leads to the assumption: »to become modern, it is still said, or today to become postmodern, is to act like the West« (Mitchell 2000: 1). Instead, he argues modernity is not the (final) stage of history but rather the »staging« itself, which similarly involves the staging of difference in a double sense: on the one hand the dualistic displacement of the West and non-West and on the other hand the representation of these spaces as different (Mitchell 2000: 23, 26). In conclusion, concepts such as the energy ladder continue with benchmarking energy systems against the bigger is better- ideal of infrastructure in the Global North. However, this infrastructural system can absolutely not serve as a global role model – neither in ecological, social nor economic regards. Instead, in the sense of »powering down societies« (Urry 2014: 17) it would be necessary to develop alternative forms of energy infrastructure, to shift from a linear idea of modernity to a concept of »multiple modernities« (Eisenstadt 2000) that are not limited to the Global North.

Nevertheless, some approaches presented above already go beyond simple dualistic conceptions as traditional/ modern, on-grid/ off-grid, electrified/ not electrified. For this study, I consider the multi-tier approach as presented by Bhatia & Angelou (2015) still as a quite useful heuristic to conceptualise energy in its different dimensions as long as it does not imply a modernization ladder with the only objective of reaching high capacities and mass-consumption. Beyond the grid would mean so far, there are more possibilities than a fully centralised grid that are worth full consideration. The next chapter (3) presents my methodological and conceptual approach, which is inspired by post-colonial and Science and Technology Studies.

3 The methodological making of »Beyond the grid«

» *Thinking is the heart and soul of doing qualitative analysis. Thinking is the engine that drives the process and brings the researcher into the analytic process. (Corbin & Strauss 2008: 163)* «

I have been working on this study for over a year, but the writing has been a rather short, albeit very intense, final phase. Still, much more time has passed on doing the empirical research, on reading and – thinking. This chapter presents the process of creating this study, starting with my conceptual lens and the global theoretical framework. It is followed by my methodological procedure, from preparatory work, the actual fieldwork to the final analysis and closing with a critical reflection of my methodology and its implications for the results presented in the succeeding chapters.

3.1 Post-colonial Technoscience

I position the research in the broader theoretical field of Science and Technology Studies (STS) as I take a general anti-essentialist and post-positivist stance on socio-technological processes. More specific, I take a post-constructivist perspective and prevailing micro approach towards practices of social interaction (Jones & Murphy 2011) that constitutes and reconfigures social and economic spaces of energy provision beyond the grid. In addition to that, my conceptual and methodological approach is, broadly speaking, sensitised by post-colonial theory. All these post-theories actually do not comprise homogeneous categories. Therefore I give a brief layout how I want to make them useful for my perspective in this work.

Starting with general epistemological assumptions about reality, I follow a post-constructivist perspective in conceiving of science, technology, knowledge and nature as actively socially constructed, which means that »all human ›knowledge‹ is developed, transmitted and maintained in social situations« (Berger & Luckmann 1966: 3). However, ontologically there is a material and natural world that matters and effects social behaviour. Making sense of complex phenomena is an active process of the mind, which involves thinking in concepts and abstracting. This process is guided by »sensitising concepts« (Bowen 2006, Blumer 1954) and is socially and contextual situated in my positionality as researcher (Haraway 1988) (for a critical reflection on my positionality see Chapter 3.3).

Crucial for STS perspectives is the focus on processes of science and technology, which are always in the making and never end-points. Thus, social construction of reality is an active process that involves both, social interaction and material practices. Post-constructivism refers to heterogeneous constructions that go beyond social interac-

tions and representations on a discursive level and focus on »the simultaneous shaping of the material and social world« (Sismondo 2010: 66f.) in a process of »co-construction« (Taylor 1995). Furthermore, my perspective is anti-positivist as I want to look beyond taken-for-granted facts and evidence to avoid the so-called black-boxing of social phenomena or infrastructure. Black-boxing is not at all limited to technical artefacts, but can be found for all kind of systems and abstract configurations, where the history and background processes are obscured (Sismondo 2010: 133). Remembering the solar-home-system from the previous chapter, one does not need to know where the single components, such as controller and battery, come from or how they were assembled and interconnected for their functioning. For most consumer and even retailer these correlations become black-boxed. Eventually this work is about opening the black-box of rural energy provision by looking at its histories and processes in the making.

Turning to post-colonial theory, it is a crucial sensitising concept that has shaped and influenced my work. For a long time, there has been a lack of attention to global perspectives in STS with predominantly Euro- and North American-centric focus (McNeil 2005: 106). Still, post-colonialism is an ambiguous term with multiple significations:

> »It has been taken to signify a time period (after the colonial); a location (where the colonial was); a critique of the legacy of colonialism; an ideological backing for newly created states; a demonstration of the complicity of Western knowledge with colonial projects; or an argument that colonial engagements can reveal the ambivalence, anxiety and instability deep within Western thought and practice.« (Anderson 2002: 645)

How does post-colonial theory influence this work? The post-colonial time-space context in reference to Anderson (after the colonial period and where the colonial was) does not make it a post-colonial work. On the contrary, many geographic and ethnographic studies rather continue with »colonial« research, in reinforcing dominant and western universalist claims through research methodologies that build on differential power relations (Howitt & Stevens 2010: 42). Post-colonial theory for me is on the one hand a critical epistemological guidance towards, in reference to Anderson, the significance and ambivalence of western concepts such as development, good governance, sustainability or modern infrastructure as presented in chapter 2.2.3. On the other hand, post-colonial theory sensitises me for my positionality as a white western researcher and its implications for methodological possibilities and limits (see chapter 3.3).

I conceive the socio-technical regimes of decentralised energy in the particular spatial context in Rwanda as »multiple modernities« (Eisenstadt 2000) that represent diverse nodes in a global network. Eisenstadt sees the contemporary world as »ongoing recon-

structions of multiple institutional and ideological patterns [...] carried forward by specific social actors [...] and social movements pursuing different programs of modernity, holding very different views on what makes societies modern« (Eisenstadt 2000: 2). That is to say, multiple modernities question the singularity and authenticity of western patterns of modernity as coined by the term »catch-up development«. Instead, I want to contribute to »provincializing« (Chakrabarty 2008 [2000]) narratives of European modernities of infrastructure. Further, I want to go beyond analysing relations between the old metropole and the periphery. Instead, thinking in multiple modernities demands to break up with colonial dichotomies of global-local, modern-traditional and to focus on networks of localities that all are equally important.

To conclude, a post-colonial critique on STS addresses their foundation in the Enlightenment belief of western scientific rationality and technical expertise and its claimed superiority over all other forms of knowledge, which means the self-declared task to disseminate modernization achievements to other poor societies (Harding 2011: 2). Otherwise, a common critique on post-colonial theory is its predominant focus on historical and cultural discourses and representations that remain abstract and theoretical (McEwan 2003: 341). Therefore, attempts to integrate post-colonial theory in STS (Anderson 2002, 2009, Harding 2011, McNeil 2005) or in material geographies (Helmreich 2003, Jackson 2014, McEwan 2003) encounters both critiques, and thus formulates a critical perspective on the role of western science and technology both in the past and nowadays (Harding 2011).

3.2 Research design

This chapter is about the story behind or the making of »beyond the grid«. Broadly speaking, I was »doing ethnographies« (Cook & Crang 1995) on energy entrepreneurs in the off-grid sector in Rwanda. The main guidance for my research comes from the methodology of Grounded Theory, first elaborated by Anselm and Strauss. Its central idea is that the production of knowledge relates to the process of interpreting human action and interaction in its particular context (Corbin 2008). Thus, grounded theory is about complexity, about dealing with different perspectives and subjective interpretations of one research problem with the final objective of abstracting the different narratives to theoretical concepts. It implies an inductive process of back-and-forth between memos, textual knowledge production through interviews, technical and non-technical literature, comparing and constantly taking notes. Although I refer a lot to insights from Corbin and Strauss (2008) there is no single way of doing Grounded Theory and in many respects I decided, either for analytical or pragmatic reason, to adjust my research design. For instance, I stuck to a rather chronological research design and disregarded to some extent the core principle of theoretical sampling, which would imply a continuous alternation between knowledge generation and analysis. In my case, a pre-inquiry and sensitising for the general topic was followed by

conducting all interviews before starting the transcription. Only then I turned to the coding process and the final analysis and interpretation. However, taking memos, elaborating first concepts and readjusting the path where to go were continuous alternating processes.

In the following I present the process of generating knowledge in post-colonial setting and reflect the different interconnected steps of my research.

3.2.1 Doing research in Rwanda

In summer 1994 a long-lasting ethnical conflict in the Greater Lake region, dramatically reinforced through indirect colonial rule, escalated to one of the world's most horrible genocides. Within the short period of three months more than 1 million[5] Tutsi and moderate Hutu lost their lives, while the international community remained incapable of action.

This research project is not about the 1994-genocide and the Hutu-Tutsi conflict of the region. But how can one write a thesis without dealing with the atrocious past? Doing research in Rwanda without acknowledging its history is not possible, even worse, it would be an act of silencing the past. However, the political and societal situation is very complex and it's still a long way to go for the Rwandan society to deal with the atrocities of the time. For an extensive engagement with the past and conflict in Rwanda I highly recommend Mamdani (1996, 2001) and Verwimp (2013) apart from further reflections given by Prunier (1995), Des Forges (1999), Pottier (2002), Straus (2006), Campioni & Noack (2012). A critical perspective on current developments provides Reyntjens (2004, 2010) and for a particular rural engagement and a focus on current policies see van Hoyweghen (1999), Ansoms (2010), Ingelaere (2010) and Pritchard (2013).

Research in Rwanda is highly regulated by the Rwandan Ministry of Education, for instance bigger research projects require, like in many other countries, an authorization from the ministry[6]. For her research project on adaptation to climate change, Gebauer (2015) states that conducting interviews with NGOs in Kigali would have been rather unproblematic and possible without showing the official research permit, whereas it would have been the opposite for going to less urbanized areas. She describes that before actually having reached village-people on household level, she would have needed to pass all administrative levels with an appointment to explain her aim and show the permission (Gebauer 2015: 8f.). Other colleagues would have made the experiences of being asked to provide »a full list of people to be interviewed, along

[5] The number of total deaths varies according to different calculation methods between 500.000 (Des Forges(1999), 800.000 (UN report) and 1.100.000 (Reyntjens(1997).

[6] http://www.mineduc.gov.rw/fileadmin/user_upload/Application_for_Authority_to_conduct_Research_in_Rwanda.pdf

with their contact details« and to sign a mandatory »document where one would agree to provide a copy of all interview recordings and personal notes to the ministry« (Gebauer 2015: 10), which would have meant severe ethical concerns regarding the anonymity of participants.

Finding the right interview partner

The way of selecting participants can best be described as some kind of purposive sampling (Micheal Patton 2015). On the one hand, I was eager to achieve a high variation of perspectives, on the other hand I made use of snowball sampling by asking for further references to interesting people after each interview (Bradshaw & Stratford 2010: 75). Accordingly, I arranged most interviews on the phone for the following day by referring to the corresponding contact person and giving a brief presentation of my research purpose and interview interest. Although I spent over one month in Rwanda for the research, I conducted more than half of the interviews within three days in my last week. At that time I had almost given up hope on the whole project, which retrospectively reflects the time consuming and difficult task of gaining access and building up a network of participants (Cook & Crang 1995: 13ff.). The short time frame, though, did not allow for a theoretical sampling in the sense of grounded theory, where I would have evaluated already the first interviews and then gone for further participants to meet a theoretical saturation.

Tab. 8: Overview on interview participants

#[7]	Name[8]	Profession	Date	Length (min.)	N° Codings
0	*Eric*	*Private Sector Consultant (specialised on renewable energy)*	*28-09-2015*	*30*	*no transcript*
1	Jamal	Biogas (+ solar) entrepreneur	29-09-2015	50	57
2	Made-leine	CEO of *Ecotricity** (Small Rwandan solar entrepreneur)	29-09-2015	60	91
3	John	CEO of *Sun House** (Rwandan solar systems distributor)	30-09-2015	80	93
4	*Anna*	*International Executive Assistant at Sole World** (International private solar business)	*1-10-2015*	*20*	*no transcript*
5	Cécile & Max	National engineer + international consultant at GIZ-programme EnDev	1-10-2015	60	81
6	Gilbert	Programme Coordinator at Rwandan Energy Group (REG)	1-10-2015	90	128
7	Jean-Bosco	Manager at *Light Life** (Small private international solar lighting business)	6-10-2015	37	73
8	Eric & Laurent	Country Manager + Technical Coordinator (international NGO working on Rural electrification)	6-10-2015	60	69
9	Lydia	International Project Manager at *Sole World**	6-11-2015	60 [9]	120

Source: own compilation.

In total I met for 10 conversations: two short informative talks and eight recorded interviews as indicated in Tab. 8. The choice of participants strived for theoretical saturation, as far as possible, to explore multiple perspectives on my research topic (Cook & Crang 1995: 12). As such, I tried to integrate diverse positionalities such as origin (Rwandans and non-Rwandans), size of business involvement and public vs. private sector.

Generating research material

Qualitative research is a multiple-constructive process, where the researcher constructs theories out of stories from participants, who themselves try to explain and make sense out of their experiences and lives (Corbin & Strauss 2008: 10). Apart from

7 Quotes from interviews refer to this table (N°# Name of participant: line in transcript).

8 All personal names are pseudonym, because they are not of particular importance for the later analysis and I want to keep equal anonymity of all research participants. Names of companies are either pseudonyms and therefore always marked as »*« in contrast to international organisations and public institutions that are indicated correctly as they are of higher institutional importance.

9 Only partly recorded.

technical literature, it builds on non-technical literature (Corbin & Strauss 2008) that was gathered in the research process and transformed to text for the later analysis. It consists of material, mainly in the form of interviews, but likewise of memos and scratches I made during the whole research process as well as documents and webpages that mostly served as background information. I use the term ›data‹ for all the generated materialised knowledge of my research process to emphasise that all, data, statistics and text, are always socially and culturally constructed (Cook & Crang 1995: 30). Data is always the result of giving meaning and interpretations of the world. In the case of interviews these interpretations are »created, confirmed, or disconfirmed as a result of interactions (language and action) with other people within specific contexts« and are therefore intersubjective (Dowling 2010: 35).

For the interviews I used a guideline of topics (see App. 2, p. 134 for the interview guideline with energy entrepreneurs), which I adjusted according to the different participants. The guideline did not determine single questions but rather helped to structure the conversations in order to make sure to talk about the same topics. In addition, talks after the interview that were no longer recorded often contained very interesting statements that I recapture in my post-scripts afterwards. I established mainly fully commented transcriptions of all recorded interviews in the original language without a further translation, which was very time-demanding. Some quotes in the following chapters are adjusted for the sake of readability.

Coding – transferring words to concepts

«Coding helps to reduce data by putting them into smaller ›packages‹« (Cope 2010: 284). A step so obvious in many qualitative research designs that hardly anyone really focusses on the methodological work behind it.

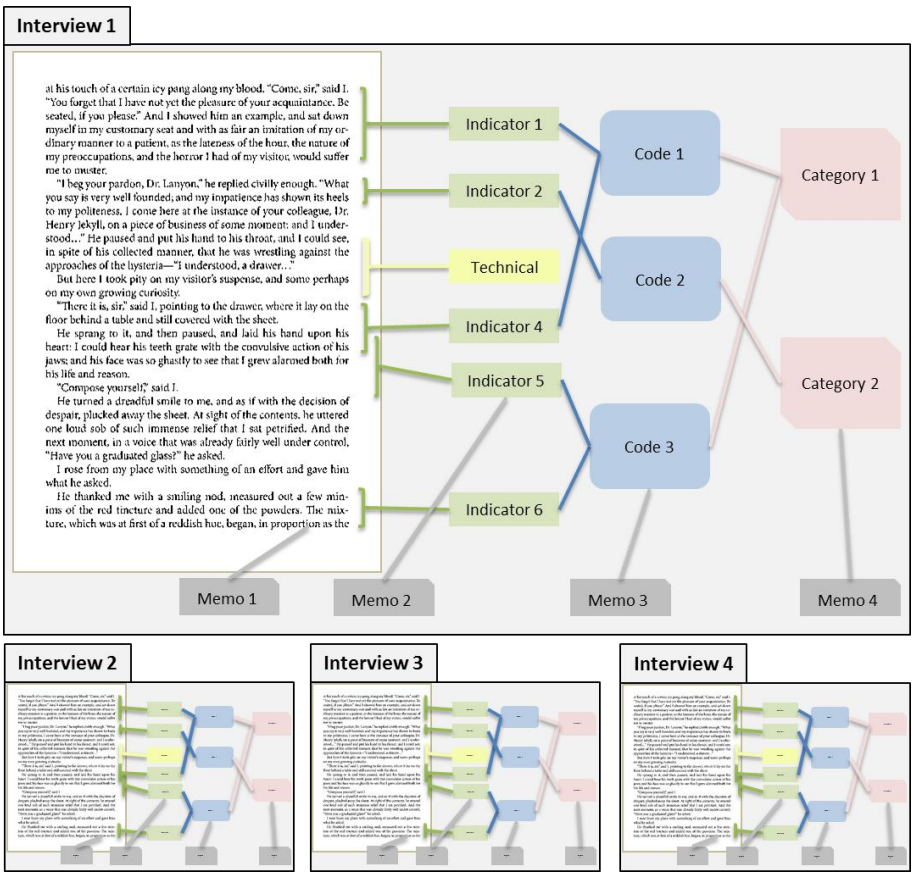
Actually, it is the process of conceptualizing data, of identifying its essence or at least what I believe is indicated by the data (Corbin & Strauss 2008: 160). Inspired by Corbin & Strauss, I developed my own step-wise procedures for elaborating conceptual theories out of my generated text, which is visualised in Fig. 2. Technically I worked with the software in MaxQDA. In the beginning, I elaborated initial concepts separately for every interview, which I only merged later for the analysis, described in the succeeding chapter. Although the interviews were already structured by my guiding interview-topics, this approach still allowed for an indicative break-up of the data.

The first step is to develop indicators, also called manifest or descriptive codes (Cope 2010: 282f.) that summarise the core argument of a sentence or smaller passage. It can even be a pointer to a special form of wording or the framing of a situation, for instance if a participant has used abstract economic terms for describing the setting of retailer relations to customer in a rural area. Moreover, indicators are always unique and refer to one single text line (coding). The main objective is to bring all indicators on the

same theoretical level and, if necessary, translate them into English. As this is a huge interpretative linguistic step the theoretical abstraction remains low and rather descriptive. One could have skipped this step; however, it makes the following ones much easier and allows getting back fast to crucial parts.

For interpreting and abstracting the ideas contained in indicators I develop concepts (also called »analytical« or »latent« codes (Cope 2010: 282f.)) in a second step. It demands a higher abstraction from the text, which is more generally applicable and which may even regroup few indicators. Following Przyborski & Wohlrab-Sahr (2014) my concepts are made of concise phrases expressing the essence of an idea rather than of a single word. In addition to that, memos again help to explain and keep my thoughts to one concept in more detail.

Fig. 2: Sketch of Indicator-Concept model



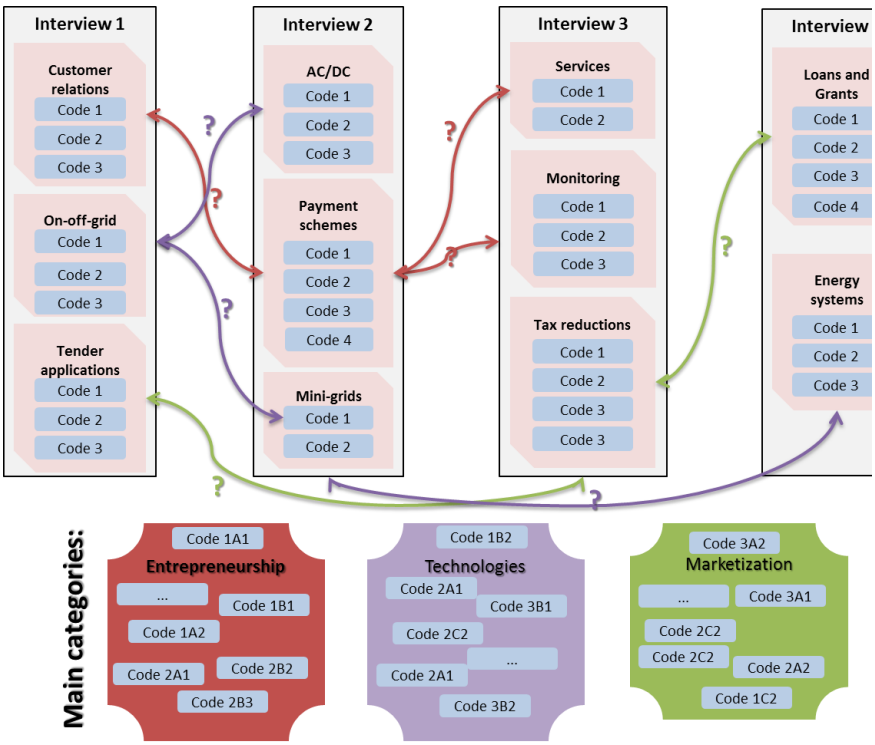
Source: Own representation.

In a third step, I regroup concepts to higher-level or main categories that consist only of single words to make up a theme or headline in order to regroup all the different concepts. Not everything being said has a deeper meaning to it. For instance information on price or the power of a system remains in one common category: technical. Furthermore, for conceptualising and analysing complex and interconnected technical processes or systems, the use of properties that specify single aspects of a category and dimensions that show variations of these properties helps to include crucial aspects of lower theoretical level.

Analysis

Coding is about breaking up the data into bits and pieces and inventing systems for ordering. So far, there are eight separate systems of ideas and arguments each referring to one narration developed from an interview. Therefore, the analysis represents the assemblage to the final system. It means to connect the different pieces, by comparing the different segments for common points and differences as illustrated in Fig. 3.

Fig. 3: Sketch of constructing main categories



Source: Own representation.

Concepts of similar categories are related to one another and regrouped under a new axial category that is generally applicable. In grounded theory, this process is referred to achieving theoretical integration and eventually finding the one core category that subsumes all other categories (Corbin & Strauss 2008: 103). In practice, I was literally puzzling like Cook & Crang (1995: 83) already did in the 90s: I assigned each interview with another colour, printed them, cut the different categories apart and assembled them in a new order and transferred this to the final MaxQDA project I was henceforth working with. The idea of colouring is that the different narratives are not interchangeable and albeit the mixture of different interviews I could always relocate each concept to its source.

In contrast to Corbin & Strauss, who express the objective to demarcate one single core category embracing all relevant aspects of the study I identify three sub-core categories that build the bases for the final research questions. The coding is a pure inductive bottom-up process with the aim to discover axial categories. For the analysis, however,

I work top-down coming from the identified core categories trying to identify all relevant aspects for answering the postulated research questions. This demands a final selective coding to identify the crucial aspects relevant for the core categories while leaving beside other interesting but not relevant aspects.

The three core categories are *technologies*, *entrepreneurship* and *market creation* that all together and only in their interplay manifest in the current energy provision in Rwanda. For breaking-up and opening the black box of decentralised energy I want to look at and analyse its single components. One should mind that components are more than technology: they comprise as much practices or regulations as material elements. Similar to large technical systems I conceive of the provision of energy as a complex socio-technical arrangement, where one component influences or even determines the functioning of the whole, and hence changing one component would change the whole arrangement. The final coding-system with all interviews brought together at the level of the main categories, axial categories, categories, dimensions and properties are listed under App. 3 (p. 135).

3.3 Critical reflection

Before presenting the results in the following chapters, I want to critically reflect my methodology, particular challenges and their implications to discuss the value of my results.

Insisting on a researcher's objectivity builds on an old myth of a positivist epistemology, where the researcher appears as an invisible and passive observer. This research is surely highly influenced by the way I approached the research problem as well as perspectives and concepts I acquired throughout the years. Even more, my background and theoretical understanding provided the mental capacity of doing the research the way I did. Therefore there is a certain sensitivity of putting me into the research context, of staying open-minded especially in a multi-cultural context, where I visibly emerge as a stranger (Corbine and Strauss 2008: 32-35).

Conducting interviews and interacting with participants are social processes and therefore always intertwined in relations of power. In neither cases the interactions were actually reciprocal, nor were they characterised by a strong asymmetrical relationship, like potentially exploitative or inferior (Dowling 2010: 31f.). However, the differences in the social relationship influenced the interaction of the talks. For balancing best the situation, I adjusted my presentation for example between »being a researcher« or »being a student« or as being more or less well informed about the topics. All participants were either entrepreneur as head of their own business or, in case of bigger institutions, employees. Unfortunately, I could not arrange an interview with an engineering company installing hydro mini-grids; still, I reflect hydro power and solar power to similar degrees. In general, it was much easier getting interviews with business people,

especially Rwandans than with public officials or international development experts. The biggest power asymmetries pertained to language differences. For the French speaking interviews the participants were mostly more eloquent and I had more difficulties in structuring the interviews than the English or German ones. Some of the Rwandan entrepreneurs might have hoped for business contacts, which I could not provide. Albeit the asymmetrical power relationships in the research setting, these relationships were complex and different in every setting. For instance, all participants were somehow internationally mobile, with fairly divergent personal backgrounds. In conclusion, seniority and linguistic influenced most the social relationships.

Although this research does not engage with the post-conflictual situation, the particular context influenced the whole research process in the sense that certain topics are left unspoken and certain research practices undone. However, I want to contribute to telling a narrative beyond the genocide in Rwanda to show that there is more to talk about than the past. The setting of the research problem, the way of approaching participants for interviews was highly influenced by the past and current policies concerning research in Rwanda. Without knowing my further research participants beforehand, my approach remained rather explorative. In addition, I decided to focus on business people within Kigali. In consequence, I did not engage with people on the household level, which would have been the final users of solar-home-systems. Engaging with consumers in an appropriate way would have required much more time and effort including personal assistance for gatekeeping and translation. It would have meant visits and conversations at the participants' homes and thus entering their privacy, which I estimated as critical due to my positionality. The analysis therefore does not deal with the direct impacts of energy systems in rural areas but on the making of it.

«Research is always bound up in networks of power/knowledge and is, therefore, inherently political« (Cook & Crang 1995: 17). Differences in race in the research processes were of course obvious. Eight out of twelve participants were black, most of them coming from Rwanda. I found myself in the privileged position of being able and having the capacities of doing this ›fieldtrip‹ and to visit them in their environment, which, conversely, would not be possible for all of them. This means that global patterns of inequity do not only become obvious with regard to the research problem, but the research itself is inevitably framed in these patterns. By positioning my work in the field of post-colonial Technosciences, I want to investigate and question lasting power relations that emerged in the wake of colonialism (McNeil 2005: 108). However, I do not claim it neither to be »decolonizing« with the attempt to break down asymmetrical power relationships nor as »inclusionary« that tries to empower subordinated others (Howitt & Stevens 2010: 42).

In conclusion, my narration on energy provision beyond the grid is influenced and to some degree dependent on the interview participants and resources I could accessed. Due to the limited time frame and the political decision to avoid interviews with consumer in rural areas, the results have very much an explorative character. Nevertheless, I evaluate the findings and arguments as highly valuable and representative in delineating the broad variety of topics and critical developments in this field.

The following three chapters present the results of the analysis. They unfold by first giving a brief overview of their most relevant components, which will then be discussed in more detail. Finally, I reassemble all demarcated components to analyse their interplay.

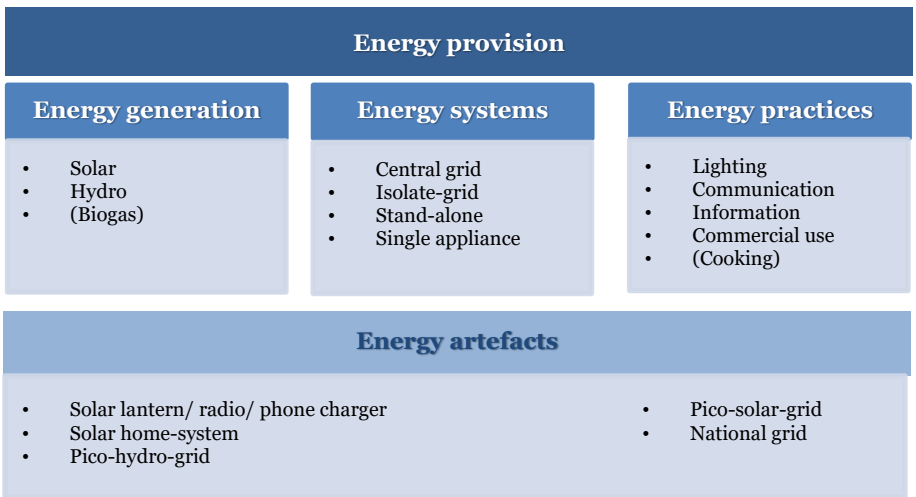
4 Technologies of power

Energy materialities constitute technical devices and systems that shape and are shaped by forms of social organisation and social practices, ranging from small single devices, such as solar lanterns, to large technical systems like the centralised grid. In this chapter, I want to analyse the spatial challenges and implications of different technologies of energy provision. They similarly include energy generation, distribution and usage, in the specific socio-political context of energy beyond the grid. I conceive energy provision as a »socio-technical agencement« (STA) (Çalışkan & Callon 2010), which is comprised of heterogeneous components, regardless if human, non-human, textual or cultural. In the following I break up this complex STA into three interrelated elements, namely, technologies for the *generation of energy*, the social organisation of distribution and *supply systems*, and *daily practices* of energy usage, as visualised in Fig. 4. In this way I want to identify the impacts of single components on the specific functioning of energy artefacts.

First, I briefly present the individual components, and then I enter into discussion on the advantages and shortcomings of the different components in comparison. Finally I look at the effects and the interplay of all components in the final products.

4.1 Energy materialities

Fig. 4: Overview on socio-technical components of energy provision



Source: Own representation.

The following overview does not provide an in-depth technical explanation or definition of the different components, but highlights the aspects that matter with respect to this study. I start with forms of energy generation, continue with different forms of ownership and organisation of energy systems and end with practices of energy – or, to put it as Shove & Walker, I ask what work do these energy materialities enable to?

Forms of energy generation – techniques

Energy provision in Rwanda is predominantly made up of electrical energy, biomass, gas and diesel. In this study I focus on off-grid energy, and thus mainly on electricity generated with solar and hydro power. Nevertheless, I draw comparisons to other energy sources, such as fossil fuels, or other systems of distribution like the national grid. Additionally, I include some considerations on biogas that emerged out of the material and which might be interesting for further research. The main primary source for electricity in Rwanda, both for off- and on-grid, is though hydropower with a total of 52 % followed by fossil fuels (gas and diesel) with 43 % and solar power with almost 5 %. All in all they add up to a total of 187.6 MW of installed capacity (of which about 150 MW are available), mainly distributed within the national grid (see Tab. 9, Rwanda Energy Board 2015). My research problem, however, deals mainly with energy provision beyond the energy forms listed in Tab. 9, except for the 0.9 % off-grid hydro power of the total installed capacities. Nevertheless one has to recognize that REG actually includes off-grid energy in its national provision calculations.

Tab. 9: Electricity generation in Rwanda 2015

Energy forms	Installed capacity (MW)	%
On-grid Hydropower Plants	78.73	42.0%
On-grid Thermal/Diesel Power Plants	37.80	20.2%
On-grid Thermal/Methane Gas Power Plants	28.60	15.2%
On-grid Solar Power Plants	8.75	4.7%
Off-grid Hydropower Plants	1.70	0.9%
Off-grid Thermal Power Plants	14.00	7.5%
Imported (Hydro) Power	18.00	9.6%
TOTAL	**187.58**	**100.0%**

Source: Rwanda Energy Board 2015.

Solar power can either be used for generating electricity or heat for warm water, less for heating rooms. The focus remains on electricity generated either using poly-crystalline or thin-film silicon photovoltaic-panels (PV). Therefore, the final products covered in this study range from about 12 W lanterns to maximum 300 W systems. *Hydro energy*, on the other hand, makes use of mechanical energy for running turbines to create a relatively stable supply. As mentioned before, hydro does not constitute an alternative energy source as it is the dominant one in Rwanda and is used both for the national grid as well as for pico-grids (usually around 15 kW hydro-grids). Many studies on decentralised energy, actually deal with *biogas*. Biogas digesters make use of organic waste for cooking or heating facilities, which can be used either in bigger institutions such as schools and prisons (Safari 2010: 527), or in small-scale for households. Rural households with at least two - three cows could produce enough waste for one digester that could substitute firewood or charcoal. Costs are around 1.000 – 1.300 USD which is supported by the National Domestic Biogas Program (NDBP) that gives loans to customers, but still the financing remains problematic and the programme is not running properly, according to a national biogas entrepreneur (Jamal, N°1: 85-103). Albeit the difficulties, the use of biogas is interesting due to the importance and prevalence of pastoralism in Rwanda. Nevertheless, my focus lies on hydro and solar power.

Forms of energy systems

Different forms of energy systems or infrastructures contribute to the production of scale (Furlong 2011: 466), which I do not conceive as a given entity but as socio-technically constructed for instance by the size and the form of organisation of energy provision. The centralised *national grid* in Rwanda consists of a transmission network of 253 km of 110 kV lines and 96 km of 70 kV lines that connect the main regions (North, East, West, South and Kigali). Additionally, sub-stations of high and medium voltage distribute electricity to the main urban areas (see App. 4, p. 139). Though the map is out-of-date, one can clearly identify the many white spaces that are not connected by the power lines, and hence remain off-grid and are of interest here. *Isolated-grids* delineate networks run by small hydro or solar power plants that are able to supply smaller villages or community centres of about 100 households although the total number may vary. Other common terms are mini-grids, village-grids (EnDev) or even pico-grids. *Stand-alone-systems* usually refer to one single household, where they are spatially fixed and form a clearly bounded limited system of one power source and a few devices. However, in theory they build ›mutable mobiles‹, because they can be moved to another place and, in addition to that, single components can be exchanged. In contrast, *single appliances*, like solar lanterns, can be considered as »immutable mobiles« (Latour 1987) that form a hybrid of power generating and practical end de-

vice. While the device itself is handy and mobile, it can rather not change its form or functioning.

Practices

Due to the limited capacities and different sizes of energy systems, their use is often limited to single activities. Probably the most prominent activity is lighting, particularly in the evening due to the early dusk around half past six. Light would improve the feeling of security (N°9 Lydia: 62), make it possible to work or learn after dark at home or run small businesses like shops or bars in the evening. At least of similar importance is the capability to charge phones in order to be permanently accessible or use any other mobile services, regardless if via smartphone or simple mobile phone. In general, information and communication technologies (ICT), including radio and TV, put a high demand on electricity either for receiving current information and news or for entertainment. Then, next to the possibility to work with light, there are many commercial activities that need electricity such as hair cutters, music shops or a phone charging stations, where people can go and charge their phones in lack of a proper charging possibility at home. More sophisticated off-grid technologies relate to household activities such as electrical cooking, or using a fridge for cooling, or heating water for the shower. The significance of the different practices will be discussed under chapter 4.4. Up to here, dealing with restrictions of practices is a fundamental difference of mall systems compared to large technical systems or even bigger mini-grids.

Energy products

The practices and activities described can be provided by different types of products and systems. The smallest products are single-solar-devices that combine a small solar-panel and a battery with one or two output appliances such as a simple solar lantern, a solar radio or hair cutter. Some of them even provide a low voltage output for charging phones. Needless to say that these products don't replace a centralised grid but they substitute other conventional products as Jean-Bosco, one of the energy entrepreneurs, states:

> »For us, it is really the replacement of cheap torches, candles, and in some cases kerosene. So you see in some cases, kerosene is really in the decline now, because of the higher prices and the availability of cheaper alternatives. But those are competitors and the advantage over all of them is either economic, so it's a lot cheaper to buy this per week than to buy batteries for your torch. Quality; the quality of the lights is intimately better than a candle or kerosene and also of these cheap torches.« (N°7 Jean-Bosco: 31)

Another group of products comprise small household systems like solar-kits that generate electricity, or solar-water-heater. Solar-kits (see Fig. 5) can vary usually between capacities of 12 to 300 W and run on DC so that most appliances, like LED-lights, radio or TV, usually come with the system. Solar-water-heaters (SWH) are much less common and given the need for water infrastructure. Hence, they are mainly installed in urban areas that already have an electricity connection. Owing to this, I'll focus more on the electrical off-grid solar-home-systems (SHS) that cover most of the practices described above. The most advanced capacity for off-grid electricity, though, constitutes mini-grids, both potentially using solar or hydro. One hydro-plant or several solar-plants connect smaller villages up to a few hundred households and balance the power between the different customers. A very good mini-grid could actually provide a better stability than an unsteadily running central-grid, so that at least at household-level it presents not only an alternative but in some areas even the better solution, affirms an international expert from the GIZ Energising Development programme (EnDev) (N°5 Max: 65).

Fig. 5: Presentation-kit for a 80 W solar-home-system

Source: R. Kranefeld 2015.

The following chapters discuss socio-technical considerations on the different forms of energy provision and supply. First, I focus on the implications and differences between solar and hydro power and introduce the term energy spaces, which I will discuss in the second chapter. The third looks at how energy beyond the grid co-constitutes daily practices, while in the fourth chapter I examine in how far they present sustainable and alternative technologies.

4.2 Battle of the systems

» *We're talking about the thousand-hills-country. Between two hills, there's usually a small river, so there is a possibility to have a small pico-hydro. (N°8 Laurent: 22)* «

Hydro power is dependent on absolute geomorphological conditions as it cannot be generated everywhere, and moreover, its energy potential is quasi-limited as rivers cannot supply endless power plants. Although hydro-grids can store a certain amount of water as potential energy, depending on the site this water is exposed to evaporation, especially on dry days. Otherwise, water needs to flow even if there is no need for generating electricity. Still, the mountainous structure of Rwanda provides a high potential for pico-hydro-power plants. In addition, geological aspects like the condition of the soil similarly influence the construction of plants, though, never determine them. While physical landscape conditions influence the energy potential of different energy forms, these landscapes can in turn be transformed to improve the energy potential or to get access to energy sites at all. Solar energy has the spatial advantage that it can be installed almost everywhere, unlike other technologies such as hydro or wind. Apart from geophysical conditions, other aspects such as existing infrastructure, like road access to a river, political will and the support or rejection of local residents can have high impact on the installation of energy sites. Bridge et al. (2013) propose the term »energy landscapes« (Bridge et al. 2013: 335f.) to emphasise the interplay and interaction of natural, technical and political or cultural aspects that mutually constitute the suitability for generating energy at a certain construction site, and thus oppose a certain place determinism. In the following, I will use the even more general term ›energy spaces‹ to demarcate it clearly from any predominant physical landscape connotation.

Time has another impact on the functioning of energy systems. Solar's dependence on the sun manifests in different times of the day, whereas hydro power is dependent on different seasons of the year. Most time of the year there is at least some or even a lot of rain in Rwanda allowing steady flows of water, but up to three months, namely June to August, can remain very dry, and therefore bring about severe difficulties for the generation of hydro power. Albeit the possibility to store water in dams, it evaporates fast during sunny days and the energy potential declines. For solar energy, the use of batteries can help to balance time shifts of energy generation and ›consumption‹ and stimulate an economic use of the remaining energy. For Hydro power, in contrast, an economic use of water, in the sense of running at half-power is, at least for small plants, not possible. Instead, limited water capacities can rather lead to hydro plants running only for some hours, yet under full power. A Programme Coordinator at the Rwandan Energy Group describes how during one visit at a hydro-plant the machines went off due to a lack of water. The operator then would have stocked some water and

put it on just in the morning from about 6 to 9 am, so that people could have done some work. In this regard, the physical shortage is interlinked with social norms of practices that manifest in power peaks in the morning.

The temporality of these renewable energy forms can be related to a common discussion in ecological economics whether to conceive of energy (or natural resources in general) as *capital* or *income* as expressed for instance by Ernst Friedrich Schumacher:

> »The illusion of unlimited power, nourished by astonishing scientific and technological achievements, has produced the concurrent illusion of having solved the problem of production. The latter illusion is based on the failure to distinguish between income and capital where this distinction matters most. Every economist and businessman is familiar with the distinction, and applies it conscientiously and with considerable subtlety to all economic affairs - except where it really matters - namely, the irreplaceable capital which man had not made, but simply found, and without which he can do nothing.« (Schumacher 1973: 3)

Fossil fuels typically constitute *capital*, whereas hydro and solar powers in form of a continuous flow of radiation or water stream represent a limited but theoretically regular *income*. In practice, to power a device is irrespective of its energy source; however, its condition either as capital or income can influence practices and norms of efficiency and effectiveness. Apart from time-space arrangements, a striking difference between solar and hydro power concerns the related electrical current systems, which eventually impacts the range of devices used in the systems. Admittedly, the so-called ›battle of the system‹ between alternating-current (AC) applied in most grid systems, and direct-current (DC) used for instance in solar-systems, is as old as the history of electricity. It already played a salient role in the development of large technical systems:

> »By the end of the 1880s, Edison's direct-current system faced substantial competition from the more recently developed alternating current system. [...] During the closing years of the eighties, technical journals and even the popular press kept readers informed of ›the battle of the currents‹, or ›the battle of the systems‹. Professional societies held debates concerning the merits of each system, and engineers and station managers filled the technical journals with articles proclaiming the technical and economic advantages of one system as compared to the other. The debate continued until the 1890s, with low-voltage direct current competing against single-phase alternating current for the incandescent lighting market.« (Hughes 1983: 106)

At the time, both systems have had their advantages and but also one great drawback: for DC it is the high costs for long-distance transmission, for AC the lack of a practical motor. Primarily the conflict was based on technical and economic arguments that depending on the density of a region – heavy populated city versus sparely populated

towns – favoured the one or the other system. But in many regions, no straightforward decision could be reached and arguments went far beyond rational decisions and were more and more dependent on personal influence and power. Hughes emphasises that technology is always contested, and hence technological change goes beyond the decisions of engineers and cost accountants (Hughes 1983: 106 ff). Eventually, the resolution of the battle of the systems was the invention of the ›universal system‹ that emerged out of the two conflicting ones and made long-distance high-voltage transmission possible (Hughes 1983: 134 ff).

With respect to the capacities of hydro and solar power, it can be seen as a revisit of the AC/DC-battle, as solar power generates DC, whereas hydro power generates AC. As long as the current is not transformed, all appliances that run on solar are specifically developed for that system. It needs a specific DC-TV, DC-phone charger and DC-LED lights that come with the finalised system and cannot be replaced individually by conventional products that run on AC. Thus, they constitute closed-systems that on first sight contradict a capitalist ideal of freedom of consumption and endless growth. In addition, small DC-solar products only run for a limited amount of hours, depending on their electricity consumption. Transforming DC to AC makes no sense for small-scale devices, like for household-kits, due to energy efficiency losses. However, the larger the system, the bigger the significance of the decision on the current type in light of the impact it has on the users' practices. Especially for solar-mini-grids it is an ongoing topic whether to remain within a closed DC-system with exclusive DC-devices, which consequently allows higher control and better regulation of the system, or to convert the power to AC and hence give more autonomy to individual households. Other technical aspects are load stability, reliability of the technical components and their maintenance, which are all linked to temporal and spatial aspects mentioned previously.

In conclusion, all these aspects are relevant for taking a decision between hydro and solar energy provisions. Due to the AC system of hydro-grids, they come closest to the centralised grid and provide an almost similar ›experience‹ of energy materiality. However, the development of DC devices that for instance come along with USB-ports, like many mobile phones already do, would be a possible development to push solar-systems.

4.3 Scales of energy spaces

The first and probably most striking reason for thinking energy provision along a five-folded tier system is that it brings quality in the discussion on energy spaces, as Max from EnDev explains: »In the beginning there was just access or no access, but a solar lamp is not the same as a mini-grid or a grid connection. So the tiers bring in some quality to grid connections.« (N° 5 Max: 44-45)

However, the different tiers are mainly determined through quantitatively measured capacity differences. Compared to the national grid, all off-grid technologies considered here use lower power sources, distribute fewer amperes and the total capacity of kWh that can be used is limited in one way or the other. However, differences already occur between basic solar systems with 20 W that provide about 5 V and bigger solar systems of 200 W that can even provide 220 V power plugs, used for example in bars that run – apart from the lighting – a fridge and a laptop and a sound system. Consequently, the bigger the system the greater the possibilities it offers. John, entrepreneur on solar-systems, confirms the technical advantages of mini-grids over solar-home-systems:

> »Mini-grids are a solution to rural areas. It's an available solution because it doesn't limit someone, [...] like if you install some solar-systems, there are some things that you can never use in this system. Like, if I put a small system of 100 W, I'll tell you: ›No, don't use an iron to iron your cloth, don't use a big machine, [...] don't use powerful things‹. But with a mini-grid with huge capacity, they can freely use it and also in a mini-grid everyone is connected to each other, the power supply is big and they can complement each other. The people are not limited to hours, like no, don't use your light more than four or five hours. Yes, mini-grids have all these advantages.« (John 03: 140)

Only business-related considerations, which I will consider later on, would keep him away from investing in mini-grids. But, technically seen, on a household-level mini-grids can satisfy similar needs as the central grid. Regarding areas with frequent power cuts, the idea of a smoothly-functioning infrastructure even becomes more the exception than the rule, explains Max from GIZ, who draws parallels with a similar project in Bolivia:

> »Related to EnDev Bolivia, the grid does not always have the quality as in Kigali. Same for some regions in Rwanda, like Nyungwe, they only have about 3 hours of grid, as there were a lot of power cuts. In this case, a mini-grid could offer a better service. That is what happened in Bolivia, some communities stuck to mini-grid as it provided a better quality than the existing grid.« (N° 5 Max: 65)

Nevertheless, Gilbert from REG states that most people would prefer having grid access, as they are more used to it than to the concept and functionality of an off-grid system (N° 6: Gilbert: 90). Furthermore, when it comes to industrial purposes such as running factories, stable and at least medium voltage power is elementary, exceeding the capacities of conventional mini-grids. However, I exclude industrial concerns from this discussion and remain with small-scale power loads.

In their very nature, networks function completely differently from stand-alone-systems. Following a comparison between large centralised networks and a »sustaina-

ble techno-ecocycle« by Coutard & Rutherford (2011: 109 f), I sum-up main aspects of the organisation of networks and post-networks. A centralised network is dependent on fluidity and interconnection, which means the electricity input and output must always be perfectly balanced to avoid blackouts. Viewed differently, this implies a territorial solidarity by balancing surplus and deficit over time and space to allow for a continuous supply of all users. At the same time, networks are orientated at economics of expansion and imply unbounded consumption as the continuous flow of goods suggests unlimited resources. Hughes (1983) argues with regard to large technical systems that the growth of a network is accompanied by two economic principles: the first is load balancing, which means growth is not oriented at size but at balancing load diversity caused by different peak times of users, and the second is to establish a complementing energy mix to exploit different conditions of energy sources necessary for basic, medium and peak load (Hughes 1983: 462ff.). Spatially seen, a network allows for a decoupling of local resources, energy generation and utilization. In other words, spatially separated they can still be connected.

Stand-alone systems, on the contrary, function on the basis of stasis and stocks that can be reduced and refilled, and thus allow only bounded consumption, which encourages economics of preservation. This brings about a (re)coupling of generation and usage of local resources, which manifests in a territorial autonomy, where the owner or community decides on the energy practices. This individualization of energy access and usage leads as well to an increased visibility of socio-economic disparities, as the condition of owning a system and having access at all depends on the financial capacities of each individual user (Coutard & Rutherford 2011: 119).

Gilbert gives an example from the public decentralisation programme that shows how considerations on ownership can motivate to very diverse motivations:

> »Je crois que, selon mon expérience, les gens aiment les installations individuelles beaucoup plus que les mini-grids. Parce que, quand c'est communautaire, [...] les gens ne sont pas indépendant dans leur décision. [...] Le seul avantage, c'est que, quand on est ensemble en association ou en coopérative, on peut recevoir des aides des organisations, qui disent on veut aider des gens, qui sont en coopérative. Ou, par exemple, s'ils veuillent prendre un crédit à la banque, on peut considérer la garantie de la solidarité. Il n'y a que ça. Mais, pour la gestion, moi, je vois que les gens veuillent avoir leur installation
>
> »I think, to my experience, people prefer individual installations much than mini-grids. Because, if it's communal the people are not independent any more in their decision. The only advantage of being together in an association or cooperative is the help of organisations that commit themselves to help people of cooperatives. Or, for example, if they want to get a credit at the bank, they can count on the solidarity for the guarantee. But that's it. But in terms of usage, I see that people want to have their own installation, especially the subsidised installations, because they can sell it again. I received aid to buy a system for which I

propre ; et surtout pour les installations subventionnées, les gens peuvent vendre ça. [...] On m'a aidé à acheter une installation où je paye seulement la moitié et après quelques temps, je vent. A un moment donné, dans un village, l'investissement était mille et ils ont vendu aux autres personnes à prix très bas, parce qu'il a eu besoin de l'argent. Un jour, [...] il commence encore une fois à allumer le pétrole et des bougies.«

only paid half and after some time, I sell. Once the investment in their village was thousand and they have sold to other people for a very low price, because they were in need of money. And then one day they start again lighting with kerosene and candles.« (N°6 Gilbert : 9)

Selling a subsidised product in need of liquid money is a typical example of practices that »overflow« (Callon 1998) the initial contract between customer, engineering company and donor[10]. This example shows that people are engaged in many social worlds and that the one of receiving energy can never be wholly detached from other involvements. Instead interests can flow in many directions and from one world to the other (Callon 1998: 253). Being independent in one's own future decision that might differ from the current one could be one reason for the attractiveness of individualized standalone systems, compared to networks based on principles of solidarity.

Regardless of the differences between ›post-network‹, ›off-grid‹, ›decentralised‹ or ›beyond the net‹, all terms delineate spaces in relation to a centralised network, which historically became the dominant form of electrical infrastructure. While ›off-grid‹ and ›decentralised‹ are dualistic terms, energy ›beyond the grid‹ similar to ›post-network‹ make it possible to describe spaces that are connected without being connected, that are neither fully ›on‹ nor ›off‹ and still only exist in relation to the two extremes as something in the middle and so I use the last two terms interchangeably.

Post-networks usually emerge in spaces that firstly are completely off-grid and secondly, where there will be no on-grid connection in the near future. In this way it combines physical conditions with political considerations of residents or utility managers, who consider the chances for a grid connection in the near future and therewith the chances for alternative forms of connection (N°9: 58, 102). From the perspective of a utility manager, reasons for not installing the grid would be too long distances to the next grid pole or too high investment costs, due to only few potential new customers (N°6 Gilbert: 90). Thus, spaces beyond the grid emerge out of socio-technical processes; however, these do not follow any straight logical rationality, but are always contested and outcomes of negotiations and diverging interests, as Max delineates.

»There are no real plans, where the grid will be, but it's a [...] process. You have certain areas that are marked as end of this year, some for the next year and it's

[10] The relations between the different agents will be discussed in more detail later in chapter 3.

> always budget dependent. Depending on how much money is spent on the grid extension, and there are also shifting priorities, if there is a new company that wants to settle somewhere and which uses a lot of electricity then the utility might just connect that one. Because they want a productive use of energy as they have more consumption. In our collaboration we sit down with someone from the Grid extension programme from REG and we get the GPS coordinates of the site so that we can share it. First, they tell us if they tend to electrify yes or no and it might shift their priorities. If they for example know, that there will be a hydro-power plant, then there's no need to connect it to the grid.« (N°5 Max: 31)

Although there are some basic rules such as prioritising the grid enlargement in areas in reach of 5 km to the grid (N°6 Gilbert: 23), in practices the outcome might be arbitrary situations, where people actually live in sight of the transmission net but don't have a distribution pole to get connected, as the private solar distributor John tells:

> »We find people that live close to the grid and that have connectivity, but like 15 meters behind, they are far from getting the grid. I was also told by someone that there are people 5 km from the pole, they won't get the grid in the next five years at least. […] So it's very difficult to get the grid to them and we're having people that are twenty or thirty kilometres from the pole. We are having people that are like close to the pole, but they are not having the grid and don't have hope for electricity. So, for these people it's the same. They are near connection, but with no grid.« (N°3 John: 47)

However, post-network connections do not linearly derive from on-grid enrolment plans, but influence them likewise. When two regions are in consideration for a grid-connection and one, for instance, is favourable for a mini-grid construction then the grid-enrolment could prioritise the other one, explains the technical coordinator of an international NGO on rural electrification.

> »If this is well done, then that area has no reason to wait for the government to bring the grid there. So it's a solution, and then there's no need to go there, they can prioritize other areas. So, it's a matter of quality, how things are done and if people are satisfied. If they are not satisfied at the end of the day, they will call the government to come up with the grid.« (N°8 Laurent: 24)

A further scenario emerges, if eventually the grid arrives at former post-network sites. Depending on the current-system, power plants can be integrated into the national grid through a feed-in tariff. For example, three off-grid hydro-power plants from the EnDev-programme were within the reach of the grid at the end of their construction period and consequently were integrated into the grid (N° 5: Max: 15). However, in case they are not compatible, the off-grid plants can still function as back-up systems, complementing the other one. For instance, solar-systems could primarily be used

during power-cuts, or the other way round, the national grid could only be used, when batteries for solar run out. Another option would be to relocate the ›off-grid‹ system to a new site that is not connected yet. However, bigger solar-systems, in theory ›mutable mobiles‹, can present themselves as only semi-mobile. Gilbert points out that in consideration of high costs and efforts for the reconstruction of systems, including breaking up concrete-pillars and cutting metallic constructions, they preferred refunctioning them as back-up systems (N°6 Gilbert: 31). Having a back-up is likewise interesting for people already living with the grid, due to frequent power cuts (N°3 John: 49, 138). Beyond that co-existence, stand-alone-systems and the grid can complement each other (N°3 John: 49, 138) such as solar-water-heaters that only work with water-connection (N°2 Madeleine), or biogas-systems that replace more expensive electrical cooking facilities in the city (N°1 Jamal: 44).

Tab. 10: Adjusted tier-typology

Attribute		T0	T1	T2	T3	T4	T5
1. Capacity	Power		Very low min 3 W	Low min 50 W	Medium min 200 W	High min 800 W	Very high min 2 kW
	AND Daily Capacity		min 12 Wh	min 200 Wh	min 1 kWh	min 3,4 kWh	min 8,2 kWh
	OR Services		Basic Lighting and phone charging	Lighting, radio and television, and phone charging are possible	cooling (fridge), laptop, water heating	unlimited	unlimited
	Systems		*single appliances*	*Weak stand-alone-*	*pico-grids or strong stand-alone*	*mini-grids or bad grid*	*stable, full grid*

Source: Adjusted from Bhatia & Angelou 2015: 6.

The scenarios presented above support the argument for going beyond dualistic perceptions of on-off-grid supply, as there is more than one alternative to the national grid in the debate on energy transitions. In his comparison of network systems within separated societies, Hughes states that despite of transactions between societies such as knowledge transfer, the outcome of the system is structured differently in every society (Hughes 1983: 363 ff). In the following, I want to discuss the adequacy of the two typologies for off-grid provision presented in chapter 2.2.3 (p. 24). Starting with the five-folded tier system used by SE4ALL and others I adopted the capacity categories and integrated the different systems in Tab. 10 (similar to a proposition by EnDev N°5 Max: 43-51). Albeit the many different indicators of the full tier-typology, ›capacity‹ seems to be the guiding one. Indicators, such as ›economic efficiency‹ or ›ecological sustainability‹ are missing in this overview. They would turn this linearity up-side down, presenting tier 5 as the least efficient and ecological one. Furthermore, it is

merely impossible to clearly separate the tiers one from the other; instead the categories should be seen as fluent so that for example stronger stand-alone systems are closer to tier 3, while weaker ones refer more to tier 2.

Besides all the strengths of the tier system compared to others, the typology still remains within a classical modernisation thinking, where the highest technical capacity refers to the best solution. Therefore I argue, if one ever wants to break up the underlying bigger-is-better thinking, one must leave behind any step-wise folded representation of the world or systems. Thus, the (urban) post-network grid-typology of Coutard & Rutherford conceptually follows a different approach, which I transferred to the particular non-urban context, discussed in this study (see Tab. 11).

Tab. 11: A typology of energy systems beyond the grid

		Organisation	
		Delinking, unlinking, (local authority)	*New forms of linking (local autonomy)*
Decision	*Collective, local scale of decision*	A. Mini-grids	B. Complementary or concurrency
	Individualized (or quasi-individualized) scale of decision	C. Home system/ Solar lantern	D. Feed-in to grid

Source: Adjusted from Coutard & Rutherford 2011: 112.

I mainly adopted the organisational categories delinked/ linked and the decision categories collective/ individualised. As such, mini-grids (A) refer to systems of local solidary autonomy that are thus delinked from the grid but collective in their management and decision making. In contrast single appliances or solar-home systems (C) are individualised forms of decentralised supply. Furthermore, I distinguish between two forms of new linkages, namely first the complementing or concurrent usage of both systems (B), which keeps some local autonomy and decision with the formerly unlinked owners in the sense that they can decide on ways of back-up or mixing. Second, feed-in options transform former autarkic systems to mere energy providers and thus decouple former locally-closed networks (D). In comparison to the other typology, it only considers qualitative aspects without benchmarking them on quantitative indicators. With this adjusted grid I want to open a perspective that includes non-urban spaces without limiting them to somehow rural spaces, as especially the new forms of linkage can similarly manifest in cities as in sparely populated areas. But, in this way I question the urban transition paradigm that states that »energy transitions always work at least partly through urban processes, urban practices and urban change« (Rutherford & Coutard 2014: 1354). Moreover, I pledge for a wider perspective on energy transitions that goes beyond any rural-urban dualism, but focuses on socio-technical transitions in relation to a centralised grid. Energy spaces, even if individual-

ised and delinked from centralised supply, remain in some way relationally interconnected with other places, as I will show in the following chapters. Hence, they are never fully local.

4.4 C'est un autre monde

The choice of a product or one specific kind of system opens new spaces for specific energy related activities and possibilities. But how do particularly electrical devices change daily lives? Owing to the research focus on entrepreneurs and not consumers, such an analysis exceeds the scope of this study. However, I want to look from the energy entrepreneurs' perspective, how they give meaning to their products, which mostly reflects their motivation for doing such a business. By this, I want to show that the provision of energy does not follow a single story, but that there are various meanings given to the use and importance of energy.

In general, all entrepreneurs are convinced of the strong impact of electricity on rural livelihoods:

> »L'importance, c'est que, pour un petit enfant, il n'y a plus la fumée dans la maison, on peut faire un petit commerce, parce qu'on a un peu d'électricité, on dorme plus tard, on a une vie sociale un peu plus tard dans la nuit. Non, ça change complètement. Oui. C'est un autre monde, quand on a de l'électricité.«
>
> »The point is that at home for small children, there is no more smoke, you can start some businesses, because you have some electricity. You can go to sleep late, enjoy a social life a bit later in the evening. No, this changes completely. It's another world, if you have electricity.« (N°2 Madeleine: 53)

In the interviews, participants mentioned predominantly three aspects, on how energy would improve one's life. One refers to health in the sense that especially small solar products would substitute conventional chemical energy forms that produce a flame and smoke such as candles, kerosene lamps or open fires. The second refers to improved quality aspects: LED-lights would produce better light than flames and most systems use stronger and rechargeable batteries compared for instance to cheap torches or other battery run devices. The last point refers to opening new time-spaces of activities, such as working, studying or socialising even late after dark, or entering new spaces of activity that require energy. Typical Development narratives of this time-space enlargement are that children would from then on do their homework late at night. People would go to bed later, because now they can. As such, it defines energy-absent live as sense-less and poor, as if after 7 pm and without being equipped with a (charged!) mobile phone the day would be over. These narratives are framed by a modernity belief, which puts a techno-determinism in place of a former nature-determinism. My point is not to disclaim the manifold opportunities of the new decen-

tralised technologies; however, I want to emphasise that neither nature nor technology determine social life, but they are interrelated.

With respect to the impact of light, Gilbert pleads not to overestimate it, because daily habits would not forcefully change. For instance, many people would not be interested in reading a book at night, because they can't read and write at all (N°6: 52). So, light alone would not change anything. During one mission field trip for REG, a woman would have reported to use the solar lamp at night only for two minutes: just to prepare the bed before going to sleep – that would be it. The time of sleeping would not have changed at all (N°6: 56). On the most prominent narrative of school-children working at night, he comments that pupils in the villages would rarely repeat at home:

»Au Rwanda, les enfants dans les écoles dans le milieu rural, ils ne veuillent pas des devoirs à faire à la maison. La plupart déjà, on doit l'accepter, c'est la vérité, la plupart des enfants ils sont loin de l'école. Ils vont peut-être 3 kilomètres ou 4 et ils quittent l'école ils rentrent en courant, ils arrivent chez eux et ils aident les parents un peu et plus c'est tout.

Les gens à la campagne ils se dorment assez tôt. Même quand ils ont de l'électricité on a vu, qu'ils ne reculent pas l'heure de dormir. J'essayais de demander aussi : ›si avant, vous avez dormi à 19 h, est-ce que maintenant vous dormez à 21 h, parce que vous avez l'électricité?‹ Ils ont dit: ›non, ça ne change pas beaucoup en fait‹. Donc, la vie ne change pas beaucoup dans ce sens-là.«

»In Rwanda, school children in rural areas don't want to do their homework at home. One should accept that most of them, and that's true, live far away from the school. They maybe come 3 or 4 kilometres and afterwards they run back home, there, they help their parents with the household and that's it.

People in the country side go to bed really early; we figured out, even if they have electricity they don't shift the time of sleeping. Once, I tried to ask: ›if before you went to bed at 7 pm, do you now go to bed at 9 pm, because you have electricity?‹ They answered: ›no, this doesn't change anything.‹ So, life doesn't change much in this sense.« (N°6 Gilbert: 56)

This example does not provide any evidence on the use of electricity in rural areas and besides, there might be completely different narratives. Still, one should be careful in drawing any causal linearity between energy access and a change of lifestyle. By this I don't want to argue against any positive effects of electrical devices; however, the final use might be completely different than initially thought within modernity discourses.

While the last examples focussed around discourses of basic needs and elementary livelihood improvements, electricity can similarly be aligned to status and improved lifestyle, as John states for solar-home-systems (SHS).

»It shows the value of someone. People can say, this house is owned by someone who has light, in this house, they don't have light. […] People are feeling, ok, we

> are mattering. It's not like that kids can read and so on and women can work and that it is healthy. No it becomes lifestyle and goes beyond.« (N°3 John: 62)

In contrast to one grid, where at least in one area every household is equally connected, different sizes of off-grid systems directly reflect income disparities. In addition, new technological possibilities may shift social expectancies, particularly with regard to ICT:

> »We are in a world of communication and here in Rwanda, we have around four million people with access to mobile phones. So all these people, they want to charge. And nowadays, it's not tolerated if one's mobile phone gets off. And you find someone, who goes eight or twenty kilometres only for charging the phone. It's happening.« (N°3 John: 66)

The example illustrates how social change and technology mutually influence each other. The increased importance of communication via mobile phones has put a certain exigency on recharge-facilities. But with improved possibilities to charge phones, the expectation of mobile accessibility has shifted, too. Similar developments refer to information possibilities:

> »Previously, TV and radio was not a basic need. But now, with the generation we're in, people need to know what is happening. Even if they're in rural areas, like let's say farmers, they need to know, how the climate changes, or the cattle-keepers, they need the market prices. They need to know, how the country is, the life of the country. How people in other areas are living. How they are doing their activities. So, now it becomes a basic need for them to get access for the information. Before, where lighting was basic, you found people who had [a SHS-system]. They said, we don't need light, we need a radio. We need access to the information. For example the market in Kimironko for potatoes. If someone [...] wants to sell the potatoes at 50 RWF but they are sold at 100 RWF in Kigali, how can I get this? So that's why the need for information has risen.« (N°3 John: 64)

Though the significance of energy should not be confounded with basic needs such as water and shelter, it is in a process of turning from being a ›luxury‹ nice-to-have to rudimentary infrastructure, which becomes an inherent part of daily life. However, energy presents the basis for ICT devices and therefore energy and ICT are closely connected. Murphy & Carmody (2015) engage critically with the rising ›information and communication technologies for development‹ (ICT4D) discourse that would herald ICT as Africa's growth miracle by offering possibilities to »plug in« to globalised flows of information and capital. Despite remarkable diffusion of mobile phones in the last years, it would remain »unclear what their everyday availability and use has meant specifically for socioeconomic development« (Murphy & Carmody 2015: 2), apart from single business success-stories. Likewise, further research on spatial impacts and soci-

oeconomic developments of electrical energy provision with regard to consumers would be necessary.

The prior explications on energy practices provided various examples how daily life is shaped by technology. Actor-network-theory (ANT) provides a relationalist view on the mutual influence of artefacts and humans and conceptualises non-human likewise as ›actants‹ that have agency on humans. Typical situations are, when technology seemingly acts on its own without being comprehensible to human users. Comprehensibility of technology, then again, is closely connected with trust in technology. Particularly solar-technologies produce great black-boxes, which are subject to certain scepticism for users and even entrepreneurs, describes Laurent from the international NGO: »The cooperatives are more used to hydro than to solar, so they are more confident in hydro. For solar, they say, we never know, if it doesn't work, forget« (N°8 Laurent: 43).

John makes a similar claim. As a business-man, he himself would not know how the systems work and that one could never trust it to 100 % (N°3: 70; 136). Though, the inner workings of black-boxed artefacts, like solar-systems don't need to be understood for their functioning, they need to gain the trust of future users. In this sense, a new technology would first need to prove itself before being widely accepted. In this regard, hydro technology has some advantage over solar.

Furthermore, the expansion of a technology requires the concordant growth of all of its components or, in other words, its growth is dependent on components that don't »march along harmoniously with other components« (Hughes 1983: 79). Hughes takes a former military concept of a ›reverse salient‹ to describe an »extremely complex situation in which individuals, groups, material forces, historical influences, and other factors have idiosyncratic, causal roles, and in which accidents as well as trends play a part« (Hughes 1983: 79). The fast growth of energy beyond the grid relates to great parts on technological improvements of solar technologies, which typically consists of four to five components that need to harmonise with each other.

> »You'll find that this mini-grid is composed of almost three to four things: panels, batteries, the system, there is always a controller – charge controller, whatever and cables. But of all these four things, 60 % goes to battery. 60-70 % [of the costs] go to the battery. And these batteries, you have to replace them after four to five years.« (N°3 John: 141)

Batteries remain the ›reverse salient‹ of solar technology. While the PV panels last for about 25 years, batteries need to be replaced on average every five years, depending on the quality (N°6 Gilbert: 44-48). In addition, the bad quality of batteries can influence the success of solar in general, even if the quality of panels and applications, like TVs or LED-lights might improve. Investors and engineers therefore look for systems, where they can avoid batteries, either by using hybrid-systems that combine solar with

another better storable form of energy, for example diesel or they directly feed into the central grid.

The ›reverse salient‹ demands the continuous identification, analysis and solution of critical situations. For *Sole World**, an international solar-kit company, the most important component is actually the controller, which is in an on-going process of improvement.

> »Der Controller ist auf jeden Fall das Herzstück. Der durchläuft auch sehr, sehr viele Änderungen, sehr, sehr viele neue Versionen. Wir veröffentlichen jedes Jahr bestimmt zwei neue Produktversionen, einfach nur um weiterhin dieses Produkt immer weiter zu verbessern.«
>
> »The controller is definitively the heart. It therefore passes many, many changes and many, many new versions. Every year, we publish two new product versions, for sure, just to make the product constantly better.« (N°9 Lydia: 85)

For them, the quality of the whole product does not that much depend on PV-panels or the quality of the end-devices, as one could guess, but on the technical possibilities for managing and controlling the system (on controlling, see as well chapter 5.5).

The concept of the ›reverse salient‹ is not limited to the interplay of technical components, but rather can refer to financial, social, organisational or political aspects, as well. As I conceive energy provision in general as a complex socio-technical ›agencement‹, all these aspects need to be harmonised for a successful provision of energy beyond the grid. While in this chapter I focus more on socio-technical aspects, in the two following ones I turn to more financial and political components.

4.5 Appropriate Technologies

Common definitions on energy transition conceive it as »a radical, systemic and managed change towards ›more sustainable‹ or ›more effective‹ patterns of provision and use of energy« (Rutherford & Coutard 2014: 1354). The dispersion of decentralised energy provision is likewise often ideologically framed in discourses on alternatives and sustainability. However, without a spatial contextualisation both terms remain empty signifiers. In their policy analysis on Africa's energy future with particular regard to the SE4ALL-Initiative, Thorne & Felten (2015) make the following statement, which represents a general stance within Development organisations:

> »The fact that Africa's energy infrastructure is so relatively underdeveloped [*sic*] presents a tremendous opportunity. Going forward, sub-Saharan Africa does not have to follow the same (or similar) industrial revolution development model (based on a large, centralized, dirty and hidden energy system) that developed economies rely on. Africa could build its energy sectors around more sound busi-

> ness models that are less dependent on imported and polluting fossil fuels. Africa can build energy sectors based on decentralized power generation and distribution (often referred to as distributed power), exploiting its own indigenous renewable energy sources and, thereby, reducing transmission losses, creating jobs and augmenting income in rural areas.« (Thorne & Felten 2015: 108)

Apart from the problematic spatial generalisation of Africa as energetically ›underdeveloped‹ compared to a global energised North, which ignores the very differences in energy sources and supply among countries such as Egypt, Nigeria, South Africa or Rwanda, I want to focus on the underlying idea of sustainable energy development. Firstly, sustainability can have various meaning. It can incorporate economic efficiency, ecological pertinence or environmental protection, social equity or temporal durability, thus very different objectives, and not all always harmonise easily. Many policy concepts, as exemplified in the quote above, unproblematically assume a smooth harmonisation of very divergent objectives, such as ›sound business models‹, ›renewable energy extraction‹, ›job creation‹ and ›decentralised organisation‹. However, any changes in the provision of energy, regardless if radical or moderate and institutionalised, are involved in conflicts of interest and hardly ever align with manageable transformations that fulfil ›sustainable‹ criteria (Rutherford & Coutard 2014: 1354).

Secondly, sustainable energy provision, as presented in the SE4ALL-Initiative, is strongly influenced by the concept of ›ecological modernisation‹, which emerged in the 1970s in Western Europe in dissociation from radical environmentalism. The concept tries to combine the seemingly paradoxical approaches of rational, technology-led modernisation and ecological pertinence. At the time it was strongly influenced by the report of the Club of Rome (1972), the oil crisis in 1973 and it reversely later influenced the concept of sustainable development as presented in the Brundtland Report (1987) and the Earth Summit conference in Rio de Janeiro (1992) (Hajer 1997). Today, it is prominently supported for instance by Mol, Sonnenfeld and Spaargaren (Mol et al. 2009). They present manageable solutions based on econometric evidence-based approaches on the integration of ecological concerns in economic development. The idea of skipping the Western »industrial revolution development model« (Thorne & Felten 2015: 108) commonly draws on the image that ›less-developed‹ areas could directly enter into ecologically clean ways of production by ›leap-frogging‹ the learning-process of dirty carbon-based technologies made by industry-intensive societies. Still, ecological modernisation is teleological as it is still assuming a single and linear development-path that heralds the economic development of the Global North on top. In contrast, Eisenstadt's (2000) concept of »multiple modernities« allows for thinking of technology and socio-economic change beyond an exclusive vision of development. With respect to Rwanda, I want to examine in how far post-network energy provision is subject to alternative and sustainable transitions, howsoever defined?

Technically seen, the main advantage of solar power is its clean functioning, because energy generation and consumption can, without any difficulty, take place at home. They can substitute conventional products such as candles and kerosene lamps that are more dangerous and pose health risks due to their open flames. Nevertheless, the production of solar panels is energy-intensive and needs valuable resources such as nickel and lithium and the toxic heavy metal cadmium as semiconductor for thin-film panels. This raises the questions, whether photovoltaic systems can be considered as a green/clean technology (Mulvaney 2014). Hence, there are many advantages of solar technology, for instance regarding mobility, but taking solar-products for »clean« is a way of reducing it to the end product while black-boxing the production-process. Similar concerns refer to the use of batteries, which, as mentioned earlier, need to be replaced repeatedly after some years.

> »There's always a goal strategy. So when people are done with their Life Lights*, then we can come back and get a better product, we take it again, we recycle it, we can put in a better battery, so there should be an alternative just to throw it away, it should be a sustainable trajectory.« (N°7 Jean-Bosco: 103)

Companies might be aware of recycling, exchange of components and replacements, but so far these issues did not matter that much, as many companies started their retailing only recently. Owing to the durability of technologies, most regard solar-systems only as temporary solutions that bridge a time-gap until other means of supply are available. In contrast, mini-grids could present a long-term solution in some areas (N°2 Madeleine: 111), though this remains contested. The government, for example, would still envisage a complete grid-provision one day (N°5 Max: 64).

> »On sustainability, I say off-grid is a solution for Rwanda, if you see the capacity of the grid to expand in the near future. We have a mission target, but they are just ambitious, it's difficult to see them [realised] in 5, 10, 15 years. Even the government has now realised that we're talking about hybrid-systems, we're talking about this hydro.« (N°8 Laurent : 21)

The years to come will show whether mini-grids will become a lasting alternative to the central grid. With respect to the energy form, hydro power can't be labelled as alternative given the pre-dominance of hydro-power in Rwanda's energy mix (see Tab. 9: Electricity generation in Rwanda 2015, p. 48). Even in a long global historical perspective, hydro power has been used for centuries all over the world, whereas the intensive use of carbon-busted energy relates to a much shorter time-frame since the 18th century. In this sense, hydro power can be seen as a »surviving technology« (Hughes 1983: 286), which has effects far beyond the time in which it was invented in the past under substantially different circumstances. Thus, hydro-mini-grids bring back a certain character of the past, when hydro power was used as mechanical energy in small-

scale facilities to work near river-sides, before it was used to generate electrical energy. Furthermore, it has many other ›sustainable‹ characteristics, particularly regarding ecological aspects as it is not subject to loud noise or any form of combustion. Thus, small-scale hydro-power projects have the potential for inclusive and socially acceptable planning and implementation towards spatially near-living habitants, in contrast to large-scale hydro-power dam projects. These often face problematic histories in terms of social justice owing to mass re-settlements and deprivations. In this regard, many small-scale projects can have large impacts without radical change in terms of a ›battle of the systems‹ or large technical revolutions. Instead Furlong (2011) argues, »breaking infrastructure down into assemblages of small technologies that matter enables one to see the possibility to employ small change to mediate large problems« (Furlong 2011: 477).

The belief in small-scale technologies was coined with the slogan »small is beautiful« by Schumacher in 1973, who argued against the modernist belief of »bigger is better«, representing excessive capital-intensive materialism and meaningless growth. Instead, he saw the need for a context-related appropriate technology that would benefit both humankind and the environment. Influenced by the philosophy of Mahatma Gandhi, Schumacher pledged for the installation of labour-intensive (production by the masses) and small-scale industries that would use so-called »intermediate technologies«, defined as somewhere between indigenous and western capital-intensive technologies of mass production. Such a technology would be »conducive to decentralisation, compatible with the laws of ecology, gentle in its use of scarce resources, and designed to serve the human person instead of making him the servant of machines« (Schumacher 1973: 146).

Furthermore, the inclusion and adaptation to regional and local circumstances are central to intermediate technologies and accordingly define their appropriate scale of action:

> »The intermediate technology would also fit much more smoothly into the relatively unsophisticated environment in which it is to be utilised. The equipment would be fairly simple and therefore understandable, suitable for maintenance and repair on the spot. Simple equipment is normally far less dependent on raw materials of great purity or exact specifications and much more adaptable to market fluctuations than highly sophisticated equipment. Men are more easily trained: supervision, control, and organisation are simpler; and there is far less vulnerability.« (Schumacher 1973: 149)

Pertaining to energy provision beyond the grid, »small is beautiful« could likewise serve as a suitable slogan and I would support the view that many of Schumacher claims on intermediate technology could apply to energy systems. Appropriate energy

systems beyond the grid should make use of locally affordable resources. While wind is seemingly too weak in Rwanda for wind power plants (N°6 Gilbert: 91); the mountainous landscape is advantageous for small hydro-grids and the average daily solar radiation likewise facilitates solar panels. While components for power plants, both for solar-systems and hydro-power generators, are mainly imported from China, basic engineering capacities can be trained locally and don't require the expensive knowledge of international expats. To run many mini-grids could actually create more workplaces than the installation of single large-scale power plants. Though this would not be cost-efficient, it would follow the idea of integrating local labour forces. Nonetheless, I would argue differently than Schumacher that appropriate technologies and systems would still need the use and enlargement of a centralised network. Jean-Bosco, CEO of an international solar company, refers to this as the need for the right energy mix. This, however, is finally enmeshed in political decisions.

> »It should be a sustainable trajectory, but and as a very big supporter of renewable energy, I don't think that it is realistic to think that you can drive this country on Light Life's* or solar-home systems, I mean you need actual power. You need it for this country to really grow, you actually need it and even if it's ICT. They want to be an ICT hub and I think it's a great idea, you still need power and you see it in Kigali, power sometimes breaks down, etc. I lived in Nigeria and this is intimately better than Nigeria, but still. So I think, there'll be always a combination.« (N°7 Jean-Bosco: 103)

In short, defining an appropriate technology in general is not possible but depends on specific spatial contexts. However, *alternative* and *sustainable* are the least appropriate criteria for deciding on one technology or the other as they are too vast and therefore bear the risk of not harmonising all promised targets.

4.6 Conclusion on technologies of power

In conclusion, from a technical perspective, *hydro-pico-grids* present a smart possibility to provide energy beyond the centralised grid. It is a system built on solidarity that can balance electric current differences within small communal networks, while allowing for a high diversity of end-appliances. Thus it enables to exercise diverse energy related practices. It's a clean, long-lasting technology that one day could easily be integrated to the national grid, via feed-in tariffs. However, it's impossible to claim mini-grids to be the best solution for rural areas, because this generalisation would ignore many particular socio-technical aspects that could be in favour of other technologies as discussed in this chapter. The advantage of *solar technologies*, in contrast, is their mobile application. Solar-home systems can principally be installed everywhere and mutable single devices can permanently be taken along. Though hydro power itself cannot be seen as an alternative technology and solar power is not an ecologically clean

one, both still present possibilities for sustainable - only differently defined - energy provision beyond the grid. The most striking advantages for the two technologies therefore relate to their spatial implementation. They allow for a (re)coupling of generation and provision at the same place, and can in relation to their spatial context provide an appropriate technology, compared to a centralised grid connection. The idea of ›energy spaces‹ opens a perspective on energy provision and supply that, next to geophysical conditions and technical parameters, includes political interests as well as social conventions and practices.

The following two chapters will show that pico-grids, albeit their technical advantages, actually face many difficulties in their realisation. Chapter 5 focusses on energy entrepreneurs and their business activities, while the final chapter (6) looks at the whole interplay of customers, entrepreneurs, financing and political institutions. For all of them, the socio-technical elements discussed in this chapter are of high relevance and influence their activities and thus the outcome of energy provision.

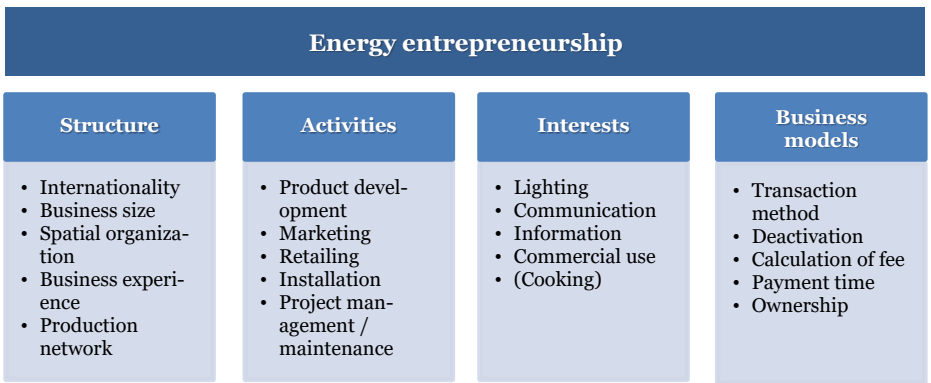
5 Energy entrepreneurship

The provision of decentralised energy involves decentralised - private companies. The private sector, especially for decentralised energy is still small and young in Rwanda. But instead of comparing the private-sector to the public-sector on a general level, in this chapter I want to look closer at the individual companies that are engaged in energy provision beyond the grid, to which I refer as *energy entrepreneurs* in the following. Thus, it presents a kind of portray of the various companies I encountered during my field research. More specific I want to analyse how energy entrepreneurs are engaged in the provision of energy and how they organize their activities.

This chapter unfolds similarly to the last one, in conceiving this time entrepreneurship or the business with off-grid energy as a complex STA. Again, I want to single out different components of it that eventually influence the way energy provision is done. Thus, the first part delineates the different aspects and components of energy entrepreneurs, while the succeeding discusses their interplay. For this I look at the challenge of private companies to address, on the one hand, the so-called economic ›bottom-of-the-pyramid‹ with, on the other hand, for-profit businesses. Actually, it requires well-tailored business-models and product offers that are based on continuous market-analyses of customer behaviour, which I analyse accordingly. The last subchapter resumes the main aspects.

5.1 Opening up energy entrepreneurship

Fig. 6: Overview on energy entrepreneurship



Source: Own representation.

Energy entrepreneurs do not constitute a homogeneous group but differentiate themselves in respect to their structure, their activities, their business objectives and finally the business models they offer, as listed in Fig. 6. I enter the sector of energy entrepreneurs by portraying exemplarily two different kinds of companies, namely *Sun House** (N°3 John) and *Sole World** (N°9 Lydia). Both represent a particular type of company in the sector of solar-home-systems[11] in Rwanda. Though, one could think of more types those two are typical within a wide range, so that most others could be related broadly either to one or the other type.

John, the owner from *Sun House**, was raised in a small Rwandan village and did his university degree in finance and business at Kigali University. At the end of his studies he started doing business with solar lanterns, which at the time were still very expensive and hardly affordable, at schools in rural areas. However, he realized the potential and need for the clean technology as a substitute for kerosene lamps and candles and did a market analysis on how to promote alternative energy technologies for rural regions. In 2013 he founded the company *Sun House** and promoted solar cook-stoves as his first product before switching to solar-home-systems (SHS) in 2015. Today, he operates as distributor for two different systems, one smaller of 20 W, only equipped with lights and a radio, and one bigger 80 W system with more lights and a TV (N°3: 68-72). In his company he employs about 15 people, in his main office or in district offices; besides, many more temporal agents and technicians work on commission (N°3: 15). His next project would be entering the mini-grid business within a few years' time.

*Sole World** is a European start-up company, founded in 2012 following two years of experimentation, business development and market analysis. After realising the high potential for solar products in neighbouring countries, the two founders developed first prototypes of small SHS and cooperated with companies in other East African countries for entering the market. In 2014 they entered the market in Rwanda after gaining a big grant from the European Union and the support of the Rwandan government to roll out a rural electrification programme of 22 million euro in line with the public Energy Development Corporation Ltd (EDCL) which belongs to the Rwandan Energy Group (REG). The objective is to provide 49.000 households plus 1.000 schools with off-grid solar-systems. This implies close collaboration with the ministries of finance and economics (MINECOFIN) planning and of infrastructure (MININFRA) and other public institutions such as the Rwandan Development Board (RDB) (N°9 Lydia: 17-28). While the company's head office remains in Europe, regional offices

[11] Although the two companies are related to the real companies I encountered for the interviews, the descriptions are more typical for the two different types of companies I want to present here. Further, in respect to the anonymity of internal details, not all information is accurate and can be mixed with examples from other companies. All information concerning Rwandan energy politics are accurate, though.

opened in Kigali in Rwanda and several shops in central cities. Product development and testing are located at the European headquarter, whereas single components are produced in China and then assembled in Rwanda, which means the company controls the whole production network. Total employment has passed the number of 300 with more than 80 % national employees, so that they established an own training centre for electricians and sales-persons (N°9 Lydia: 116). While first limited to only one region, the company expanded and today promotes its products in the whole country and specialises on bigger SHS ranging between 80 and 200 W (N°9 Lydia: 66).

Structure

Regarding the structure, one striking difference among all entrepreneurs is the international background. *Sun House** is a Rwandan national company, whereas some others operate on a regional level in neighbouring countries such as Kenya or Tanzania. Lastly there are some international companies, such as *Sole World*,* mainly from Europe or the United States that often operate in several countries. Moreover, there is a huge correlation between internationality and business size, in terms of financial capacity and number of employees. Apart from single shop owners, selling solar lanterns, mainly national entrepreneurs, who are involved in the solar-kit or mini-grid business operate with around 5 – 20 full-time employees. In contrast, some international companies with headquarters in Europe have more than 100 employees, though not all work on full-time contracts as I will discuss later on. Even if Rwanda is a small country, not all companies cover the whole national territory, but either focus on single regions or operate within a certain radius of bigger cities. Still, a main task is actually reaching sparely populated regions and organising the related business activities. Many solar-companies were founded around 2010, starting as smaller start-ups, doing first market analysis and product development and grew in the following years so that this time can be seen as the momentum of solar energy. Although engineers, sales people, business developers might have gained experience in various fields, the whole sector especially on solar energy remains young and is in a steady process of learning. While many of the international companies have a strong engineering background, most Rwandan companies emerged from former retail-businesses that specialised on decentralised energy products. In respect to the activities performed, the companies are embedded differently within global production networks of decentralised energy. Especially the international companies develop and sell their own products and as such control the production network, whereas many Rwandan companies focus on retailing of different products. As such, they are linearly integrated in a production network, where they either sell a complete system as distributors or assemble individually chosen components to one new system.

Activities

Next, I want to delineate the activities performed by the companies comprising both overhead work and the localised core-business, by following the product roughly in chronological order from cradle to grave – or even back to cradle. Although *Sole World** initially started by developing and designing their products »in a garage« (N°9 Lydia: 17), hardly any company operating in Rwanda produces the different components of their system on their own. Instead, most individual components such as the battery, panel, controller, LED-lights or any other appliances are produced externally. However, an analysis of the different global production networks exceeds the scope of this study. As mentioned earlier, decentralised energy is still a relatively new business field so that marketing plays a salient role for companies, as Madeleine explains:

> »Avant de faire le contrat, il faut la recherche des clientes, parce que c'était un marché, qui était complètement inconnu ici. Donc, tu peux pas t'assoies et attendre à tes clients. *No one will come, they don't know you, they don't know what you're doing, no one will come.* Donc, c'est à toi d'aller chercher et faire du marketing. Donc, tu fais du marketing et sur 100 clients, que tu vas contacter il y a peut-être dix ou quinze, qui vont être intéressé.«
>
> »Before signing a contract, you need to go out and search for clients, because this was a completely unknown market. You cannot sit down and wait for your clients. No one will come, they don't know you, they don't know what you're doing, no one will come. So, it's up to you to get clients and do some marketing. With some marketing, out of hundred that you contact, ten to fifteen will be interested.« (N°2 Madeleine: 85)

Companies follow different strategies with respect to their target groups, to the products they promote, and to regional differences. One strategy builds on personal recommendations of current clients; another is to organise promotion events and roadshows such as going to villages and organising public events that mix entertaining and product presentation. A further strategy is identifying influencing personalities and to engage them as promoters. For instance Jean-Bosco (N°7) describes how they start working with farmers-cooperatives and use the community to spread their products (N° 7: 81). The core-business, the retailing of products and energy systems presents a further activity, which can be organised very differently, for example through an own shop but as well through involving external small-dealers and distributors. A crucial aspect of this chapter is actually to analyse how entrepreneurs try to reach low-income target groups with relatively high technical and as such expensive products. It all starts with promotion and business related activities that lead, if successful, to some kind of contract signing and finally ends with the more technical activity of installing the system. Finally, the last energy entrepreneurs' activities comprise services and maintenance of products and systems. While mini-grids demand some kind of continuous project management and maintenance of the technical components, solar-lanterns and

home-systems only need incidental repairs and the potential recycling of single components, which is often included in a guarantee-period.

Interests

Although my perspective is more focused on practices, one should bear in mind that energy entrepreneurs follow individual interests and have divergent objectives to other players in this sector, as I will show more detailed in the next chapter. Furthermore, I distinguish between visionary long-term goals and more operational short-term targets. The first years for many start-ups are characterised by high up-front investments for overhead activities, research and development and general learning; yet, the main long-term goal for all private companies is running a profitable business that can sustain itself through its incomes. Apart from that, companies name a humanitarian and or ecological impetus for their business-activities.

> »Our aim, especially for local companies, is to increase the accessibility of energy. So, like, we have the same vision. We are a social enterprise. Our first aim is not to sell and get profit, our first aim is to sell and to make people happy. To make people access light.« (N°3 John: 80)

As described in chapter 4.4, a strong motivation for energy entrepreneurs is the belief that their technologies and products improve people's lives; they are healthier, more efficient, based on renewable sources of energy instead of fossil fuels and thus more ecological, and they provide better quality than conventional products (N°2 Madeleine: 53, 57; N°7 Jean-Bosco: 31; N°9 Lydia: 62).

To achieve this, they define operational targets focussing on business growth and the development of a good product portfolio for reaching a particular target group. The target group subsumes people mainly living beyond the central grid and therefore in lightly populated areas. In general, this group is often referred to as the ›bottom-of-the-pyramid‹, the lowest income group in society. However, many companies newly discover them as potential market participants. Ultimately, this opens up a space in which humanitarian and ecological goals intermix with profit orientation, and hence many define themselves as social entrepreneurs:

> »I would say, [we are] really a social-enterprise. What we often say, if you have a NGO, really impact-driven and if you have a pure business shareholder value-driven company, we say, we are somewhere in the middle. So, we have a high focus on impacts but also a definite need for business projects, so that's how we see ourselves.« (N°7 Jean-Bosco: 37)

Business models

Having a target group with low and unstable income means for the companies that most customers are not able to pay for ›luxury products‹ at once. Therefore they design diverse payment-schemes that enlarge the payment period over a few years and entangle client and entrepreneur in complex contracts. Tab. 12 shows different options within business models that companies can follow, according to their structure and objectives as expressed before. Franz et al. (2014) give an overview on different aspects in their »toolkit« for mini-grids; however, I established the following overview based on the terms and descriptions as used in the interviews:

Tab. 12: Typology of different payment-options for energy systems

Ownership	Calculation of fee	Payment time	Transaction method	Deactivation
– immediate – rent-to-own – fee-for-service	– service-based – time-based	– up-front – post-paid – flexible pre-paid (pay-as-you-go) – fixed pre-paid (instalments)	– Mobile Money – Pin pad/ Scratch card – Banking	– no – yes

Source: Own visualisation.

A very general difference relates to ownership of the product or energy system. Either the customer becomes the owner of the system at the moment of contract signing, or the ownership remains with the provider until a final tranche has been paid, for the time being he *rents-to-own*. In a third scenario, in contrast, the ownership remains always with the provider, while the customer *pays a fee* for limited services of the system or product. To simplify, a small solar lantern sold in a shop typically changes the ownership immediately, thus there is no need for a payment scheme, whereas the centralised national energy system always remains with the utility. With respect to fees, energy is not a solid product and one can calculate its fee either based on a *temporal usage*, like hours, days or months or, it is based on *services consumed*, i.e. electrical energy measured in kWh.

Next, the payment of fees has a temporal dimension. Apart from paying the whole sum *up-front*, there are several possibilities for paying in tranches. The most progressive or far-reaching changes relate to the establishment of pre-paid-systems, even for smaller systems or products in the form of *pay-as-you-go (PAYG)* schemes. The practice is taken from mobile-phone providers, where customers pay a certain amount of their choice and in turn get access to a given number of kWh or time of electrical energy. Once the balance is depleted, users must recharge in order to have further access to electricity, though – in theory – they can leave breaks in between. Another way of not

paying at once is paying by *pre-fixed instalments*, either through a third-party or directly to the provider. Instalments rely on a fixed pay-plan including total number, sum and date of final instalment. Whereas, instalments are more common for larger investments via bank transfers, PAYG are rather applied for smaller amounts that avoid conventional payment methods. Many PAYG systems come along with a pin-pad and are charged via scratch-cards similar to mobile-phones. Alternatively, energy providers collaborate with mobile-providers, such as MTN in Rwanda, for using Mobile Money services that allow minor money transactions. The last salient component for the business models is the possibility of deactivating a system or product in case of non-payment. All kinds of PAYG-systems only work if they lock once the balance is depleted and can be unlocked via a new transaction. Again, not all options can be mixed but for one type of product, like solar-home-systems, companies provide different forms of payment schemes such as rent-to-own based on PAYG or payment by instalments or even PAYG fee-to-service-solutions. Besides, the centralised grid in Rwanda, in contrast to most grids in the Global North, runs on a PAYG fee-to-service-scheme and not a post-paid billing system.

In conclusion, energy entrepreneurs are a heterogeneous group with different structures and interests. Hence, that they engage differently in the supply of energy by providing different business models. Nevertheless, as private companies they are all for-profit oriented. In the following, I want to discuss the presented aspects of decentralised energy provision.

5.2 Bottom-billion capitalism

In 1998 Hart and Prahalad published a first working-paper on »the fortune at the bottom of the Pyramid« with the central argument to see the poorest of the »world economic pyramid«, namely 4 billion people, not as needy but as potential consumers and market participants. The concept was followed by an award-winning-book (Prahalad 2010) that even went a step further by proposing to see the poor not only as consumers but »as a giant laboratory in which new business models, and a new kind of business infrastructure, could be found« (Elyachar 2012: 110). The approach calls for the combination of two thitherto contrasting ideas of profit orientation and humanitarianism to establish an ›ethicalisation‹ of market rule (Roy 2012: 105). Large multinational corporations should adapt approaches of NGOs and develop a somehow inclusive capitalism. University courses took up the idea and started to develop products that could meet the challenge of improving living conditions by being both affordable and profitable, in other words, products sustaining themselves through sales and not subsidies or philanthropy (Cross 2013: 373f.). Although the idea of integrating the poor into the global economy via appropriate market mechanisms has considerably influenced Development programmes, (see for instance the DFID programme on »Making Markets Work for the Poor« (M4P)), there have been only limited critical reflections

on the bottom-billion-capitalism approach (see for example, a special issue on »Poverty Markets« in Public Culture (Roy 2012)).

With regard to Rwanda, many potential customers work for instance as farmers and cattle keepers and mix it with small-scale trade, or as civil servants such as teachers or officers in rural administrations (N° 1: 78, N°3: 41-44). For the entrepreneurs, however, it is salient that their customers typically have a low and unstable income.

> »Financial power in rural areas, you cannot trust. It's not something that you can predict on. […] Our clients are seasonal clients. It can work in this region, at this time and work in another region at another time. […] Let's say, during the rainy season, if it rains very well, I can sell more in cattle keeping areas than in agricultural areas. Because, when it rains, there is no harvest. When there is the sunny season, when people are harvesting, I would not sell in cattle keeping areas, because there is no grass and water, I would sell in those ones that harvest.« (N°3 John: 132-134)

But even within this group, differences are made out as exemplified by the different approaches of the international companies *Light Life** selling small-scale devices, and *Sole World** specialised on bigger SHS:

> »So at Light Life* the idea is really to reach the real bottom layers. […] Our aim is to get to the people, who live on very, very low-incomes. So small-holder farmers, this group, this is really the most difficult group. There is liquidity, but it's not constant and that's the group we are looking for.« (N°7 Jean-Bosco: 15, 29)

> »Unsere Zielgruppe sind normalerweise ländliche Haushalte, die im Durchschnitt so, zwischen vier und fünf Familienmitglieder haben, zwei, drei Kinder. Zwei-Drittel ungefähr sind […] irgendwie in der Landwirtschaft tätig oder beziehen zumindest einen Teil ihres Einkommens daraus. Es sind sozusagen nicht die ärmsten der Armen, sondern so ein bisschen die Mittelschicht der ›base of the pyramid‹. Das heißt, die, die meist mehrere Einkommensmöglichkeiten haben und die teilweise auch noch angestellt sind.«

> »Our target group are normally rural households with four to five family members on average, two to three kids. Two-third is somehow doing farming or makes at least partly their income with it. They are sort of not the poorest of the poor, but kind of the middle-class of the base of the pyramid. Which means, those that have several sources of income and that partly are employed.« (N°9 Lydia: 69)

One striking difference to development programmes and NGO projects was coined by Jean-Bosco's statement that there is ›liquidity‹. Even on the lowest-income scale, they see a realistic chance for generating incomes.

Still, all companies in this study, regardless if bigger international producer or smaller national retailer incorporated the two aspects of humanitarian and profit-seeking interests in their business model and defined themselves in one way or the other as social-enterprises that somehow want to make a difference by immersing in something utile.

> »Je voulais créer mon propre entreprise, je travaillais avant au Croix-Rouge international. Entreprise, c'est business, Croix-Rouge c'est humanitaire. Donc, je voulais [… ?] faire quelque chose qui est une utilité. Donc, je ne voulais pas vendre des chemises ou vendre des computers, quelque chose qui a une certaine utilité. Voilà. Donc, le solaire – voilà.«
>
> »I wanted to build my own enterprise. Before, I worked for the Red Cross international. Enterprise, that's business, Red Cross, that's humanity. I wanted to do something useful and I was not keen on selling shirts or computers. So, I went for solar.« (N°2 Madeleine: 25)

As such, I argue that the commitment of social entrepreneurs in the fields of basic infrastructure provision is part of a »bottom-billion capitalism«, which Roy with respect to Prahalad defines as »a set of dispersed but coherent efforts to construct, and make productive, a global economy where poverty is a frontier of profit and accumulation« (Roy 2012: 106). Jean-Bosco accentuates the difference of their market-driven approach to NGOs, Development and public programmes. To exemplify, for *Light Life** the health caring aspect of their product is of minor importance, compared to the overall quality and good-value-for-money:

> »If you talk about kerosene it's kind of this old development story, while we say, […] we are just trying to do something in the market, which is just better.« (N°7 Jean-Bosco: 31)

While ›the old development story‹ would focus on livelihood deficits regarding for instance health, they instead would focus on the product itself and its qualities. Albeit the similar involvement in the provision of energy infrastructure, the private companies attach great importance on their different approach and strategy compared to official development aid. Nonetheless, there are similarities with humanitarian objectives of ›the old development story‹. Lydia from *Sole World** still stresses the importance of their social impact, such as, the objective to empower local businesses. This corresponds with Prahalad's vision of building new business models for sustainable solutions (Prahalad 2010: 5).

»Also Sole World* ist ein Social Business, das kann man glaube ich schon so nennen, weil wir sehr viel Wert auf unseren *Social Impact* legen. Aber wir sind in jedem Fall eine for-profit Firma. [...] Wir messen natürlich auch viel unseres Erfolges daran, wie viel wir auch wirklich sozial erreichen mit dem System. [...] Also für uns ist ein ganz wichtiger Indikator zum Beispiel, wie sehr wir beobachten, dass unsere Kunden unsere Systeme auch für den Aufbau von Businesses nutzen.«

»Well, I think you can call Sole World* a social business, because we put very much emphasis on our social impact. But still, we're definitively a for-profit company. [...] We measure much of our success on our social-outreach with the system. [...] For us a very crucial indicator, for example, is when we observe that customer use our system to build their own businesses.« (N°9 Lydia: 41)

Examples for such solar start-ups are solar hair-cutters, multiple-phone charging boxes or bars with longer opening hours owing to LED lights at night (N°9 Lydia: 41).

In an analysis of the materiality of a particular solar lantern, Jamie Cross (2013) refers to it as a humanitarian good that has the »power to materialise both an ethic of humanitarianism and an ethic of market exchange« (Cross 2013: 370). There are several examples, where technical devices are attributed to »do good« such as the Zimbabwe Bush Pump discussed by Laet & Mol or a particular water-filter designed as a straw, named *LifeStraw*®, delineated by Redfield (2012, 2016). Redfield subsumes these life-caring devices as »life technologies«. Cross, in contrast, confers the solar lantern to a »for-profit« humanitarian good, which actually puts the business opportunity as first priority and only appends to it the humanitarian orientation.

Moreover, Cross in taking an »economization« perspective (Çalışkan & Callon 2009, 2010), argues that attributes as ›being-healthy‹, ›doing-good‹ or just ›being-cool‹ require active processes of »qualification« and »requalification« (Callon et al. 2002) to give objects such meanings (Cross 2013: 371). On the one hand companies follow marketing strategies to give a certain meaning to products so that people want it while, on the other hand, meaning is given in its final use that might differ from initial intentions. This »qualification« process is key to the marketing strategy of private companies as the manager of Light Life* explains:

»I think the messaging is very strong on, ›you want to have the product‹. There has to be something aspirational, I want it [he holds up the device], it's a need, it's a real market need [...] and then of course the light is better and it charges your phone, so there are these things. But we don't go in and say: ›oh, but you are so poor, it would be great of you‹ that's totally not our objective. [...] We don't market a sad story, but we market a very happy story, a good story. Saying, ›hey, this is a quality product, it's super cool, you want it‹. That's what we do like anyway you would market Coca-Cola to phones – that's how we push it. We don't put

it in a way that tries to tell people how they should improve their lives.« (N° 7 Jean Bosco: 40-42)

Similarly, Lydia confirms that including a TV in the bigger solar home systems plays a decisive marketing role as it is another way of giving meaning to the system and the consumer (N°9 Lydia: 62). Marketing consequently is more than approaching and advertising new clients; it likewise involves a process of qualification of the customers either as ›poor‹ and ›deficient‹ or as ›equal market participants‹. Following Prahalad (2010), such an ›inclusive capitalism‹ would be more respectful. This means that ›humanitarian goods‹ can be more than ›life technologies‹ such as the water filter or water pump, which have the prime quality of improving one's life expectation. Although Jean-Bosco's device has the power to improve health-conditions, it similarly shapes one's life-style and makes it possible to experience some qualities of modernity.

All in all, a for-profit driven approach towards low-income groups contrasts at first glance with a deficit-driven *Development* approach. At second glance, differences become smaller in light of the growing importance of economic principles guiding development projects, however. I regard the involvement of private actors in infrastructure provision as a »frontier region« (Mitchell 2007: 247) for investments and profits. Conceptually, these frontiers should not be considered as a thin and sharp line that demarcates market from non-market spaces but as contested political spaces about moral claims, justice, norms and entitlements. Bottom-billion-capitalism then refers to processes that make frontier regions to »explorative zones in which entrepreneurs recognize opportunities for commodification and surplus extraction that had either not existed before or which others are unaware of or find too risky to explore« (Ouma 2015: 61). In chapter 6, I will come back to the concept of the frontier region, when discussing the outcomes and potential effects of a stronger private responsibility in energy provision in contrast to approaches from public or *Development* institutions.

5.3 Long-way to profitability

In spite of the technical possibilities of supplying energy spaces beyond the grid, there are high organisational challenges and limitations for doing this profitably.

A salient quality of bottom-billion-devices, according to Prahalad is their functioning in ›hostile environments‹. »They must endure noise, dust, unsanitary conditions, and abuse. They must accommodate low- quality infrastructure for electricity (e.g., wide fluctuations in voltage, blackouts, and brownouts) and for water (e.g., particulate, bacterial, and viral pollution)« (Prahalad 2010: 51). Similarly, bottom-billion-capitalists invent business-models for challenging market situations such as unsteady incomes owing to seasonal dependency. Despite the high demand for their products they still need to find ways to enable people to pay. Therefore, all companies have stressed the need for intense market analysis and good business organisation before

entering the market (N°2 Madeleine: 53; N°3 John: 134; N°6 Gilbert: 94). Madeleine identified a niche with solar-water-heaters in Kigali for middle- and high-income classes and just recently started her business with *Ecotricity**. However, she still hesitates entering solar-markets in more rural areas:

> »De temps en temps, je fais des installations dans l'intérieur du pays, mais c'est marginal, en fait seulement quelques-unes. Mais je me concentre pour le moment à Kigali, parce que je n'ai pas encore le personnel pour pouvoir faire, parce que les kits-solaires, c'est dans les lieux ruraux. Donc, c'est très spécifique, il faut vraiment un personnel spécifique pour s'organiser. Ça demande plus de l'organisation.«
>
> »From time to time, I install inside the country, but this is marginal, actually only a few times. Instead, I focus more on Kigali for the moment, as I don't have the personnel to do it, because the solar-kits are for rural areas. So, they are very specific and it really needs specific personnel to organise. It needs much more organisation.« (N°2 Madeleine: 27)

All companies have developed sophisticated retailing concepts with their proper complex employment structures.

> »In every district, we have district coordinators and those are fulltime paid employees. Then we have agents (or dealers) and they are working on commission. 90 % of them are women. Then under the agents, there are the installers, […] because most of our products have to be installed and they are paid by commission as well. Then under the distributors and technicians, we have scratch-card distributors. They only distribute the cards in areas, where we have clients, but nobody is [paid] permanently in this area.« (N°3 John: 15)

The whole network of the relatively small company *Sun House** would comprise about 250 people, but most of them would be paid on commission (N°3 John: 116). The main retailing process is done through highly flexible, mobile agents that are spread over large areas and who get in contact with clients and sign the contracts. *Sole World** and *Light Life** train their own staff and Jean-Bosco (Light Life*) describes that their retailing structure would even vary from district to district, as mentioned earlier (N°7 Jean-Bosco: 91). Admittedly, these structures evolve gradually. Once, they all began as start-up companies and experimented within a limited space with small products before enlarging over space and increasing their product portfolio. Especially for local companies it remains a great challenge to supply remote areas in a profitable way without having substantial financial back-up. John, operating as local retailer, admits that since the foundation of the company, he remains within red numbers. Only the humanitarian aspect of his work, to »do good« with his business, would encourage him to continue:

»And also, if you look at our distributor channels, it's complicated. We take the products from here to the last customer, which is costly. No one would do that. So, it's something social. It's a passion. People that don't have the passion would not do such business.« (N°3 John: 82)

5.4 Pay as you are

At the time of the study in September 2015, fees for on-grid connection were rising dramatically about 35 % within a short time-frame (N°1 Jamal: 205; N°2 Madeleine: 83), which in comparison increases the attractiveness of off-grid systems. From the national utilities perspective, costs for on-grid enlargement are very high in some areas that are scarcely populated or mountainous and therefore difficult to access. Hence, off-gird alternatives would be more cost-effective (N°6 Gilbert: 89). Still, both technologies, solar and hydro systems, require relatively high investments. Pico-hydro-grids (about 15 kW) would cost between 15-22.000 USD. Compared to solar-mini-grids the costs would be still quite good, whereas the installation and maintenance would need more inputs (N°8 Laurent: 21). For solar it is the other way round; it requires low maintenance, a fast and uncomplicated installation, provides a high technical reliability, but upfront investment and reinvestment for batteries are high (see chapter 4.4 on reverse salient). Business models based on immediate up-front payments only work for a limited group of clients. The application of paying by instalments and prepaid-plans are a central tool for moving the frontier of bottom-billion-capitalism to create new spaces of accumulation, consumption and profit. Prices for SHS start at around 100 euros for small (~ 20 W systems) with only basic devices and go up to 1,000 euros for big systems, including several lights and a large (19" or even 23") TV-screen. Smaller systems that already come with a smaller (14") TV are available for 400 euros, depending on the company. Pay plans for the top price products range between 0.5 and 0.7 euros per day. *Light Life** even provides PAYG for solar lanterns that in total cost around 55 euros but are offered via a pay plan of about 0.7 euros per week. Although most companies give reductions if customers pay at once or at least only in two tranches, the main marketing works over the daily or weekly prices. It makes a great difference, if talking about some Rwandan Franc per day or a total sum, which almost corresponds with one's annual income.

Anita von Schnitzler (2013) followed the history of prepaid meters back to the ›penny-in-the-slot-meter‹, which was first invented in the late 19th century in Britain, when many working-class homes remained excluded from the central grid. Through the activation of the meter, families could temporally connect to central utility services. However, this became not necessary for wealthier households that were trusted to pay monthly bills on a contractual basis. Schnitzler concludes, »while the slot meter enabled the integration of the whole city within a networked grid, it simultaneously divided its population into two sets« (Schnitzler 2013: 677).

In a different context, prepaid meters played another prominent role. Schnitzler further points to anti-apartheid rent boycotts in the 1980s in South Africa:

> »Township residents all over South Africa withheld payment for rents and service charges as part of the effort to make the townships ›ungovernable‹. Such acts of ›fiscal disobedience‹ became both symbolic and material tools of insurgency with dramatic effects, disabling the running of township administrations and turning disconnections from services and evictions into sites of political struggle.« (Schnitzler 2013: 680)

In a previous article, Schnitzler (2008: 901f.) argues meters present a kind of governance, which is fundamentally inscribed in economic rationalities. It would open ›spaces of calculability‹, encouraging economic calculative and optimised cost/benefit behaviour. Today, meters have become the dominant form of connecting infrastructure and households for the pragmatic reason that they replace any municipal official and enable a general accountability of utility services (Schnitzler 2008: 912). However, as in the late 19th century in Britain, prepaid-meters embody a certain materiality of politics:

> »While conventional credit metering technologies (meters that are read and billed at the end of the month) are invested with a relationship of trust, and the assumption of a citizenry willing and able to pay for the services provided, the prepaid meter is based on and invested with mistrust.« (Schnitzler 2008: 912)

Fig. 7: Pre-paid meter for grid provision

Source: R. Kranefeld 2015

Fig. 8: Off-grid pre-paid meter for SHS

Source: http://zdnet3.cbsistatic.com

Technically, it looks as if meters beyond the grid (Fig. 8) would function the same way as for the centralised grid (Fig. 7) – you only get services as long as you activate the meter by paying; however their function is fundamentally different. In the first place, most devices beyond the grid are rent-to-own and not fee-for-services as for the grid. While prepaid for grids replace the post-paid bill, PAYG prepaid systems beyond the grid replace conventional payments by instalment or, to put it another way, they present a new way of micro-financing without a bank. Owing to high interest rates of banks, enterprises took up the bank's role themselves in developing a credit system. John describes it as the following:

> »Actually the payment is not for value. The way we set the business the customer pays 3,500 RWF every month, but it can change, they can pay 5000, 1000, it depends. But this scratch card doesn't have a fixed value. It's a mode of payment, if you agree on something.« (N°3 John: 19)

In the second place, grid-meters mostly calculate the consumption of services (the payment refers to a certain amount of energy), whereas for solar energy the calculation is time-based. While utilities might have an interest in an economic or balanced consumption of energy, this is not of importance for a theoretically constantly running

solar system. Yet, the politics inscribed in the possibility to deactivate the system is similar to the fee-for-service concept, since both present a disciplinary action against non-payment. Thus, for private companies, the deactivation reduces the risks of non-payment, but more importantly it avoids personal conflicts as the ›agency of punishment‹ is shifted from the company to the device that, literally, acts on its own. Schnitzler calls it a »silent disconnection«, as »there is no negotiating, pleading or protesting when confronted with a prepaid meter« (Schnitzler 2008: 912). Additionally, Gilbert states that though nobody has an interest in running after unpaid bills, a state company may have other means of intervention than a private company (N°6 Gilbert: 93).

Nevertheless, companies operate with the calculated risk of non-payment in time and from the beginning accept certain irregularities. Jean-Bosco expects two-third of their clients to pay-off the products in time, which would be two years for which they give as well the warranty. »So there is quite a big sort of up-cost to having it split almost over two years. Because we don't expect everybody to buy on a weekly basis« (N°7 Jean-Bosco: 17). This calculation would include already 30 weeks of non-payment and though the deactivation of the system is a relative straight action, the single payment tranches can be organised much more flexible than fixed monthly instalments. Lydia expresses likewise their tolerance towards temporary payment pauses, unless they don't stop paying completely. Instead, they would have a high interest that customer eventually pay-off the total sum and don't leave it unused after some time (N°9 Lydia: 93). Therefore the disciplinary act of the deactivation should more work as an encouragement than as a punishment. In addition, the model rent-to-own would give a great incentive for customers to take care of the device and fulfil the pay plan in contrast to fee-for-service models, where the ownership always remains with the company or utility, like for mini-grids.

With regard to differences in the payment method between scratch cards (Fig. 9) and Mobile Money, they are in first place technical. Mobile Money allows for a more accurate follow-up of payment practices and works without a local intermediary, who sells the scratch cards. In this sense, scratch cards are more locally bound than Mobile Money, which easily allows sending remittances to others. For instance, Mobile Money provides the possibility for people in the city to contribute to the weekly fees of their relatives (N°9 Lydia: 71-73). Thus, the loop of paying via Mobile Money to be able to charge the phone for the payment depicts how energy and ICT are co-constitutive.

Apart from that, offering rent-to-own models, either by PAYG or by instalments, premises relatively high financial back-up of the companies. Thus, in general only bigger international companies are able to offer it. This means that the smaller, local energy entrepreneurs, like Jamal, Madeleine and John try to avoid instalments completely or keep them as low as possible and, instead, try to reach customers with higher incomes:

Fig. 9: Scratch card for SHS

Source: R. Kranefeld (2015).

»Ils ont le choix de payer en deux fois ou à une fois. S'ils me paient à une fois, moi je les donnes une réduction, parce que it's a nightmare to recall the costs. (..) Donc, je préfère qu'ils paient à une fois, parce que les gens en générale c'est middle and high-class et normalement, ils peuvent le faire. Oui. Et puis, moi, je n'ai pas des moyens à commencer à financer… it's impossible, (rigolant). Je n'ai pas des subsides pour pouvoir commencer…«

»They get the choice to pay at two times or at once. If they pay me at once, I give them a reduction, because it's a nightmare to recall the costs. So, I prefer if they pay at once, because the people in general are middle and high-class and normally, they can do it. Yes. And in addition, I don't have the means to start financing… it's impossible (laughs). I don't have subsidies to start…« (N°2 Madeleine: 70)

With regard to mini-grids, the use of meters is still in progress (N°8 Laurent: 38-40) and both models, service-based and time-based calculation of fees, would be possible. For the time being, the usage in pico-grid is unlimited and costs are orientated on the number of appliances such as LED-lights. Owing to higher-investment and maintenance costs, mini-grids are more dependent on a regular consumption. Financially the supplier is more dependent on permanent payments and technically mini-grids require more balanced energy consumption. Consequently they are only attractive in areas with relatively moderate incomes. Hence, for energy entrepreneurs they are less attractive and more risky compared to small household-systems. Besides, many local companies would lack the technical knowhow and would need support with the installation of mini-grids (N°5 Max: 81).

In chapter 6, I will discuss the relation between the different companies and the implications of divergent financial capacities.

5.5 Monitoring and Control

The previous chapters have already shown that energy systems do more than generating and providing energy to customers. In addition, they »mediate« (Furlong 2011) between entrepreneurs and consumers by using new communication technologies that inform about and similarly shape daily consumption practices of energy use. Most systems that anyhow are framed in long-lasting payment schemes, like PAYG, are enmeshed in practices of payment control and monitoring of consumption activities. Though closely connected, I will analyse them separately in the following.

Creating the possibility of deactivating systems for long-term payment models, either rent-to-own or fee-for-service, is a way of reducing the risk of defection of the social contract between retailer and consumer. To agree on a contract that includes a pay plan of weekly payments over a longer time frame, even several years, it is in fact not necessary to make use of such supple technologies. However, from a Science-and-Technology perspective, they are means to reduce the high risks of »overflows« (Callon 1998) that would lead to non-payments or violations of the complex contract. In this sense, the deactivation of energy systems is framed by principles of rewarding and punishing. In case of cooperation, namely, respecting the designed contract through regular payments, the customer is rewarded through the final unlocking of the system (N°3 John: 21-22). In contrast, a defection of the contract is punished through locking or deactivation of the system (N°3 John: 17). In other words, the technological possibilities present disciplinary techniques that reduce the risk of overflows and therefore are an incentive for companies to offer such complex pay plans. However, this disciplinary power should not be seen in a negative sense as to prevent customers from doing something, but in a positive sense to make them do something. In reference to Foucault, discipline is the power to control individuals in their behaviour and this even includes techniques »to intensify their performance, multiply their capacities, [and] to put them in the place where they will be most useful« (Foucault 2007/1976: 159). Though Foucault refers to examples of ›productive‹ discipline in the army or at an assembly line, rent-to-own systems similarly make use of a disciplinary method to generate a positive outcome for the entrepreneur.

The flip side of disciplinary techniques is their potential for new overflows, like attempts to bypass or trick the technological control. Schnitzler (2008) describes how water-prepaid meters became the central objects of protest in Soweto in 2004. Citizens removed them from their homes to show their protest against civil water reforms. While on the one hand, the use of meters avoids any personal negotiations, on the other hand, the temptation to trick the machine might be stronger than towards a

human opponent. Madeleine (N°2) reports of rumours that some people would have succeeded in cracking meters to use solar-devices without paying (N°2 Madeleine: 126-128). Therefore she would not be convinced about the technological possibilities of framing contracts. Still, the possibilities of tricking the system is again different between fee-for-service and rent-to-own models. While the former provides the risk that customers use more services unnoticed than they have paid for, the latter is, owing to the role of the meter as fee and service calculator, only supplement to the contract. This means that even if customers succeed in circumventing the locking-mechanism, they would still have an open credit contract and, though, non-payment for a limited time-period is mostly accepted, a complete end of payments would somehow catch the provider's attention and make him act, as Lydia describes:

> »Da kommt sofort eine Meldung: dieser Kunde hat nicht überwiesen oder die Zahlung ist ausstehend und die Datenbank schaltet das dann automatisch ab. Das müssen wir nicht manuell machen, aber natürlich ist das für uns eine Art Mittel oder auch Risikoeinschränkung das System ausschalten zu können, weil die Leute dann eigentlich automatisch wieder einschalten, wenn sie eben zwei Wochen lang weg sind. Sie haben auch eine bestimmte Zeitdauer, die wir ihnen ermöglichen nicht zu überweisen. Aber normalerweise kann das System nicht einfach ewig rumstehen. Das ist uns auch wichtig, dass wenn ein System nicht mehr genutzt wird, aus welchen Gründen auch immer, entweder, weil das Geld nicht mehr da ist, oder weil es nicht mehr gebraucht wird und so weiter, dann möchten wir uns auch gerne darum kümmern und schauen, was damit passiert. Das heißt, wir müssen das einfach auch wissen und auch irgendwie einschränken. Aber, auf jeden Fall, die Möglichkeit haben wir, das auch immer einzusehen.«
>
> »Immediately we get a message: this customer hasn't transferred or this is an outstanding payment and then the database switches it off immediately. We don't need to do this manually, but needless to say, for us it is sort of an instrument or even risk calculation to be able to disconnect the system, because then people use to plug in automatically, after they've been away for instance. They have a certain time that we allow them not to pay. But normally, the system can't just stand there unused. That's really important to us, if a system isn't used anymore, for whatever reason, either, because they run out of money, or because they don't need it anymore and so on, then we want to care about it and see what's happening. This means, we really need to know and somehow restrict it. But, for sure, we have the possibility to review it.« (N°9 Lydia: 93)

The quote already indicates that mediating technological devices attached to the systems, such as meters and GPS- and GSM-transmitters, have the power to do more than control work. As private companies, energy entrepreneurs are not only interested in present consumption behaviours, but as well in assumptions on future. Future scenarios that play into business strategies and spatial provision approaches consist of data

collected from the user's behaviour. *Sole World** and *Light Life** both stressed the importance of their data-based monitoring programmes for future developments. While in the former chapter I underlined the critical role of batteries as the reverse salient for the technological functioning of a system, for *Sole World** it is the controller that builds the »heart« of the system.

> »Wir fokussieren uns ganz stark auf diesen Technologieaspekt, eben indem wir dem Controller ermöglichen, dass der auf stündlicher Basis mit uns kommuniziert – hier in Europa*. Und das ist zum Beispiel ein großer Unterschied zu fast allen anderen Firmen, die ihre Produkte entweder nur lokal irgendwie monitoren können, also die wissen, wo die stehen, aber viel mehr nicht, oder sie verkaufen sie und dann gehen sie dahin, wo auch immer sie gehen. Und bei uns ist es wichtig: der Controller kann den Batteriestatus, die geographische Location, wieviel Elektrizität oder wieviel Strom wird gerade produziert vom Panel, wie ist die Sonneneinstrahlung und noch zwanzig andere Werte also wirklich auf regelmäßiger Basis an uns liefern, sodass wir selbst von hier sagen können: dieses System in Gitarama, in Ruanda, erzeugt gerade so und so viel Strom und wir sehen auch, wie viel wird tatsächlich verbraucht wird vom Kunden.«
>
> »We focus very much on this technology aspect, in enabling the controller to communicate with us on hourly basis – here in Europe*. And that's in fact a great difference to almost all other companies, which either only can monitor their products locally, so that know where they stand but nothing more, or they just sell them and then they go wherever they go. While for us it is important; the controller can report on the battery status, of course its geographical position, how much electricity or current the panel is producing, however, how is the solar radiation and twenty more values on a regular basis, so that even we from where we are can tell: right now, this system in Gitarama, in Rwanda, produces this amount of current and, in addition, we see what the customer actually consumes.« (N°9 Lydia: 87)

So-called »dataveillance«, the »systematic monitoring of people's actions or communications through the application of information technology« (Clarke 1988: 499) is by far a new and probably a never diminishing topic. Still, monitoring in the sense of surveillance was for long-time predominantly discussed in the context of state control and risk prevention or at least with respect to state-related activities such as tax calculations or insurance claims. But governmental surveillance is limited and can be retracked to one controlling body, whereas private surveillance and data-monitoring involves even much more diffusive actors and wide-spread databases that are much more difficult to follow back, as »commercial data move with less inhibition, as personal data gleaned from many sources are collected, sold, and resold within the vast repositories of database marketing« (Lyon 2003: 174).

Again, it needs a positive understanding of monitoring, which does not concern itself with restrictive actions but capitalist productive interests, in the sense to multiply people's energy.

> »We have a really data driven approach. We can monitor and see everything that happens from the activation to the distribution, so we can put the two together and we can see the performances of the different dealers in the different districts in different areas in different times so that we can sort of tailor our marketing, if we do these road shows or these little events or markets. It presents, we can sort of see what is best, where should we go, where should we not go. Does this area need it more than the other one, what is there actually happening?« (N°7 Jean-Bosco: 91)

Energy entrepreneurs' interests are not limited to providing energy for the moment. Of course they have a strong interest in reaching new customers, and, instead of just keeping established customers they have an interest in ›upgrading‹ them, which means to make them consume even more after some time. All companies expressed the strategy of starting with small-scale systems and then, one by one, sell bigger systems (N°3 John: 124). In comparison to water infrastructure or even central electrical-grids with limited power capacities, utility managers have a certain interest in economic consumption behaviours. For these small-scale hydro- and solar-technologies, interests are reverse in the sense, the more the better.

> »Es gibt diese pico-Systeme, die einfach keinen Fernseher oder gar einen DC-Kühlschrank betreiben können. Dann sind das eben vielleicht Einstiegsmodelle für die Kunden. Aber wir gehen eben davon aus, dass jeder Kunde, der vielleicht 2 bis 3 Lichter hat, aber nicht viel mehr, irgendwann das verlangen haben wird, auch mal was größeres zu haben, um vielleicht ein bisschen mehr mit seinem Strom zu machen. Und das wird dann sozusagen da ins Spiel kommen.«
>
> »There are these pico-systems that don't come with a television or rather can't run a DC-refrigerator. Those might be starter-models for customer. But we just assume that one day every customer, who only has two to three lights but nothing more, is longing for something bigger to do a bit more with his power, however. And that's where we come in.« (N°9 Lydia: 49)

In addition to long-term business-scenarios, this real-time monitoring gives entrepreneurs the power to directly approach customers with suitable and customer-oriented product variations. All in all, the combination of ICT and off-grid energy opens to rethink spaces of energy provision. While on the one hand, a village in Gitarama is detached from the national grid, on the other hand, it is relationally connected to the databases somewhere in Europe* and to the Mobil Money account in Kigali. In turn, calculations made in Europe* based on data from Gitarama inform strategic decision

makers in Kigali and then again influence the daily life of the user in Gitarama. As such, small-scale energy systems beyond the grid are enmeshed in much larger relations than the national territory of the centralised grid. Admittedly, not all systems are provided with GSM-transmitters and the degree of ›datavaillance‹ might differ among the companies. In addition, this monitoring only works with sufficient mobile-network coverage, which leads to another dimension of off-grid provision.

Finally, practices and possibilities of monitoring and control demarcate private (for-profit) energy provision from public provision. Apart from the technological possibilities and entrepreneurs' interest in user-data, the perspective of the subjects of data collection, namely the customer's, hasn't been considered so far, but must be included as a top concern. Although this wasn't part of my research, I think that especially in case of limited regulations and policies, companies must develop a stance towards data-transparency and customer's right for privacy and dignity. Any form of data collection needs to be based on the customer's willingness and agreement. To which extend customers of energy systems are aware of monitoring possibilities and in which way they have entered in exchange with providers remains an important open topic for further research.

5.6 Conclusion on energy entrepreneurship

The so-called ›energy entrepreneurs‹ are the main focus group of this study. In this chapter I have shown that they comprise a heterogeneous group with respect to company size, internationality or business organisation. Some develop and promote their own products within a hierarchical business organisation, whereas others act as distributor and retailer at the end of a more horizontal production network. Albeit the differences, all companies consider themselves somehow as social-businesses (or social entrepreneurs) as they are, though to different degrees, doing business with a humanitarian, and in addition ecological, orientation. Hence one could refer to them as socio-ecological energy entrepreneurs. In addition, they have the common intention of clearly differentiating themselves from »the old development story« or to put it in other words, social impact matters but business comes first. This is to say, private-led energy provision beyond the grid can be framed as a form of »bottom-billion-capitalism«, which shifts the frontier of accumulation and profit. The target group for energy entrepreneurs are not people deprived from energy, but potential customer with a demand for energy products. Still, business at the bottom of the pyramid remains challenging and does not provide high profit margins and therefore requires complex business models. Energy entrepreneurs try to adapt to the minimal and irregular income situation of their customer by splitting the payments for their relatively high-class products in infinitesimal payment tranches that could substitute costs for conventional products such as candles or kerosene. Furthermore, the payment is based on sophisticated ICT-devices that help to manage and control it, for instance by deactivating systems in case

of non-payment. This presents a disciplinary but similarly encouraging technique towards customers with the goal to make them fulfil their payment-contract. However, only big companies with sufficient financial back-up can offer this, whereas smaller companies, in turn, rather try to reach for richer clients, who have the capacity to pay at once or at least only by few instalments. Finally, a coupling of energy provision and ICT allows for new forms of customer surveillance and monitoring, which fundamentally changes the relation between client and supplier, compared to public energy provision. The outcome of this data-based provision opens space for further research.

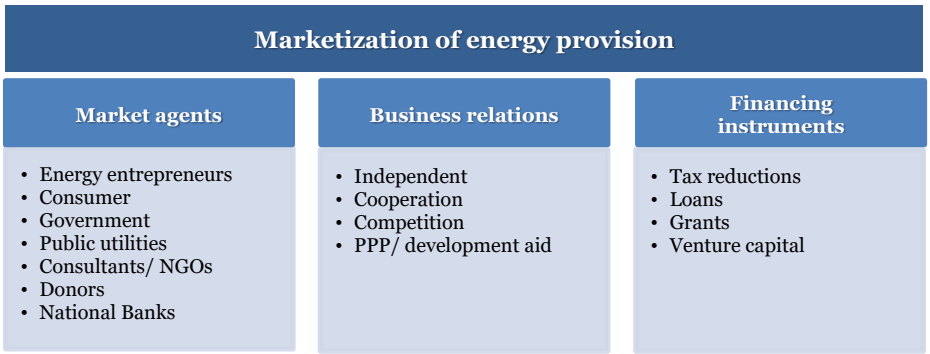
6 Marketization of energy provision

In the two former chapters I looked at technologies and entrepreneurs as two vital elements of energy provision separately. To make provision actually happen, entrepreneurs with their technologies and customers, somehow, must physically meet and engage in market relations. Besides, suppliers and customers are not the only relevant agents for energy provision beyond the grid. There are also public and private agents, financial and legal instruments that support and influence the implementation of energy projects. In this chapter I take an explicit »economization« perspective (Çalışkan & Callon 2009, 2010), which I already introduced in the former one. The focus lies on the role of markets in the provision of energy. Conceptually, I conceive of markets as socio-technical *agencements* made up of human agents but as well of non-human, technical and material devices as well as of norms and rules for regulating market relations that all have certain capacity to influence market relations (Çalışkan & Callon 2010: 9). This means, »markets do not simply fall out of thin air, but are continually produced and constructed socially with the help of actors who are interlinked in dense and extensive webs of social relations« (Berndt & Boeckler 2009: 536).

While the former two chapters dealt with the conversion of energy into a commodity through calculative agencies such as meters that charge a certain time or amount of kWh for money, this chapter focusses more on »the formative settings [...] through which encounters between goods and agencies are organized« (Berndt & Boeckler 2009: 543). With respect to the third lead question, I delineate how the different actors involved in the provision of energy interact with each other and how they build the preconditions for a market-oriented energy provision. The chapter unfolds in the same way as the previous ones. Firstly, I present the different agents, their social relations and the financial tools that come into play (see Fig. 10). Secondly, I discuss the different understandings of market and business-led infrastructure development and how these affect the sector. Furthermore, I look at the impact of international donors, the role of the state and finally the interplay of the private and public sector in this field.

6.1 Energizing markets

Fig. 10: Overview on marketization of energy provision



Source: Own representation.

Market agents

Besides the already presented group of energy entrepreneurs and the final customers, the GoR is highly involved in decentralised activities. In particular, the Ministry of Finance and Economics (MINECOFIN), the Ministry of Planning and of Infrastructure (MININFRA), the Rwandan Development Board (RDB) and the Rwanda Utilities Regulatory Authority (RURA) cover this field. The national utilities that still belong to the Rwandan Energy Group (REG) were restructured in an unbundling process and now are organised as state-owned private companies. Energy Development Corporation Ltd (EDCL) is responsible for grid development and enlargement, while Energy Utility Corporation Limited (EUCL) for grid maintenance. As such, REG is not only involved in demarcating spaces for off-grid, but involved itself in projects beyond the grid, such as the »Increase rural energy access in Rwanda through PPP«-project (IREARPPP). A further group of agents are external consultants. They are represented in the interviews by governmental organisations, like the EnDev programme from GIZ, or Non-governmental organisations like GVEP. In my study, both act as business and, in the case of Rwanda, as financial supporters for companies without installing power connections themselves. For heuristic reasons I regard international donor such as the World Bank separated from technical assistance as they influence the whole sector differently. The last group of agents are national banks; their involvement in decentralised energy projects is rather restrained, however.

Business relations

Hitherto, I treated energy entrepreneurs as agents acting independently, who do not interfere with others in their businesses. However, each company does its business in

relation to the others', which can either lead to competitive or cooperative situations. Cooperations exist for instance between bigger international and smaller national enterprises, where the former provide technical and organisational know-how and the latter facilitate the market entry and marketing and retailing activities (N°5 Max: 79). Another form of cooperation exists in dividing the global production chain horizontally from whole-seller, who import and distribute products to smaller enterprises or shops, who undertake the final retailing (N°8 Eric: 88). Analysing competition is much more difficult as most companies seem to avoid direct competitors and try to find their specialised niche. As such, only companies of the same size and with similar portfolios truly enter competition (N°9 Lydia: 49). Public-Private-Partnerships present a particular form of relation. Either a private company operates technically in the field of energy provision and collaborates with a public institution (like EDCL) or a private company directly operates on behalf of the GoR. For example, in the case of mini-grids, the GoR contracts out sites to private companies that install as well as manage the pico-power-plants (N°6 Gilbert: 80).

Financial instruments

There are several possibilities how energy entrepreneurs can get financial support from the other agents named above. The GoR, for instance, can give tax reductions on particular products, such as solar devices (N°2 Madeleine: 53; N°3 John: 94), or promote off-grid technologies in general through public campaigns, without supporting one single company immediately. If it comes to financial support, there is a fundamental difference between loans with high interest rates typically provided by national banks, and those provided with lower or no interest at all from development banks. Loans are both relevant for customers to finance their purchase, or for companies to make up-front investments possible. In contrast, grants or special subsidies are generally more related to Development programmes such as e.g. from the World Bank. Recently, Devex, a USAID-related Development platform listed »6 initiatives tackling African electrification« (Mendoza 2016); among them are initiatives like the *Power Africa* from USAID, *The New Deal for Energy in Africa* from the African Development Bank (AfDB), *Energy Africa campaign* from DfID, the multi-*national Sustainable Energy Fund for Africa* administered by AfDB, the *Electrification Financing Initiative* from the EU and the *African Energy Leaders Group* launched by heads of states and CEOs from across the African continent. A further very prominent initiative is the *Scaling Up Renewable Energy in Low Income Countries Program* (SREP), a 8.1 billion USD fund of the *Climate Investment Funds* (CIF) that selected Rwanda as one of its beneficent countries in 2014.

New entrants in the field of financial support are venture capital initiatives. *Venture Capital 4 Africa* (VC4A) is a web-platform to connect start-up enterprises with investors and provides possibilities for mentoring or fundraising campaigns.

> »The ventures on VC4A are early stage and require investments between USD $10,000 and USD $1 million. The primary sectors include innovative technology, renewable energy, sustainable agriculture, healthcare and education amongst others. Each venture is disruptive in their use of technology or in their application of a disruptive business model. Thirty percent of the registered ventures have some form of social mission and could be qualified as a social enterprise.« (Venture Capital For Africa 2016)

Another example is *The African Private Equity and Venture Capital Association* (AVCA), a networking platform that »provides independent, thoughtful and crucial research to the African private equity and venture capital industry« (African Private Equity and Venture Capital Association 2016). Both follow a similar vision of building »game changing companies on the African continent« (Venture Capital For Africa 2016) and promise investors »to be part of the Africa growth story« (African Private Equity and Venture Capital Association 2016).

6.2 We have the same vision

For the last years the »new social studies of markets« is establishing itself as a broad interdisciplinary field that tries to formulate alternative conceptions of a hitherto taken-for-granted and mostly unquestioned assumption of an ideal singular market. Following this ideal, markets are a tool for an efficient resource-allocation that has the capacity to identify a state of equilibrium, which satisfies both buyers and suppliers. For such an ideal to work it needs perfect or, in other words, ›clean‹ conditions such as a limited number of atomized market agents that seek to maximise their interests and act according to given preferences. All further activities and happenings of an ›outside world‹ are regarded as externalities that must be set apart for not disturbing the state of market harmony and equilibrium (Berndt & Boeckler 2012: 200f.). Socio-economic approaches, in contrast, argue that markets are through and through socially structured and embedded in cultural contexts and always influenced by uncertainties, relational ties or formal institutions, depending on the particular school of thought. My interest is less to conceptualise the particular setting of energy markets in Rwanda, but to delineate the different market perceptions and ideals of the involved agents. My argument is that despite a shared belief in the efficiency and innovative power of a market-led energy provision, perceptions on this market are still very diverse. Hence, acting according to different market ›logics‹ eventually shapes the outcome of the agents' market practices.

For instance, Jean-Bosco describes the market for several reasons as »very distorted« and very different to his ideal of a market.

> »From a Rwandan public side it's distorted, from a donor side it's very distorted and from a European/ American finance side, it's very distorted. It's not a level playing field. As Light Life*, we wanted to come in here, from a purely commercial base.« (N°7 Jean-Bosco: 44)

In contrast, Lydia, even if using many classic economic related expressions, like market saturation, first-mover, or business-indicator, presents the off-grid market as »ordinary« (N°9 Lydia: 119). For John, the market is »huge«, »virgin« and continuously in movement, »because the technologies of solar keep on changing and the needs keep on changing« (N°3 John: 74). Whatever the market is, either a ›playing field‹ or a ›living being‹ itself, it is always descripted in relation to one ›original‹ form of market. Besides, there are some attributions to the off-grid market that somehow everyone agrees on. One is that even for Rwanda as a rather small country the demand for energy devices beyond the grid would be big, especially for solar products. Even with one or two companies dominating the market, they don't seem to present a real threat to the others. »If 90 % of the population in rural areas is not electrified, I think there is enough to do and this is Rwanda, [and] the same problem goes for 15 or 20 other countries in Sub-Saharan Africa« (N°7 Jean-Bosco: 60). The same could apply for other technologies such as pico-hydro and biogas. Though, with respect to biogas, the market potential would be much lower, because of a less attractive national programme for customers, as Jamal states:

> »The market is big, at least in terms of that programme [...] and the companies in this business are still very few. So, you can go to the East, a few companies go to the East, a few others go to the Noth. So there is no big competition in that term. But again, you can't compete for something that is not running.« (N°1 Jamal: 120)

Another common concern for all enterprises are low quality products that could ›enter‹ the market. Eric describes a situation, where they tried to train people on solar systems instead of using car batteries:

> »Then we saw, there were some companies and they brought solar products, where they were told that they would give services for 5 years, but within 2 months they were completely out and not giving services any more. So, you see, these things disturb the market. People start losing trust.« (N°8 Laurent: 75)

Especially for the new and relatively unknown solar technologies one company can affect all other companies so that »if you don't provide according to product« (N°3 John: 55) or »at the end of the day some products are not really good« (N°8 Laurent: 19), you are »destroying« (John) or »killing« (Laurent) the market. This risk relates especially to the black boxing of solar technology. Retailers as well as customers have difficulties in evaluating the quality of batteries or solar panels, thus need to trust the

producers. In other words, the market can be a very fragile being that ties its market agents together, who try to keep it alive and running.

All companies affirm their unevenness in size and capacity. While there would be many companies dealing with small solar lanterns only few would operate and therefore compete for high-capacity solar systems like *Sole World**. Nevertheless, John admits he must get along with them:

> »Big companies like Sole World*. They have like millions and millions of euros. So, for those ones, you cannot say, unless you're crazy enough to compete with them. (laughs) You see. That's the difference, there are those ones that are big, that are huge and that can swallow all other companies.« (N°3 John: 86)

Madeleine, likewise, complains that if she competes against the subsidised European companies she would lose, unless she would develop an even more creative business-model, but for the time being she would stay out of their business (N°2 Madeleine: 49).

Still, even the smaller companies are not completely hostile against bigger companies, but have a divided opinion on their activities:

> »Mixed feeling, parce qu'il faut, qu'il soit la place pour tout le monde, on ne peut pas les chasser. Mais, le grand problème, c'est que ces gens viennent, bon, c'est un problème pour nous, qui n'est pas un problème pour eux, ils viennent avec beaucoup de fonds, beaucoup de subsides. Beaucoup, beaucoup, et finalement on ne joue pas dans la même ligue. Finalement, c'est une concurrence, qui est un peu ›déplorable‹ (entre guillemets). Parce qu'eux, ils ont des subsides et nous on n'a pas. Mais, ils se sont battus aussi pour avoir des subsides. Ils se sont battus, ils ont des connexions, ils ont des idées, voilà.« (N°2 Madeleine: 130)
>
> »Mixed feeling, because there must be place for everyone, you cannot chase them away. But the big problem, at least for us, not for them, they come with many funds, many subsidies. Many, many, and finally we don't play in the same league. Finally, this concurrence is a bit ›deplorable‹ (under quotation mark). Because they have subsidies and we don't. But they fought for it to get the subsidies. They fought for it, they have the connections, they have the ideas, voilà.«

Still, she wants them to be successful for two reasons. One, she believes in the technology itself and wishes that finally customers will profit from it and second, owing to the influence of a big company on the reputation for the whole sector, a well-performing big company would be better than the contrary. Although she can't compete with them, solar products in general would have a better standing and there is an increased trust (N°2 Madeleine: 132). This mixed situation of competing-but-being-dependent is expressed in the same way by John and Jean-Bosco, who, though the latter being international, in this case identify as small entrepreneurs:

> »Yeah, we are competing, because we're on the same market, but also, we are complementing each other [...]. We are complementing and also our aim, especially for local companies, is to increase the accessibility of energy. So, like, we have the same vision.« (N°3 John: 78-80)

> »I wish them [big companies] all the luck and I think they will do a really good job and if they do a good job for solar in general for the general consensus and idea that will be good for everybody.« (N°7 Jean-Bosco: 70)

To conclude, the different entrepreneurs are interlinked in complex relations. They identify as one group with a similar approach compared to donors or public institutions, who don't know »what it is like to operate in the private sector« (N°7 Jean-Bosco: 58). Similarly, they engage in a mixed relation of competitive-cooperation, where everyone tries to find his or her place. In this sense, the market appears, on the one hand, as a living being that needs to be treated carefully and kept alive; on the other hand, it constitutes a space of mutual interaction, which is far from the ideal of a level playing field or any place of harmony and equilibrium. Instead, I would argue the depicted energy markets build a »contact zone« that comprises all the various interactions and relationships of actors. The concept originally referred to »social spaces where disparate cultures meet, clash and grapple with each other, often in highly asymmetrical relations of dominance and subordination – like colonialism, slavery, or their aftermaths as they are lived out across the globe today« (Pratt 1991: 34). However, the concept has developed further to include diverse »sites of multivocality; of negotiation, borrowing, and exchange; and of redeployment and reversal« (Joseph cited in Anderson 2002: 651). Therefore, to understand market relations as a contact zone, we need to look beyond energy entrepreneurs. Next I consider particularly the role of the state and of financing institutions.

6.3 Don't disturb the market

For receiving external money it needs a convincing story, a story that is worth to support the underlying business concept. One can imagine the distribution of funds as a market-process, where similar to other markets »the best wins« (N°5 Max: 19). The market for funds is very closely interlinked with the market for energy-systems or, in other words, they both make up one component of energy provision beyond the net. External money gives companies an additional energy push and the capacity to do even more of their work, but it also has an impact on the work of the other companies. In the following, I first want to look on the design of the different financing-models and then analyse the application processes for them.

Starting with loans, those from Rwandan banks are mostly covered by high interest rates. Therefore they are only of limited interest, both, for small entrepreneurs to in-

vest in the company and for customers to finance the purchase of an expensive energy product. Madeleine resumes that any programme based on high interest rates would not work. As an example she refers to a public programme on solar-water-heater with a mixed financing approach:

> »En fait, comme il y a le subside et le prêt à taux zéro. Au départ le projet prévoyait que le prêt à taux zéro c'est au début et après les banques prennent le relais. Donc, ils ont discuté avec des banques, mais nous, on leur a dit, *forget about the bank*, parce que s'ils font un prêt à 16 %... *people will not take it, they prefer to stay without hot water*.« (N°2 Madeleine: 72)

> »There is the difference between subsidies and loans with zero interest rates. In the beginning, the programme foresaw to start with the loans without interest and then the bank would take over. So, they discussed with the banks, but we told them, forget about the bank, because they take interest rates of 16 %... people will not take it, they prefer to stay without hot water.«

Jamal refers to another public programme on biogas that as well addresses customers. He complains that it is made up of a complicated application process and recently has been stopped completely.

> »I mean, as a household through that scheme there are so many endeavours. [...] You need to act with the sector, with the district, from the district to the ministry, from the ministry to the bank. You know, there are so many other things and this tends to take their time and money. You see, for you to access the bank loan there are so many requirements. Sometimes, they request you to show what you are doing, what other businesses you are doing, what is your source of payment or where do you take the money to?« (N°1 Jamal: 132)

In conclusion, both would try to avoid such public programmes that work with national banks and instead try to reach higher income customers that could invest without additional financial support.

Besides, there are loans without interest rates that come from international or public Development programmes. Grants that mainly come from international Development organisations have a much higher output and follow a specific objective. *Sole World** received a EUR 22 million grant from the EU to roll out their off-grid electrification programme. *GVEP* is involved in the EUR 1.7 billion large *Swedish Capital Access for Renewable Energy Enterprises* (CARE2) programme that targets the creation of new jobs in so-called ›e-MSMEs‹ (micro, small and medium energy-focused enterprises). Although all companies would welcome financial support, many deprecate the exclusive support to single enterprises that disturb the imagined ›clean‹ market. *GVEP*, who are interested in business-development and long term profitability of enterprises criticize grants that are focused on electrification roll-out:

> »If there is another company that has subsidised an almost similar product for half the price, and you are importing those equipment and materials then you are not able to distribute, because people will always go for the cheapest prices.« (N°8: Eric 74)

Owing to their different intentions, donor programmes can even be conflictive. EnDev and *Light Life** were faced with the effects of the charity organisation World Vision, which gave solar lanterns to children for free financed through donations in the Global North. When *Light Life** tried to engage with cooperatives, they showed no interest in paying for lamps as they already would have gotten some for free. EnDev faced another problem due to a World Bank programme, which gave up-front grants to companies so that they would start retailing solar lamps. Max resumes:

> »They [WB] thought they [the companies] would sell the lamps very fast, but they didn't. So they couldn't start with us before they haven't finished that, because we can't pay a bonus or an incentive for selling a product you receive for free. Then we had to wait, until they finished that.« (N°5 Max: 84)

When the first company reached the World Bank target, they switched and signed a contract with EnDev under their payment-scheme. Since the third phase of the EnDev programme, in 2014, it works with a particular financing tool, called results-based-financing (RBF), which is a combined loan-grant-scheme in cooperation with a national bank that targets entrepreneurs of solar lanterns and of mini-grids. Instead of receiving an up-front grant, entrepreneurs take a loan from the national bank to finance the construction of a pico-hydro-plant. Within one year, the plant must be finished and the results approved by a commission. Only then, the programme rewards the entrepreneur with one part of a grant, while the other part is conditioned by the number of total households connected. In the current model the entrepreneur receives USD 20 for each connected household every quarter during the first year of implementation.

From a donor's perspective, the general problem with grant financing is that it allures customers or companies that are not fully convinced of the approach, but do it for the sake of the money they receive. This provides the risk that the beneficiaries step out again in the middle of the programme or try to channel the money in other directions (N°1 Jamel: 151; N°6 Gilbert: 96; N°5 Max: 92). The decision between supporting companies via loans or grants would depend on the maturity of companies. While start-ups in general would need grants before being profitable, Max explains that the Rwandan companies they want to support already would have a certain capacity (N°5 Max: 77).

Still, from a business perspective, all the examples contradict the idea of an efficient resource-allocation and a ›clean‹ market. Jean-Bosco underlines the fundamental

difference between business-orientation and impact-orientation of private enterprises and donors:

> »Donors do not know how it is to cooperate in a private sector environment. There's nothing in a donor (…) system from top to bottom that knows what it is like to operate in the private sector. I've worked for research institutes, I've worked for governments, I've worked very closely with donors – they don't. It's a totally different system; they work with budgets that have to be finished by the end of the year. They have very high bureaucratic demands, accountability that goes up the line very political procedures. It's completely different and I think, if they would switch their focus on providing money to create a level playing field so that the best-may-win-sort of thing. I think this would be a way better than engaging in the markets and picking…« (N°7 Jean-Bosco: 58)

But what would this level playing field look like? Callon (1998) presents two contrasting perceptions of markets: One conceives markets as »closed interactional spaces« that allow for effective decision making, while externalities or so-called overflows »are simply the results of imperfections or failures in the framing process« (Callon 1998: 251). The other one takes these overflows as the norm and the framing of an efficient market as an expensive and always imperfect process. Moreover, the sources of overflows are those elements and attempts to create solidity. In other words, every attempt to establish a level playing field presents another source for disturbance. But as long as one takes these overflows as the norm, accepts that companies are not equal, that interests are manifold, and accepts that exclusive advantages for single agents are possible, Lydia's description of the Rwandan off-grid energy market as »ordinary« fits perfectly.

The second aspect I want to discuss is the accessibility of funds. In general everyone, be it applying firms or evaluating donors, describe tender processes as very time-consuming and bureaucratic. For instance, Max describes their tender review as three-folded, consisting of them, the national bank and a third party (external) consultant. Applying the theoretic idea of the best-one-wins can be quite difficult in practice. Eric gives examples for application processes and resumes:

> »The grant process can be two years and be very technical. So you might have a valuable project, very good business, but putting that into paper to be able to attract a grant is also another thing.« (N°8 Eric: 79)

To put it another way, not always the best paper entails the best project. However, the project with the best paper will be put into practice eventually. From a donor perspective, the reason to give grants that are worth several million euros to one company instead of many is, ironically, market-based, because economically it's cheaper and demands less administrative and bureaucratic work. Development ministries would

deal with millions of euro to spend on programmes, with only a few people in charge. How could they deal with Madeleine asking for EUR 2000, Jean-Bosco responses (N°7: 70). Gilbert confirms this logic and presents a big public programme of EUR 6 million for electrifying schools.

»Les gens ont suggéré qu'on divise en plusieurs, pour qu'on ait beaucoup d'entreprises. Mais on a dit, faire le suivie de 10 ou 20 entreprises, ça sera difficile pour nous. Donc, on a dit, on lance un marché international et les entreprises internationales vont venir et on les oblige à travailler avec 2 ou 3 entreprises locales comme sous-traitants, qui sont encore petits, mais au bout de 3 à 4 ans, ils vont avoir l'expérience et peut-être ils vont avoir l'argent aussi pour pouvoir continuer un jour aussi.« (N°6 Gilbert: 78)

»Some have proposed to divide among several to have many enterprises. But we said that doing the follow-up for 10-20 enterprises is too difficult for us. Hence, we agreed to tender out internationally and oblige the international company to work with 2 or 3 local companies as sub-contractors. Those would still be small, but after 3-4 years they would have the experience and potentially the money to continue one day alone.«

In a nutshell, there are two contradicting expectations towards the role of financing instruments, which can either more relate to the global target of energy provision or to the target of business support.

With respect to international funds, the Rwandan entrepreneurs remark that apparently only international companies operate with big funds:

»The problem is. Where they get the funds, we don't have access. Because they're getting them at the European Union, they are getting them from GIZ, from UN, all those, where we, the local companies, we either cannot, or we don't have the information on how we can get those funds or we are not eligible to get these funds. I don't know. Let me say it like this, maybe, maybe, maybe, … because we are Africans, (lowers his voice) because I've never seen an African company getting a loan.« (N°3 John: 95)

Madeleine raises the same point still she adds that the European companies would have merited their support due to their good proposals. Jean-Bosco admits that dealing with international tenders and donors is administratively »super challenging«:

»So I think, there are only few Rwandan companies that can apply for these things. It's always companies from abroad or international companies here.« (N°7 Jean-Bosco: 56)

With respect to the disadvantage of African companies he refers to one tender they had won and admits:

> »But who says that we are better? We are better writing proposals than Madeleine*, but then Madeleine* has a better idea, but she can't write proposals well. I do it, because I have ten years of experience in writing proposals and these things and then okay, here it is. My product could be worthless, could be bad, could be nothing, but just because I know how to write a proposal, I get access to finance – free finance-, which gives me the right to do something.« (N°7 John: 58)

The experiences show that companies from the Global North, though foreign, are in a privileged situation that opens them more possibilities than companies from the Global South, at least in terms of access to finance. Consequently, Jean-Bosco expresses that: »at one point, sometimes I hope, there would be no funding, it would be great if it would be zero. I mean, this small country has a Telecom. No one funded the telecom; maybe it's a good idea to cut it out« (N°7 Jean-Bosco: 76), which expresses the ideal of a »clean« market.

In contrast to complex donor-tender procedures for grants and loans, venture capital presents a new form of financing. For the site *VC4A.com*, most companies are listed in East African countries (Kenya, Tanzania, Uganda and Rwanda) and partly in West Africa, particularly in Ghana and Nigeria and in South Africa. Jean-Bosco outlines that private funding opens up new possibilities and better suits their business model:

> »I do see that the funding is changing in a way, if I look at ourselves, we're moving away from the traditional funds and are looking more towards private funding, impact investors, looking at those kind of things, because they are more driven on business-success than on impact. If you go to a fund, they'll ask you: ›how many children have you reached out to‹ and you say, well that's not our goal, our goal is not to reach out for the children. Our goal is to sell as many Light Lifes* as profitable as possible so that we can grow and the business can reach even more people and that's the model. So there's also for us kind of a split in the funding that we start to look away from these traditional areas and try to look more towards more traditional business investments.« (N°7 Jean-Bosco: 76)

The contradictory approaches between *World-Vision and Light Life** represent the heterogeneity of energy markets beyond the grid. Although, both see the technological advantages of solar power and the possibilities for improving living conditions, they follow completely different approaches, one is impact-driven »going for the children«, the other »business-driven« promoting their product.

In conclusion, writing a convincing tender application to get whatever sort of financing is a laborious process; companies must put in a lot of energy to pass all bureaucratic requirements and not all companies have the capacity to do this work. But, there is no linear equation between deliberate energy input and successful application output, because tender processes are enmeshed in complex power relations beyond any meas-

urable Joules per second. *Power* in this case shouldn't be understood in an energetic but an early Foucaultian sense: produced and reproduced by the effects of truth and conceptually framed as in »a triangle: power, right, truth« (Foucault 1980/1976: 92). On the one hand, tenders are oriented towards a specific target group that is invited and informed about the possibilities to apply and that is formally demarcated by the criteria of eligibility. Small national Rwandan companies most likely don't have an idea of the practices of donors and Development organisations. Jamal, for instance, only perceives them as those that come and sit with the high ministries. But even if aware of them, he would most probably not meet the organisational eligibility criteria of company size (such as annual turnover or minimal number of in-house staff) or national criteria (such as being registered in the European Union or the United States for related applications). Besides those structural challenges, the experiences expressed above indicate that writing a winning tender application needs the ›right‹ methodology and therefore requires certain knowledge. Thus Foucault scrutinises the »rules of right« and how relations of power are implemented in the production of »discourses of truth«:

> »There can be no possible exercise of power without a certain economy of discourses of truth which operates through and on the basis of this association. We are subjected to the production of truth through power and we cannot exercise power except through the production of truth.« (Foucault 1980/1976: 93)

At this point I don't want to enter a deeper discussion on power, discourse and truth within Development work and Geopolitics. Such a genealogical analysis on the power-knowledge-complex of finance and tender documents exceeds the scope of this work[12]. Nonetheless, I want to emphasize the importance of knowledge and technical capacity of tender writing for the energy provision beyond the net. The work of energy entrepreneurs is highly influenced by processes of financing. Hence the provision of energy not only depends on the capacity of producing a technically sound energy-system but likewise of producing an editorially sound letter of application. The practice of tender writing is enmeshed in an order of power that does not relate to one sovereign or all-controlling body, which holds the »truth« about the »right« way to provide rural areas with energy and therefore determines how to write the »right« tender. Instead the evaluation and decision on the »right« approach is the effect of multiple mutual relations of long lasting practices of Development Aid and tender politics.

By connecting the different aspects of market-led energy provision, I want to emphasize its processual character. ›Market-led‹ does not describe an end-state but a process, hence a ›frontier region‹ of accumulation and profit, which is always contested. Any process of integrating or turning non-market agents and devices into market rela-

[12] For an analysis of expertise in the context of European diplomacy see Kuus(2014).

tions is never happing smoothly but creates a ›contact zone‹ of diverse interests, expectations, privileges and resources.

6.4 We need to have some standards

The interplay of different actors and technologies requires means of communication and common points of reference. Energy provision is framed by many different regulations and laws as well as standards that all together make up a regulating framework. But, in case something new is about to develop the regulations need to be adjusted, too, in a concurrent process of governance that goes beyond single governmental decisions. With respect to standards, there is for instance a whole bunch of differences such as formal, non-formal or voluntary standards, norms, conventions, labels and codes of conduct which further can relate to processes or sites of production or to final products. Both public as well as non-governmental regulations and standards involve a wide range of actors such as the government, but also companies, NGOs, citizens, judges or third-party evaluators, who eventually all shape the outcome of a specific regulatory framework through networked forms of organisations (Ponte et al. 2011: 1ff., Bazilian et al. 2014: 219). By defining thresholds of inclusion and exclusion, of classifications and limits they perform »boundary work« (Ponte et al. 2011: 1). However, this work always remains temporary and revisable and needs continuous maintenance and is therefore never absolute.

In this context, Bazilian et al. define »energy governance« as a »a multi-level and multi-actor process [...] that shapes how decisions are made about how to provide energy services« (Bazilian et al. 2014: 219). Adding to this, a multi-actor involvement would, according to Jaglin (2014), not necessarily demonstrate a weakening of government agency, but a clear break with a hegemonic state-centric system (Jaglin 2014: 1395). However, building on research on urban energy transitions in Cape Town, she critically remarks on the energy governance perspective and the multi-level approach that it »tends to underestimate the divergence of interests across different scales and thus the reality of conflicting views«. Policies would not be smoothly passed up and down between separated but cooperating scalar spheres of the local, national and international. In contrast, energy governance would be made up of sites of »extensive interaction« that are »based on a set of unstable power relations and resistance« (Jaglin 2014: 1410).

Returning to my case study on Rwanda, I now want to enter into such sites of extensive interaction between the various actors to explore the making of regulative frameworks. Then, I want to look more closely on the changing role of the state in an upcoming business-led energy development context.

John describes the processual making of the energy market and emphasises that not only the market is something fluid but the different agents as well.

»The market is new, the government is trying, because we are partners with the government, we are partners with REG and we partner with MININFRA. We are having their recommendations and also we partner with districts and sectors, but still, it's a process. As the business is new, it's a process to make people understand [...] And you know, the government is not something standard, stable, [but] it's something that keeps on changing. [If] we have a problem, [then] we can have someone for renewable energies, who understands very well solar. After some months, they might change him and then there comes someone else and he starts again, something like this might happen. So, but the government is willing to support. They are supportive.« (N°3 John: 90)

Though, often imagined as one singular agent, the government is made up of different ministries with differing interests that moreover depend on individual and changing personalities. Still, the GoR has agreed to a political vision that leads the general approach on improving energy access. With respect to their highly ambitious targets (70 % energy access until 2017), everybody seems to welcome the political will, though nobody estimates it as realistic. Gilbert admits it would be impossible to triple energy provision within a few years (N°6: 35). Moreover, the GoR would follow a contradicting vision by, on the one hand, wishing to supply as many people as possible, but on the other hand, trying to provide low prices. The existing energy capacities would be too low and the more the grid would be enlarged towards distanced households the more the overall costs would rise.

»D'ailleurs entre les décideurs politiques et les techniciens il y a ce problème. Parce que, par exemple, l'administration, la politique dit, il faut donner de l'électricité à beaucoup de gens, le plus possible et à prix bas. Et ça ne marche pas, parce que, si on doit donner à beaucoup de gens on doit recueillir aussi des énergies, qui sont cher, comme le diesel. Actuellement, pratiquement 30-40 % sont produits par le diesel. Donc, obligatoirement le tarif doit monter et on ne peut pas dire, faciliter des accès.« (N°6 Gilbert: 102)

»Besides, between the policy makers and the technicians there is a problem, because, for example, the administration, policy says, you must provide electricity to many people, the most possible and at a low price. But this doesn't work out, because, if you give to many people you need as well to exploit expensive resources, like diesel. For the moment, practically 30-40 % are produced with diesel. So, obligatory tariffs will rise and then you can't facilitate the access.«

Governance is not only about reconciling different political interests but it needs to be aligned with the technical possibilities. Such an ongoing topic for instance is the setting of tariffs for pico-grids, which comprises technical and administrative as well as economic and political aspects. So far, all tariffs for mini-grids beyond the grid (capacity < 100 kW) have been negotiated directly between the local community and the entrepreneur (N°8 Laurent: 34), which means prices for energy can vary from site to site.

Furthermore, regulations need to be established for a potential integration of mini-grids into the centralised grid in future (N°5 Max: 106).

> »It's a regulation issue; this is one of our priorities actually. We try to create a kind of regulative frame. If we talk about pico-hydro, we need to have some standards, so when the grid comes, it will be accumulated or it will leave it. Actually, we need to accumulate it. For now, the regulation that we're having is for above 100 kW, but if we're talking about these small plants, they are 15 kW or 40 kW. […]
> If it is well done, at the end of the day, I think the plants can be accumulated. With GIZ we were defining the standards so that when the grid comes, they can accumulate it. So we're now in a discussion with the RURA to set up that regulation standard framework and then move forward.« (N°8: Laurent: 104-105)

Technically, such integration is possible. As indicated by Laurent, the GIZ EnDev-programme together with GVEP are closely involved in the making of the regulation, which finally will be enacted under the authority of RURA. Max describes how the power-plants of the first EnDev project paved the way for later ones, as well for administrative procedures. In other words, pilot technologies similarly contribute to the establishing of norms and standards (N°5 Max: 17). But not only development organisations are involved. Lydia likewise reports of labour- and time-intensive negotiations of *Sole World** with all kind of actors, like different ministries of the government to discuss issues of taxes or implementation, with EDCL but as well regional governors or local districts. Furthermore, they had to respect donor regulations from the EU as well as national regulations from the government. But all in all they are involved themselves in designing the roll-out process of their programme and thus they are influencing the whole sector (N°9 Lydia 31, 37).

In comparison, some Rwandan companies felt as being left apart as they are not similarly involved in the making of policy and regulatory frameworks. For Jamal, all international Development work remains opaque, even when it would concern his business:

> *Jamal:* »Hm. (.) On the side of government, I hear, actually there used to be this SNV. SNV, I don't know what they did (laughs), I don't know what (laughing) they were doing for the government (laughs again), but they were supporting…«
>
> *Interviewer:* »SNV? – the Dutch.«
>
> *Jamal:* »Yah. And, initially, a lot of the subsidies were a grant or I don't know what – what it was from the Netherlands and I think that this way SNV came in. GIZ also, they had something to do in that, because they were partners of the programme, but I don't know much about that.« (N°1 Jamal: 122-124)

Madeleine likewise complains on unequal access to participate on negotiations:

»Tous les systèmes de coopération, ils ont leurs bureaux chaque fois dans les ministères ou dans les organisations concernées. Travailler pour les organisations, ce n'est pas le paradis, mais, …il y a une volonté (rigolant) de collaborer, de coopérer. Oui.	»Every time, all cooperation systems have their offices in the ministries or in the relevant organisations. Working for the organisations is not like paradise, but… there is a certain willingness (laughs) to collaborate, to cooperate. Yes.
Et nous, je parle des petits, nous ne sommes pas représentés chez WASA. il y a MINIFRA, ministère pour l'infrastructure et ils peuvent parler à GIZ, à SNV, voilà, ces sont des acteurs qui sont là et ils discutent entre eux.« (N°2 Madeleine: 67-68)	And we, I'm talking of the small ones; we're not represented at WASA. There is MININFRA, ministry for infrastructure and they can talk to GIZ, SNV, like this. Those are the actors that discuss under them.«

Following Jaglin, I argue regulatory frameworks are not based on optimised economic-technical management solutions but they are the result of intensive negotiations, which are enmeshed in unstable power relations and hence are always political. Similar to the entire sector, the regulatory framework is in the making. Only the involvement and inclusion in these founding processes is represented unequally among all actors that are concerned.

The last chapter discusses whether governance has turned more towards business-led development at the expense of state influence.

6.5 It's a political decision

Infrastructure and energy provision has been under public responsibility for the last centuries. Figures indicating that 95 % (International Energy Agency 2015b on Rwanda) of the population in rural areas are not electrified contribute to the formulation of a deficit. It defines the lack of serving a basic need, related to the risk of bad health conditions with conventional products and the circumstance that it could prevent students from education makes it a structural problem. However, to put it another way, problems only arise if articulated in a process of *problematisation* as for instance done in the Sustainable Development Goals (SDGs), while before the lack of energy wasn't problematized that much. Given that energy infrastructure generally is considered as a public task, many argumentations reason the state would fail its task, and instead see market-led initiatives as the solution that could come in to fill the gap. In this sense, *market* and *state* enter a clear dualistic relation – one as the problem, the other as the solution (Berndt 2015: 1868).

Ghanadan (2009) reflects the shift from a public-service model of state-led development to a ›marketised‹ private-led version of electricity provision in many African countries, exemplified by the example of Tanzania shown in Tab. 13. These changes would build on cross-cutting reforms that involve and shape local, national and international arenas such as national and international development policies. They also would »involve subjective shifts in the division and promises of development, influencing people's expectations, relations with the state, and understanding of national identity and citizenship« (Ghanadan 2009: 403).

Although, there are many general aspects that might apply for Rwanda as much as for Tanzania owing to common policy models, similar technologies and ideologies (Ghanadan 2009: 403), the political national context of Rwanda varies extensively from its neighbouring states. Differently to Ghanadan, I don't look at the entire energy sector and general unbundling process but limit my observation to those areas that so far are neither provided by the public nor the private sector. Still, in Rwanda the public-administrative sector generally is described as stronger than the private-sector and so is the public involvement in electricity provision (N°6 Gilbert: 68; N°9 Lydia: 99). In addition, the private sector would be »heavily regulated« (N°7 Jean-Bosco: 46) and the state much more involved in private energy business beyond the grid than in neighbouring countries (N°9 Lydia: 35). Otherwise, Lydia and John underline that in Rwanda it would be »quite easy to set-up a business« (N°7 Jean-Bosco: 19) so that *Light Life** would have chosen Rwanda as their pilot country, while *Sole World** similarly experienced an easy market entry (N°9 Lydia: 35). In addition, Lydia emphasises the particularity of Rwanda as the government would even include the private-sector in their national development goals on electrification. However, referring to this Jean-Bosco opposes that the government would follow a »silver bullet view« (N°7: 46) and only favour ›big solutions‹.

Tab. 13: Shifts from state-led development to market-led provision in electricity

	State-led development model	Liberal market development model
Sector vision	• catalyse development and effective redistribution of benefits	• implement financial cost recovery • provide infrastructure • attract investment
Provision ethos	• public service, social contract • economic development	• commodity good • economic efficiency
Utility	• employment – civil service • organ of state-led development	• corporation • collect revenue • provide commercial services
Pricing	• equity and redistribution aims: • cross-subsidy to residential and small business from industry • universal lifeline tariffs	• economy efficiency and investment aims: • marginal cost pricing • minimise subsidies • unravel cross-subsidy to reduce tariff to industry • small ›targeted‹ subsidies
Access	• sector development mandate	• subordinate to commercial goals
Finance	• dependent on national budget • extensively donor-funded	• private investment with commercial returns • often public bears extensive risk and donors mediate publicly-borne guarantees
Areas of concern in practice	• poor-service • donor-dependent • top-down, little participation of public • subject to macroeconomic crisis subsidies benefit small fraction with service expansion falling short of goals	• narrow scope • social concerns marginalised • access low priority and little improvement • small customers face large price increases • loss of parastatal jobs • revenue emphasised over service • high returns to private sector
Debates	• modernisation and dependency	• globalisation: neo-liberal and counter-hegemonic

Source: Ghanadan 2009: 404.

Gilbert looks from a public side on the possibilities of public-private-partnerships and complains about many difficulties in working with the local private-sector:

»Il y a beaucoup des mauvaises expériences avec le secteur privé parce que surtout, quand on implique les entreprises locales privées dès le départ, dans la plupart des cas, ça ne marche pas. Parce que la plupart des entreprises n'est pas familière avec des énergies. Ce sont des entreprises ou des personnes avec des commerçants en fait, qui ne sont pas expériences dans l'énergie et des fois qui n'utilisent pas bien des fonds pour ça. Donc, on a eu beaucoup des cas, par exemple le GIZ, avec des gens, qui ont pris l'argent, mais qu'ils n'ont pas fait ce qu'il devrait faire, qui ont tourné de l'argent ou bon.«

»There are many bad experiences with the private sector, because above all, when you include local companies from the beginning, in most cases it doesn't work. Because in most cases enterprises are not familiar with energies. Those are entrepreneurs or commercial people that don't have experiences with energy and that sometimes don't use the funds wisely. We had many cases, for example with GIZ, where the people took the money but did not do what they should, but who just turned the money.« (N°6 Gilbert: 16)

Nevertheless, the GoR would have a particular interest in involving private companies in the off-grid electrification. Firstly, the government hopes for private investment and secondly, they want to source-out the ownership including the maintenance services for smaller power plants (N°6 Gilbert: 69, 80). From a *relationalist* stance, business-led electrification only emerges in relation to state-led electrification as much as energy spaces beyond the grid are essentially defined through their relation to the grid. To exemplify, for the PPP-programmes REG has drawn a buffer zone five km around the existing grid in order to define all spaces beyond as off-grid priority areas (N°6 Gilbert: 25). Likewise Max states that sites for mini-grids within a relative short distance to the grid would in turn not be approved for private mini-grid constructions (N°5 Max: 17).

One central difference between the two development models is what Ghanadan describes as the »provision ethos« (see Tab. 13) or to put it in other words the spatial provision impact. It is either oriented towards a *social contract* and equal connectivity through solidarized prices or on *economic efficiency*, which in general leads to unequal spatial provision. In theory, distance would be the only criteria for the approval of public off-grid projects but in practice state-led development includes similarly economic aspects and demarcates priority areas:

»Quand on a un endroit avec un centre de santé, avec une école, avec quelques habitations, directement on met de l'électricité.« (N°6 Gilbert: 33)

»When we have a place with a medical centre, with a school, some habitations, then directly we provide electricity.«

The provision of far distanced and difficultly accessible areas in relation to the grid remains crucial. So far, only subsidised private projects operate there, as long as it

contributes to the government's vision of increased electrification. Hence, it creates some kind of mutual dependence of the public and the private sector, in other words, a *centralised decentralisation*. However, the decision to provide subsidies and support economically unprofitable regions is based on the political will of equal provision, regardless if done by the state or by private actors but with the financial support of the state.

In conclusion, the provision of energy beyond the grid in Rwanda does neither follow an exclusive market- nor state-led model but involves both forms. In practice, they don't manifest in parallel running processes but are closely interlinked. The making of decentralised energy spaces and the emergence of private-business-led developments is strongly influenced through centralised governance. Nonetheless, as Ghanadan illustrates, there are striking differences between the two approaches that would have severe impacts if followed exclusively. Anyhow, it remains a political decision to provide unprofitable areas with energy through some kind of public support. In Rwanda, the government administratively and financially supports far distanced spaces, while focussing itself on other spaces for the centralised grid enlargement. Both, spatial grid and off-gird enlargement depends on political decisions and prioritizations, like which are the next areas for on-grid enlargement, who are the target-groups for public subsidies – does it follow a silver-bullet-model or does it try to create a level playing-field, somehow? All these decisions will follow intensive exchanges and negotiations and inevitably will always remain contested.

6.6 Conclusion on energy marketization

In this chapter I have looked at implications of a market-led provision of energy, thus the *marketization* of energy infrastructure beyond the grid. This form of provision involves many more actors than a public-led provision with the responsibility mainly given to one public utility. Yet, it involves even more than some private companies that take up the task instead. Therefore, especially in the context of Rwanda, an involvement of market-based actors in the formerly public domain of energy provision does not necessarily mean a failure of the state. Even more, it is not possible to draw a clear distinction between market and non-market or public vs private-provision owing to the many different agents that influence the making of energy beyond the grid. Instead, in a process of *marketization* different perceptions of market-led provision, values, norms and interests enter into extensive negotiations and a continuous process of readjustment of conditions and regulations. In turn, markets, regardless if for energy products or for funds, are as little naturally given and universal as inequalities in the already established energy provision between rural and centralised areas.

One can constitute that energy entrepreneurs somehow stepped into the role of national banks. The sophisticated payment-systems either by PAYG or by many instal-

ments would not be necessary, if Rwandan banks provide customers with credits with moderate interest rates. But instead, private companies developed much smarter ways for financing than banks or any other form of micro-credits. In turn, energy entrepreneurs need the support of other donors to be able to offer payment periods over several years, especially during the transition phase between start-up and small and medium-sized enterprises (SME). This again creates a certain dependency on international organisations, thus public institutions. However, the political interest of donors and governments can shift and goes back and forth. For instance, Jean-Bosco describes how renewable energy would have been on the prime agenda of international politics until 2008, the financial crisis. Then it would have abruptly disappeared and be slowly coming back again ever since (N°7 Jean-Bosco: 76).

With respect to the various positions and interests on energy provision, I want to narrow them down to two contrasting concepts that are the pre-dominant ideas of market-led energy provision. On the one hand, the GoR has an interest in increasing the total electrification rate and therefore wants to make use of cost-efficient solutions next to the expensive grid enlargement, which is why it wants to involve the private sector. On the other hand, energy entrepreneurs imagine a somehow ›level playing field‹ and unbureaucratic market conditions for promoting their products. Finally, international organisations and donors act politically in whatever way of financial or technical support to private companies. The general argument for supporting a market-led provision is that market forces would allow for proper and efficient management of resources. As such a technical solution to (natural) poverty in rural areas, such as the lack of energy infrastructure, could not be provided by state bureaucrats, but the »forces of the market« (Mitchell 2002: 225ff.). The paradox as Mitchell stated about USAID is that »an agency [USAID] devoting itself to the cause of dismantling subsidies and promoting the ›private‹ sector was itself an element in the most powerful system of state subsidy in the world«. In conclusion, public promotion of the private sector is as much political as state-led infrastructure development. It is not the ›forces of the market‹ that eventually decide if energy provision includes social or ecological impacts, if it is oriented towards spatially equal provision, whether it favours big investment possibilities over many small ones or if it is oriented towards a ›level playing field‹ of competition. Within Development discourses, relating the outcome of subsidised energy provision to ›the forces of the market‹ is a way of depoliticising the power of financial support in shaping the field of energy provision. This is why I would argue that it actually needs extensive negotiations on the way to energy provision beyond the gird, including all involved actors.

7 At the end of the line

How will Akon influence the electrification rate in Sub-Saharan Africa? Are people with 3 LED-lights and a small TV, powered by a solar panel living with or without electricity – or somewhere in between? In this study I delineated that energy provision is more complex than having the capacity to switch light on or off. I conceived the provision of energy spaces beyond the grid as a socio-technical *agencement*, made up of different forms of technologies, systems, involved actors, regulations, expectations and conventions. In this sense, there is no single decentralised alternative to a centralised grid, but various possibilities for energy provision beyond the grid. The concept of energy spaces allows to think of energy provision not territorial but relational and to combine technical, economic, political and societal aspects. While the scope of this work did not allow immersing into any aspect in-depth, my interest was instead focused on the interplay of various different aspects. Thus, I showed that technical possibilities and societal needs regarding energy are co-constitutive. Different systems are designed according to specific socio-economic contexts while similarly influencing and changing the daily lives in these contexts.

Tab. 14: Global overview on energy provision beyond the grid

Technologies	**Electric Current**	**Generation**	**Systems**	**Practices**	
	• alternating • direct	• solar • hydro • biogas	• central-grid • isolated-grid • stand-alone • single-appliance	• lighting • communication • information • commercial use • household (cooking)	
Entrepreneurship	**Transaction method**	**Deactivation**	**Calculation of fees**	**Payment time**	**Ownership**
	• Mobile Money • pin pad/ scratch card • banking	• no • yes	• service-based • time-based	• post-paid (bill) • up-front • flexible pre-paid (PAYG) • fixed pre-paid (instalments)	• immediate • rent-to-own • fee-for-service
Marketization	**Governance**	**Donor**	**Financing instruments**		
	• public • private • public-private	• venture capital • private/ non-governmental spending • public funding • international development aid	• grant • loan • tax reductions		

Source: Own representation.

Tab. 14 subsumes the different elements of energy provision presented in the previous chapters. Most categories could be complemented by additional elements and new elements might emerge in future. However, their meaning or impact again only becomes apparent relationally in the interplay with the other elements.

Finally, I want to interrelate insights from the individual elements relating to technologies, entrepreneurship and marketization and discuss more global aspects. With regard to technologies, I mainly discussed the difference between solar and hydro-powered off-grid systems to delineate various dimensions of electrification. The related current-systems, the different possibilities for using end-devices or different temporal dependencies only exemplarily depict differences between the two. Further, I differentiated between communal (e.g. mini-grids) and individual (e.g. SHS) off-grid systems, and possible effects and considerations regarding ownership, management and control of the systems. I concluded, while mini-grids can present a good, reliable long-term solution, the financial and organisational implementation of smaller individual systems is much easier.

In order to overcome the difficulty of defining *electrified*, many organisations like SE4ALL refer to the quite useful 5 folded tier system. For SHS it means that they range somewhere between tier 1 and 2. Still, I regard problematic the hierarchical form of the tier, where full-grid tier 5 connections with the highest capacities are effectively positioned as the best systems. Instead, I discussed to what extent other forms of provision, though with less capacities, can provide appropriate long-term solutions. Following Eisenstadt's concept of »multiple modernities«, infrastructure and thus energy provision can vary according to different spatial contexts. Hence, the centralised grid does not always present the best way of provision. In addition, appropriate technologies would further pledge for (re)coupling local renewable energy sources, regardless if hydro, solar, biogas, wind or geothermal power with a socially adjusted system of provision. However, this requires abandoning any concept of linear modernity that, even worse, takes infrastructure models from the Global North as benchmark. With regard to energy, it requires to compare energy systems not by their capacity in the sense bigger is better, but to include further aspects relating to the particular energy spaces, as well.

In the very first quote of this study, Akon pledges for no more charity involvement in Africa, but more business-approaches instead. The solar lantern entrepreneur Jean-Bosco similarly talked about his orientation towards venture-capital investments, which would be more business-driven, in contrast to the impact-driven »old-development story«. Among many actors, there is a common belief in market-led approaches towards energy provision. Probably a public utility would not have come with such a high variety of products and business models. To address the economic bottom-of-the-pyramid as target groups for their products, energy entrepreneurs design so-

phisticated business-models that consider the relatively low and irregular income situation of their customer. Recognizing for-profit business opportunities in thitherto economically unexplored spaces can be described as a frontier region of bottom-billion-capitalism. Regardless which kind of business-model, they all follow the idea of allowing customers to pay in infinitesimal payment tranches, while even tolerating irregularities to a certain level. I have shown that formally, the generally very common PAYG system looks quite similar to fee-for-service models and rent-to-own models. The former is mostly known from mobile phone or on-grid electricity providers, whereas the latter is mainly implemented by solar-home-system providers and therefore actually presents an alternative to micro-financing institutions. This means, energy entrepreneurs themselves have taken up the role of banks. Nevertheless, there is not one single form of market-led provision but in the interviews I could constitute mainly two, partly contrasting, ideals. One would still be more *impact-driven* and remain under public control in the sense that the government tenders out particular projects to private companies, which typically represents PPPs. The other would be more *business-driven* in seeking to foster competition among private companies by creating a level-playing field. However, I showed that due to different resources and privileges and personal networks, the possibility of creating a level playing field is an old economics illusion. How could Madeleine with her small Kigali-based company *Ecotricity** and the internally organised *Sole World** company ever compete equally?

Furthermore, the risen commitment of for-profit energy entrepreneurs, like *Sole World*, Light Life*, Sun House** or Akon, in the field of energy provision don't mark the replacement of the public by the private sector or a clear shift from non-market to market-led approaches. Instead, the marketization of energy provision is a process comprised of experiments, intensive negotiations, conflicts and agreements between various agents, markets are hence »continually produced and constructed socially« (Berndt & Boeckler 2009: 536). Whatever the market of energy provision beyond the grid looks like, public financial support either by the GoR or international organisations influences current developments a lot. Therefore, the current market is far from an arena or playing field for atomized agents. However, the outcome of infrastructure provision would probably differ if financial support would solely come through venture capital investments without any public subsidies, especially in sparsely populated areas. In this sense, infrastructure always remains political and contested. It is eventually a political decision, whether energy provision should be a field for business-opportunities or a public task that seeks to increase the general electrification rate. Albeit bureaucratic processes, I would consider the function of the GoR represented by its diverse institutions such as REG, RURA or RDB as central for the governance of this multi-actor field. Nevertheless, owing to the high influence of international organisations that contribute by financial or technical support, they need to be coordinated with any political governmental vision.

A final remark concerns the enthusiasm and hope expressed by all research participants for social change related to energy provision and to the possibilities of ICT that fundamentally require energy. Actually, I share the optimism towards energy, even if only provided through small technical system. They offer new opportunities and have the capacity to change certain aspects in one's daily life. However, similarly to Murphy & Carmody (2015) on the effects of ICT, I would not overestimate the role of energy on the capacity to fundamentally change the socio-economic situation of people in rural areas. There might be incremental and thus important changes concerning safety, health, mobile accessibility and access to information or even so-called income generating activities. However, they won't bring about a revolution. The livelihoods of people particularly in rural areas are manifested in manifold ways by unequally balanced resources, income situations and dependencies that won't diminish with the access to energy. Apart from that, generating electricity might be a life-changing technology; however, it does not present a basic need such as water, food or shelter. In this regard, one reason for the popularity of electrical systems and devices might not be »old« development-related, but that they are quality products that are super cool and thus symbolise a certain lifestyle, as Jean Bosco (N° 7: 40-42) stated.

Owing to my explorative and inductive research approach, there are many topics I only covered without following and analysing them in-depth. In addition, in the course of the study many aspects and further research problems came up that would be worth further inquiry. With respect to the last point of discussion, one interesting aspect would be the effect of electrical infrastructure, namely energy and ICT, on socio-economic livelihoods in spaces beyond the grid. As outlined in chapter 3 on my methodology, this work lacks the immediate perspective of local households. Furthermore, it would be interesting to follow-up on some of the concrete promises, like improving health, education or increasing safety, for instance for women by providing more light at night. How would an individualised energy provision relate to communal infrastructure such as streets lights, schools or medical centre? What are the effects of communal systems, like mini-grids, in comparison to individualised systems on small communities? In how far do consumers accept decentralised technologies as an alternative to the grid, or will they remain temporary solutions? This would similarly include a follow up on the effect of maintenance services, like replacing and recycling individual components (especially batteries) or possible upgrades of systems. A further aspect would be how delinked, renewable energy systems change consumption behaviours and expectations towards infrastructure, when thinking of stocks and breaks instead of a steady flow of energy. With regard to the external support, how will a shift in financial support change market relations and thus the provision of energy? For instance, how would venture capital impact the sector compared to charities?

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Appendix

App. 1: 3 Multi-tier matrices on energy access

Multi-tier Matrix for Access to Household Electricity Supply

ATTRIBUTES			TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
	1. Capacity	Power[1]		Very Low Power Min 3 W	Low Power Min 50 W	Medium Power Min 200 W	High Power Min 800 W	Very High Power Min 2 kW
		AND Daily Capacity		Min 12 Wh	Min 200 Wh	Min 1.0 kWh	Min 3.4 kWh	Min 8.2 kWh
		OR Services		Lighting of 1,000 lmhrs per day and phone charging	Electrical lighting, air circulation, television, and phone charging are possible			
	2. Duration	Hours per day		Min 4 hrs	Min 4 hrs	Min 8 hrs	Min 16 hrs	Min 23 hrs
		Hours per evening		Min 1 hrs	Min 2 hrs	Min 3 hrs	Min 4 hrs	Min 4 hrs
	3. Reliability						Max 14 disruptions per week	Max 3 disruptions per week of total duration < 2 hours
	4. Quality						Voltage problems do not affect the use of desired appliances	
	5. Affordability					Cost of a standard consumption package of 365 kWh per annum is less than 5% of household income		
	6. Legality						Bill is paid to the utility, prepaid card seller, or authorized representative	
	7. Health and Safety						Absence of past accidents and perception of high risk in the future	

[1]The minimum power capacity ratings in watts are indicative, particularly for Tier 1 and Tier 2, as the efficiency of end-user appliances is critical to determining the real level of capacity, and thus the type of electricity services that can be performed.

TABLE ES.2

Multi-tier Matrix for Access to Household Electricity Services

	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Tier criteria	Not applicable	Task lighting Phone charging	General lighting Television Fan (if needed)	Tier 2 AND Any medium-power appliances	Tier 3 AND Any high-power appliances	Tier 4 AND Any very high-power appliances

TABLE ES.3

Multi-tier Matrix for Electricity Consumption

	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Annual consumption levels, in kilowatt-hours (kWh)	<4.5	≥4.5	≥73	≥365	≥1,250	≥3,000
Daily consumption levels, in watt-hours (Wh)	<12	≥12	≥200	≥1,000	≥3,425	≥8,219

Source: Bhatia & Angelou 2015: 6

App. 2: Guiding questions for energy entrepreneurs

Topic	Guiding questions
Business description	• Could you please give a brief description of your business? • How has your business developed during the last years? • Where in Rwanda are you operating? • Who are the main actors (companies) in your business? • What are the main advantages of your technology? → who benefits?
Functioning of markets	• Who are your clients? • How would you describe the market you're operating in? • In which way does the government interfere in the market, how does he regulate it? • How does the payment work for your technologies (from clients)? • How do external (foreign) actors interfere in the business? • How do you see other companies in your business field - competitors or
Daily business	• Could you please describe the enrolment of a typical business project - from start (contract/tender) to end (your final contribution)? • What challenges do you face?
Energy access	• What is the importance of energy access in Rwanda? • Why are people investing in energy?
Spatial distribution of energy infrastructure	• What are the main spatial and technical advantages and challenges for the installation of your technology/ power plant in comparison to other technologies? • What are the main reasons for not operating? • How do you expect the future of energy infrastructure in Rwanda will look like?

Source: Own concept.

App. 3: Final Coding-system with all interviews

Axial Category	Categories	Subcategories	Dimensions
Main category: Energy entrepreneurship			
Customer relations			•
	• Target group		•
	• Monitoring and Control		•
		• Control of disregarding contract	•
		• Monitoring of customer activities	•
	• Services		•
		• recycling / disposal	•
		• Maintenance + repair	•
		• Installation of the system	•
		• Transport of system	•
	• Payment schemes		•
		• Transaction method	•
			• Mobile Money
			• Scratch card
		• Deactivation?	•
			• no
			• yes
		• Calculation of fee	•
			• service-based
			• time-based
		• Payment time	•
			• post-paid
			• up-front
			• flexible pre-paid (pay-as-you-go)
			• fixed pre-paid (instalments)
		• Ownership	•
			• immediate
			• rent-to-own

			• fee-for-service
	• Marketing		
		• Working with cooperatives • Personal recommendations • Organizing events	
Practices of energy (market-potential)			
	• Commercial use • Communication • Information • Lighting		
Types of companies			
	• project management • Retailing • Product development		
Running the company			
	• Value chain management		
	• Development of company • internal structure • Vision, values and goals		
Technologies of power			
Energy generation (products)			
	• Biogas • Water • Solar		
Energy systems (connection)			
	• On-off-grid dualism		
		• centralised-grid • island-grid (isolated) • stand-alone	

	• Tier system	• T5 • T4 • T3 • T2 • T1 • T0
Energy market in the making		
Business relations		
	• Independent / separate activities • Cooperation • Competition	
Governance		
	• Public-private partnership • Regulations and Standards • Public coordination	
Financing		
	• Applications and Tendering process • Tax reductions • Loans • Grants • Venture capital	

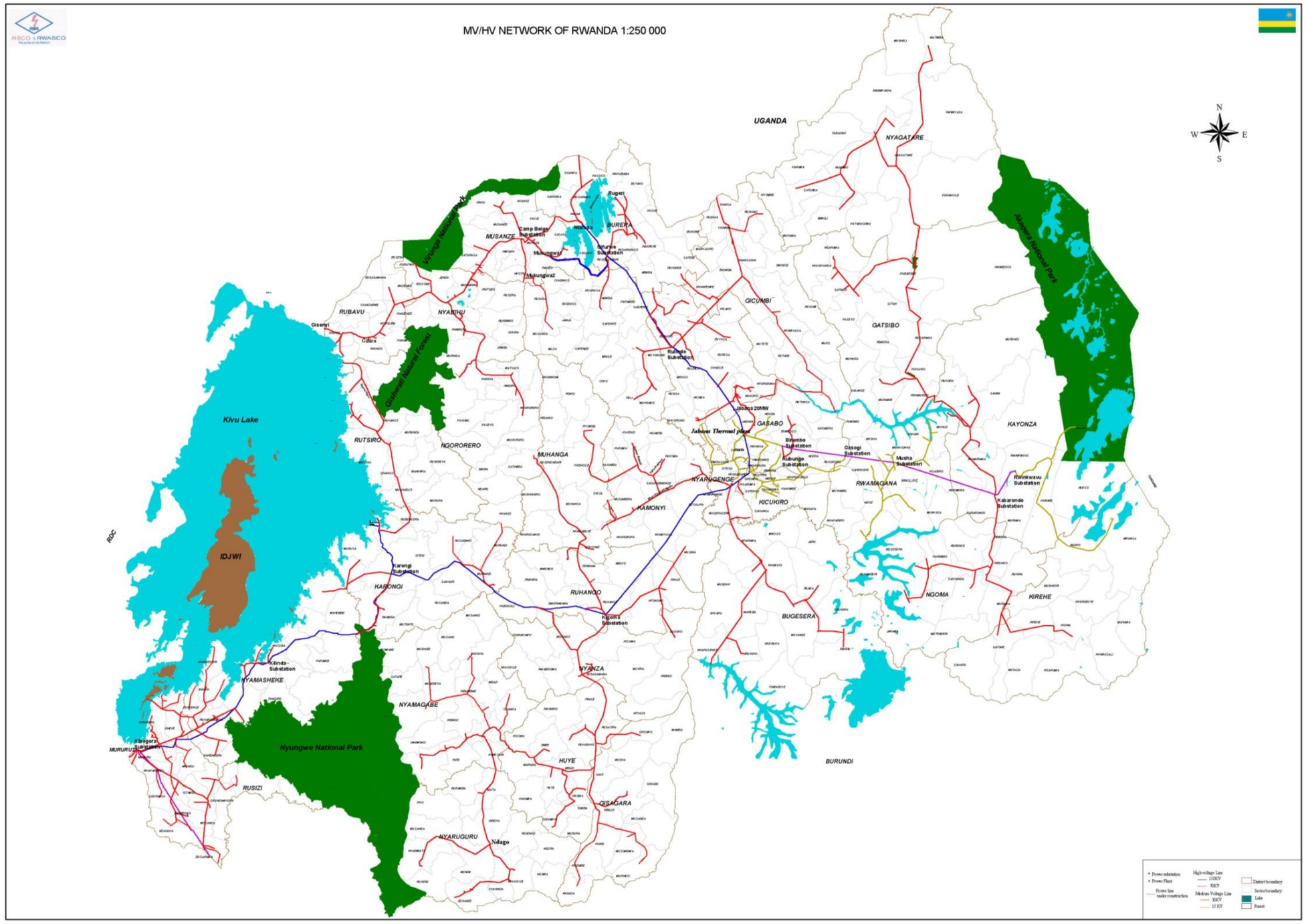
Caption:

Main categories	Axial Categories	• Categories	• Properties	• Dimensions

Indicator, Concepts and technical indicator are not listed here for the sake of brevity.

Source: Own representation.

App. 4: Map of power lines in Rwanda (from 2011)



Source: RECO & RWASCO

Beyond the grid

In many parts of the world, the centralized grid provides energy to the population only to a limited extent. The electrification for sub-Saharan Africa countries is the lowest in the world, representing half of the world's population without electricity. However, during the last years there has been an increased attention to rural areas in the Global South beyond the centralised grid, especially with respect to improved possibilities of solar power systems. The transition from one dominant form of energy provision to various alternatives includes different dimensions and depends on specific socio-spatial contexts. Energy systems are framed within systems of spatial practices, performed by a variety of involved actors, like consumers, local suppliers, international for-profit companies, international development donors as well as national and regional authorities. As such power systems are always cause and effect of socio-technical change This study takes the example of Rwanda to analyse the marketization of decentralised energy systems. Based on empirical field work with energy entrepreneurs it combines Post-Colonial Theory with Science and Technology-Studies to theorise the role of energy to the social production of space beyond the grid.