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UNIVERSITY OF TURKU

FOUR FUTURES OF THE ENERGY TRANSITION IN THE GLOBAL SOUTH

A case study of an off-grid solar photovoltaics start-up boom in Kenya and Tanzania

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University of Turku

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Finland Futures Research Centre
Futures Studies
Doctoral programme of Turku School of Economics

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The originality of this publication has been checked in accordance with the University of Turku quality assurance system using the Turnitin OriginalityCheck service.

Cover Image: Illustration by liuzishan on iStock

ISBN 978-952-02-0728-1 (PRINT)
ISBN 978-952-02-0729-8 (PDF)
ISSN 2343-3159 (Print)
ISSN 2343-3167 (Online)
Painosalama, Turku, Finland 2026

UNIVERSITY OF TURKU
Turku School of Economics
Finland Futures Research Centre
Futures Studies
JONI KARJALAINEN: Four futures of the energy transition in the Global South – a case study of an off-grid solar photovoltaics start-up boom in Kenya and Tanzania
Doctoral Dissertation, 217 pp.
Doctoral Programme of Turku School of Economics
June 2026

ABSTRACT

This doctoral dissertation in Futures Studies adopts an anticipatory perspective and pays systematic attention to actions at the forefronts of the energy transition in the Global South. My research aims to answer how looking at pioneers, as catalysing actors, helps in conceptualising the emerging dynamics of the energy transition, as a gradual, complex and non-linear process, and especially to study its economic potential. As elaborated in futures studies, the future already manifests as the potential of the present, and can be observed through the early signs of change. Foresight helps one to detach from the present and to move forward in time, and has untapped potential to be harnessed around the world. By identifying pioneers and weak signals, we do not only ask what is, but also what could be. Possibilistic-transformative foresight opens our minds to thinking of challenges or problems as opportunities as well as the wider patterns of transformative change.

Methodologically, this exploratory study deployed a qualitative research methodology to examine the seeds of change, and identified off-grid solar photovoltaics start-ups in the Kenyan and Tanzanian lead markets as vanguards who are pulling us to the future. After identifying these highly-innovative agents of change, a new four-level typology was developed to assess their innovation capabilities, based on data from 2019. Investment, finance and market data were analysed to evaluate the economic value of their innovativeness. In parallel, learning from the energy transition in Chile in the Latin American context widened the political-economic perspective of the study. In parallel, horizon scanning assisted in detecting emerging issues and weak signals of change. The intuitive logics scenario technique assisted in clustering the identified dynamics into driving and hindering forces, affecting some of these forerunner actors.

Four futures called *"Lost Opportunity!"*, *"Tackling the Youth Unemployment Crisis!"*, *"Breaking Through!"* and *"Surfing the Wave!"* examine the evolution of start-ups in the Global South until the year 2050. Capability-accumulation and strategic regime support differentiate these images of the future as two critical uncertainties of the transition. They reveal power asymmetries in the global innovation networks affecting entrepreneurial firms as innovators. By exploring long-term market change within the energy transition, these futures illustrate the role of the private sector in addressing sustainability challenges. Speaking to the concerns

of a just transition, they are suggestive of a new mission in an increasingly volatile and uncertain world. They can be used to stimulate policies and programmes aimed at guiding innovation and development efforts. The study contributes to assessments of the innovativeness of environmentally-friendly firms operating in the Global South markets. It also encourages the scaling up of co-creative learning efforts about futures, as deliberative foresight.

KEYWORDS: East Africa, foresight, innovation capability, leapfrogging, pioneer analysis, startup company, sustainability transition

TURUN YLIOPISTO
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Tulevaisuuden tutkimuskeskus
Tulevaisuudentutkimus
JONI KARJALAINEN: Four futures of the energy transition in the Global South – a case study of an off-grid solar photovoltaics start-up boom in Kenya and Tanzania
Väitöskirja, 217 s.
Turun kauppakorkeakoulun tohtoriohjelma
Kesäkuu 2026

TIIVISTELMÄ

Tämä tulevaisuudentutkimuksen väitöstyö kiinnittää huomiota energiamurroksen eturintamaan globaalissa etelässä. Tulevaisuudentutkimuksessa tulevaisuus ilmenee nykyhetken potentiaalina ja sitä voidaan tarkastella muutosten varhaisten merkkien ja heikkojen signaalien avulla systemaattisesti. Innovaatio- ja kehitystutkimuksen tutkimusotteeseen nojaten analysoin valtavirtaistunutta muutosteoriaa, missä yksityinen sektori esitetään erilaisten kestävyyshaasteiden ratkaisijana. Ennakointi voi auttaa tarkastelemaan tähän suuntaukseen liittyviä haasteita ja ongelmia mahdollisuuksina sekä tutkimaan orastavien muutosten laajempaa ja syvempää potentiaalia. Oma väitöstutkimukseni pyrkii tutkimaan ja tulkitsemaan energiamurroksen edelläkävijöitä sekä erittelemään sen dynamiikkaa ja taloudellista potentiaalia.

Laadullisiin ennakointimenetelmiin nojaten tunnistin työssäni hajautettua aurinkoenergiaa hyödyntävät startup-yritykset Kenian ja Tansanian edelläkävijämarkkinoilla energiamurroksen johtotähtinä. Työssäni koostin tietokannan näiden yritysten innovaatiokyvykkyyksistä eli tiedoista, taidoista ja verkostoista, minkä avulla ne ottivat käyttöön uusia tuotteita ja palveluita vuoden 2019 tilanteeseen pohjaten. Alan markkina- ja sijoitusraportteja analysoimalla ja toimintaympäristöä luotaamalla kuvaan hajautetun aurinkoenergian ekosysteemin rakentumista Itä-Afrikassa sekä kasvualan kehitykseen vaikuttavia muutosvoimia ja heikkoja signaaleja. Lisäksi vertailen näitä pyrintöjä aurinkoenergian edistämispyrkimyksiin Chilessä energiamurrokseen liittyviä laajempia poliittis-taloudellisia odotuksia ja jännitteitä valottaen.

Esitän työni tulokset skenaariotekniikkaa mukaillen neljänä vuoteen 2050 ulottuvana tulevaisuuskuvana nimeltään "Menetetty mahdollisuus!", ”Ratkaisuja nuorisotyöttömyyteen!”, "Läpimurto!" sekä "Aalloilla surffaamista!" Näissä tulevaisuuskuvissa innovaatiokyvykkyyksien kasautuminen sekä valtaregiimin tuki esitetään kriittisinä epävarmuustekijöinä, jotka erottavat kuvat toisistaan. Työssäni väitän, että vallan epätasapaino maailmanlaajuisissa tiedon, teknologian, innovaatioiden ja rahoituksen verkostoissa tulee huomioida, kun pohditaan startup-yritysten toimintaedellytyksiä sekä pitkän aikavälin markkinakehitystä. Näiden kuvien perusteella tutkimus esittää, että tarvitaan nykyistä kunnianhimoisempia, lähes missiolähtöisiä toimia oikeudenmukaisen energiamurroksen edistämiseksi myös

paikalliset talouskehityksen vaateet huomioiden. Kansalliset ja kansainväliset tahot voivat hyödyntää tulevaisuuskuvia ymmärtääkseen yksityisen sektorin roolin energiamurroksessa ja politiikka- ja ohjelmatoimia arvioidessaan. Tutkimus auttaa tulkitsemaan ympäristöystävällisten yritysten innovatiivisuutta globaalissa etelässä. Se kannustaa deliberatiiviseen eli keskustelevaan ennakointiin yhteiskehittämisen opein ja menetelmin muuttuvassa maailmassa.

ASIASANAT: edelläkävijäanalyysi, ennakointi, innovaatiokyky, Itä-Afrikka, kasvuyrittäjyys, kestävyysmurros, teknologinen harppaus

Acknowledgements

The journey already started before it formally began. And, it started long before a single word appeared in this manuscript.

Upon starting this journey, the future felt and was unknown. At the early stages of a doctoral journey, one feels rather overwhelmed and puzzled, as the path is little known, skills are limited, and accordingly, the expected steps are challenging to take. Every now and then in life, we imagine transformational highs. In reality, also in this research, progress has often been incremental. At times, time has even stood still – perhaps to provide fresh perspectives. This eventual piece aims to capture the related efforts in their many forms. Along the way, I have been reminded that research is not merely a cognitive or solitary exercise. In fact, it is very much a social, emotional, and in some of its best moments, a collective effort and even an adventure to be shared with others.

Many stories are easy to tell afterwards. Over the years, a couple of eyebrows have been raised when I have shared that I am studying futures. And yet, anyone and anywhere can study and also begin to act upon futures. I suppose that if a social scientist looks at societies, then a futures researcher aims to address their futures in their respective environments. And, because as human beings, we are able to challenge our own beliefs concerning the future, through dialogues, we also interrogate assumptions thought to be pertinent or absolute. Therefore, as one of the many lessons learned from this work, it appears to me that we should always remind ourselves of our ability to think about the future and allow us to expand our horizons in analytical, creative as well as explorative fashion.

Formally, I started this research journey as part of Neo-Carbon Energy Project (2014–2017), strategic research opening of Tekes - the Finnish Funding Agency for Innovation [40101/40], a pioneering, multidisciplinary, four-year research project alongside energy scholars. I extend my gratitude to the University of Turku Graduate School (UTUGS), Liikesivistysrahasto - the Foundation for Economic Education, and Jenny and Antti Wihuri Foundation who helped me advance this journey. Small grants from Turun Kauppaseuran säätiö, UniPID - Finnish University Partnership for International Development as well as GIZ - Deutsche Gesellschaft für

Internationale Zusammenarbeit (German Agency for International Cooperation) added to the international dimension.

I owe immense gratitude to my main supervisor, professor emerita Sirkka Heinonen, for her intellectual curiosity, extensive knowledge and unwavering support – your tremendous attentiveness does not go unnoticed. I appreciate professor Alan Colin Brent for being candid and open-minded to the idea of engaging with this work, as my second supervisor. I thank very warmly colleagues at Finland Futures Research Centre, including Juho, Marjukka, Marianna, Mikkel, Sanna, Amos, Nick, Riikka, Jyrki, Jarmo, Nina, Anne as well as fellow PhD students for your tips and commentary. I highly value Mika, Noora, Osku and Kalpani for your comradery. Many thanks to Juha for our cooperation and Pete for your honest insights.

Assuming a scientific form and language, this dissertation is an invitation to decolonise. Many of its ideas derive from ideas, observations, sentiments and perceptions shared and voiced by real people. I'd like to thank from the bottom of my heart all those whom I encountered along the way, and who have participated in this journey one way or the other. These include my interviewees, a range of stakeholders and individuals in informal conversations who shared their time and energy. I also think about friends and Blandine Olive Tchamou in Douala, Cameroon working around environmental change in postcolonial contexts. Peter Kuria Githinji stimulated my interest in decentralised renewable energy with curiosity and creativity by combining knowledge and action. With Eva Kagiri, we sat in those green benches in Brighton. I want to thank Rob Byrne for your patience, guidance and intellectual rigour, and I appreciate your problematisations over cups of coffee in the Brighton city centre and in the Science Policy Research Unit (SPRU). I thank Steve Karekezi, Philipp Späth and Leena Ilmola-Sheppard for their unselfish support as well as Moeketsi Mpholo and Zak Thamae for your sincerity. I also acknowledge the work of the Millennium Project's East African node as well as the Institute for Futures Research (IFR) in South Africa. There are many more in Tanzania, Ghana, Namibia, Lesotho, and beyond to appreciate.

I want to recognise the valuable commentary by the pre-examiners of this dissertation. I greatly appreciate Franklin Obeng-Odoom for sharing his academic expertise and the useful remarks that assisted in gaining clarity, and especially for agreeing to act as an opponent to the thesis defence. I would equally like to thank Geci Karuri-Sebina for granting her time into this process. Together, your commentaries have added spark and provoked many further thoughts.

Thank you to my dear friends. I very much would like to single out all of you. In your heart, I believe you know who you are, and what you mean to me. We shall let our good conversations and long evenings to be enjoyed also in the future. After all, transnational research also can be time away from one's closest. Kaisa, your role in

this journey is considerable. Many of you are equally early scholars and change-makers. I thank Kamilla for our friendship and peer support, Tomi Lehtimäki for our chess matches in Seili, Sakari Höysniemi for amicable commentary and Eva Nilsson for political economy perspectives. On academic peers, I will mention Juho Korhonen and Nora Stenius. Thank you to Martin Boucher, Kweku Korateng, Ebenaezer Appies and Lois Gicheru, as well as Njeri Mwagiru for your spirit in the field of futures. Thank you so much, Iris, for your kind presence. Many of you have been there, when it most mattered.

Visibly, we stand on the shoulders of those who walked before us. Thank you, mother Tuula, for your importance and support, which is irreplaceable in this world, and my belated father, Kimmo, for providing me inspiration, and I sincerely hope you are somewhere celebrating. I also wish to recognise close family members and friends. Finally, I'd like to dedicate this future-oriented piece to the generations that came before. Alongside my grandfathers, I have been fortunate to feel the care of my two grandmothers, Martta Hemminki ("Mumma") and Kirsti Karjalainen ("Isoäiti"), two loving women whom I will always continue to look up to.

Your memory and love will live in my mind, as we look into the far future.

Brussels 17.5.2026
Joni Karjalainen

JONI KARJALAINEN

Joni Karjalainen is a researcher at the Finland Futures Research Centre, University of Turku. His research interests include off-grid solar energy entrepreneurship, innovation collaboration in the energy transition, development pathways, and learning with futures. He has experience in global development, climate, energy and environmental policy as well as associated scenario-building efforts in Europe, Africa, and beyond. Karjalainen holds a M Soc Sc degree in Political Science from the University of Helsinki.

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Figures

List of Original Publications

This dissertation is based on the following original publications, which are referred to in the text by their Roman numerals:

I Karjalainen, Joni & Heinonen, Sirkka (2018). The pioneers of renewable energy are around the world – what can we learn from them? *Journal of Futures Studies* 22 (4): 83-100. https://doi.org/10.6531/JFS.201806.22(4).0006

II Karjalainen, Joni & Heinonen, Sirkka (2018). Using deliberative foresight to envision a neo-carbon energy innovation ecosystem – a case study of Kenya, *African Journal of Science, Technology, Innovation and Development* 10: 5, 625-641. https://doi.org/10.1080/20421338.2017.1366133

III Karjalainen, Joni & Byrne, Rob (2021). Moving forward? Building foundational capabilities in Kenyan and Tanzanian off-grid solar PV firms. In Andersen, M., Hanlin, R., Lema, R. & Nzila, C. (eds). *Building Innovation Capabilities for Sustainable Industrialisation: Renewable Electrification in Developing Economies*. Routledge, pp. 181-204. https://doi.org/10.4324/9781003054665-9

IV Karjalainen, Joni, Vähäkari, Noora & Heinonen, Sirkka (2020). Foresight for Chile's energy transition – unleashing societal transformations. In Noura, Lucas (ed.) *The Regulation and Policy of Latin American Energy Transitions.* Elsevier Science: Amsterdam, Oxford, Cambridge, MA, pp. 263-282. https://doi.org/10.1016/B978-0-12-819521-5.00015-2

V Karjalainen, Joni (2026). Are all start-ups born equal? Images of the future of the off-grid solar photovoltaics sector in Kenya and Tanzania in 2050. [*Unpublished manuscript*]. University of Turku.

Contribution of the author to the articles

In Article I, the research was co-designed by the authors. The Author introduced climate and energy aspects, as a motivation of the study. S.H. described the use of foresight and the role of pioneers. Both Authors elaborated the methodology, and designed an international survey with a research assistant to a wider academic research project. The discussion and conclusions were jointly written.

In Article II, the Author identified the case study country. S.H. contributed to the theoretical framework, and the Author was in charge of the methodology, data collection as well as data analysis. The Author developed an assessment framework to learn how renewable energy projects, in the present, are pointing to the future. The Author was in charge of the conclusions.

In Article III, the Author designed the study. R.B. provided historical context and assisted in the theory elaboration, with specific descriptors. The Author compiled a database of off-grid solar photovoltaic firms in Kenya and Tanzania, and also developed a new categorisation that places them into four levels based on their innovativeness. Assisted by finance and market data, R.B. and the Author jointly interpreted the findings and wrote the conclusions.

In Article IV, the Futures Clinique, which is a participatory method initially developed by S.H., was co-organised and adapted by the three authors for the purposes of a wider research project on the energy transition. The Author led the research design, as well as elaborated on the study justification, analytical framework and the methodology. The clinique results were analysed by the Author and N.V. The Author led the writing of the discussion and the conclusions.

In Article V, the Author designed the analytical framework. Two new datasets, one on stakeholder forums and another on horizon scanning were introduced. The impact-uncertainty matrix was deployed for identifying driving and hindering forces, as uncertainties to the start-up dynamics. Four images of the future, inspired by off-grid solar PV start-ups, were presented, that explore the implications of these seeds of the transition.

1 Introduction

At an era when planetary boundaries are being crossed (Richardson, 2023), decarbonisation, decentralisation, digitalisation and electrification are claimed to be converging as a global energy transition (WEF, 2018; see also: Rifkin, 2011). In this transition, renewable energy technologies are phased in, as more sustainable to conventional fossil fuel-based generation technologies, which are phased out. Off-grid solar photovoltaics, as systems, products and services that are able to operate even autonomously from the electricity grid, are an extreme manifestation of decentralised renewable energy (DRE). In the Global South, promises of their uptake propagate an appetite for leapfrogging (Murphy, 2001; Levin & Thomas, 2016), inspiring claims for them to be as revolutionary as mobile telecommunications were in the early 2000s. Adding to such hype, digital technologies and the effects of the Fourth Industrial Revolution (4IR) alongside artificial intelligence, underpinned by peer-to-peer principles, are further shaping the world. While an accelerated energy transition appears to be desirable (Sovacool et al., 2025), the voices on post- or de-growth futures (Hickel et al., 2022; Kallis et al., 2025) demand us to explore even more radical directions.

At every moment, a wide range of forces are in operation. As a serious limitation, analyses of the futures of many Global South countries remain to be simplistically depicted as "doom and gloom" or too optimistically (Simmet, 2018; Hamann et al., 2020; Saha & Carter, 2022). When some forerunners, including those in the Global North, are claiming climate leadership, a range of strategic questions are raised in the Global South, including at a host of African countries. Specifically in the case of energy, the full potential and implications of the transition remain quite weakly conceptualised. Despite the fact that the history of energy is filled with innovative disruptions, typical energy studies are quite narrowly oriented to the future (Krupa & Jones, 2013; Proskuryakova, 2017; Kuchler & Bridge, 2018). Modelling studies on new technologies assess emissions and make cost assumptions (Ouedraogo, 2017; Barasa et al., 2018) that inform long-term energy scenarios (IRENA 2020; 2023). Habitually, they perpetuate the current institutional landscape (Osorio-Aravena et al., 2025) and ignore the political-economic and socio-cultural elements of

transitions (Cloke et al., 2017; Newell, 2021; Boon, 2022), such as calls for justice (Swilling & Annecke, 2012; Kumar et al., 2021).

1.1 Aim of the study

This doctoral dissertation in Futures Studies aims to pay systematic attention to actions at the forefronts of the energy transition in the Global South by assuming an anticipatory perspective and deploying a foresight approach (W. Bell, 1997a; 1997b; Poli, 2017). Foresight is recognised for its unique ability to help one detach from the present and to move forward in time (EFP, 2023). One added value of foresight is in how it allows the dynamics of change, such as the role of local creativity and ingenuity, to be considered that may help in challenging current assumptions, beliefs or technologies (Greiner et al., 2022). Furthermore, the study of new paradigms, related principles, and their implications, is central in strategic foresight, which links foresight with action to identify key steps and their actualisation (Lustig, 2015; Burrows & Gnad, 2017). As an additional benefit, foresight can bring different expert communities together. Globally, the potential of foresight may not have been comprehensively harnessed yet, but it is claimed to hold considerable opportunities for strategic use (Reilly-King et al., 2024; Benedikter, 2025).

Aligning with the principles of futures research, this work assumes an interdisciplinary social-scientific approach, and has been motivated to learn from the agency of pioneers who are already acting to shape the future (Heinonen, 2017; Heinonen & Karjalainen, 2019). Methodologically, as exploratory research, primarily qualitative methods were applied to identify forerunners of the energy transition in different ways. As the research advanced, my research identified start-ups, as a specific type of agents of change. To better understand their agency in shaping the future, a case study of off-grid solar photovoltaics start-ups in Kenya and Tanzania, and the capabilities they need to innovate (M. Bell, 2009; M. Bell & Figueiredo, 2012; Ockwell et al., 2019), is documented in more detail (Yin, 2017). As a hypothesis, I have assumed that by capturing such pioneering entrepreneurial and market dynamics on decentralised renewable energy, new insights of the futures of the energy transition in East Africa, and related pathways, can be obtained.

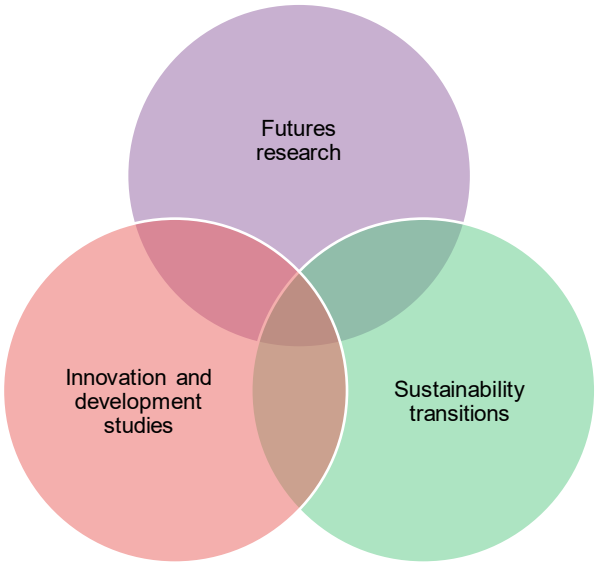

Figure 1. Conceptual framework of the dissertation. The three key scientific fields, which all assume a long-term perspective, and their relations are illustrated. Innovation and development studies assisted in analysing the entrepreneurial dynamics of transitions in the Global South, especially at the micro-level. In turn, futures studies acted as an umbrella approach for the entire work.

The conceptual framework builds upon three academic lenses, all of which share a distinct interest in long-term – and even very long-term change. The academic field of futures studies[1] (in **Figure 1**, on the top of the framework) recognises the possibility of multiple futures in a constantly changing world where hidden and latent causalities are easily ignored or overlooked (W. Bell, 1997a; see also: Poli, 2024). Besides assisting in the analysis of the forefronts of particular fields, it learns from driving and hindering forces, emerging issues as well as the weak signals of various future patterns. As part of this quest, peripheral vision helps in looking at the future widely and deeply (Schoemaker, 2019). As will be later explained, it also can help to identify pioneers, and how their actions are already pointing to new alternatives. In turn, theorisations in the field of innovation and development studies (on the left) and about the prospects of transitions in the Global South (on the right) are helpful in explaining the extent to which start-up firms as catalysts are already pointing to the future.

[1] Futures studies may have remained as an academic niche in a global picture until today, but they can be practiced anywhere in the world, as shown by a rich history and a growing range of examples in diverse contexts (Masini, 2006; Kuosa, 2011; Son, 2015; Villman et al., 2024).

Concerning foresight, this study assumes a possibilistic-transformative stance, which means that in exploring futures, critical perspectives complement an examination of possibilities and transformations (Ahlqvist & Rhisiart, 2015; Minkkinen et al., 2019). To examine such potential developments, also imaginative and visionary frameworks, methods and tools are necessary (Balcom Raleigh & Heinonen, 2018). As per its non-verifiable nature (W. Bell, 1997a), futures knowledge is about generating deep and systemic evidence amidst complexity and uncertainty. Accordingly, a typical purpose of foresight is to create awareness and alert about issues related to the future, instead of offering definitive answers (Störmer et al., 2020). When it comes to the transitions, and here, the energy transition in particular, they are usually considered as deep, evolutionary, long-term, and non-linear processes (Sovacool, 2016). Therefore, this study identified lead markets of new decentralised renewable energy technologies in East Africa as environments where the seeds of transitions in the Global South, and also their key actors, can be explored. Certainly, exploring the energy transition is not easy or straightforward, and for this reason, the study aims to generate fresh perspectives.

1.2 Research questions

My research aims to answer the following main question: "how can looking at pioneers, as catalysing actors, assist in conceptualising the emerging dynamics of the energy transition, and study especially its economic potential in the Global South?"

As described next in **Table 1**, the following four (4) sub-questions have guided the dissertation and helped me further answer this question:

- RQ1: How and what kinds of anticipatory approaches can contribute to the conceptualisation of the global energy transition, as one of our grand societal challenges?
- RQ2: How can we identify and learn from diverse types of pioneering efforts taking place at the forefront to explore where, how and what kinds of change could potentially emerge?
- RQ3: Where are the actions of off-grid solar photovoltaics start-ups, as highly-innovative market pioneers of decentralised renewable energy in East Africa, pointing to?
- RQ4: How could deliberative foresight assist in the efforts to develop global innovation ecosystems for decentralised renewable energy?

Table 1. Research question, sub-study, empirical material(s), and key method(s) applied.

Research question	Sub-study	Empirical material(s)	Key method(s)
RQ1 – How and what kinds of anticipatory approaches can contribute to the conceptualisation of the global energy transition, as one of our grand societal challenges?	I, II, III, IV, V	Grey literature (media, policy documents)	Horizon scanning Pioneer analysis Impact-uncertainty matrix Scenario-testing
RQ2 – How can we identify and learn from diverse types of pioneering efforts taking place at the forefront, and explore where, how and what kinds of change could potentially emerge?	I, II, IV, V	International expert survey (n=39)	Assessment of benchmarks Pioneer analysis Case study methodology Horizon scanning
RQ3 – Where are the actions of off-grid solar photovoltaics start-ups, as highly-innovative market pioneers of decentralised renewable energy in East Africa, pointing to?	I, III, V	Database of off-grid PV firms in Kenya and Tanzania (n=94) Finance, market and sales data Stakeholder dialogues Interview data	Pioneer analysis Novel typology of innovation capabilities Images of the future
RQ4 – How could deliberative foresight assist in the efforts to develop global innovation ecosystems for decentralised renewable energy?	I, II, IV, V	Focus group discussions (experts, stakeholders) Futures roundtables	Horizon scanning Futures clinique Futures workshop(s) Scenario-testing

In answering these questions, each of the three scientific fields has offered distinct and complementary views, theories and methods. As a result, I identified actors, novelties and related phenomena pointing to the future, which are encircled by quite complex dynamics of power, which in turn in many ways are deeply rooted in politics, economy, technology, and ideological beliefs. Especially the political-economic dimension of the transition will require careful consideration amidst neo-colonial fears (Sadik-Zada et al., 2025), as will be illustrated in the images of the future of this study, also presented to the reader. Entering into a territory of decentralised renewable energy futures in the Global South, as largely uncharted terrain, it is also an invitation for further contributions on these topics.

1.3 Structure

After this introduction, my dissertation advances through the following structure.

In Chapter 2, I next present my theoretical framework. First, I will explain why there are calls to improve scientifically based anticipatory techniques that aim to enhance our ability to engage with futures. I argue that interdisciplinary social-scientific approaches might enrich anticipatory analyses. Moreover, when it comes to processes of socio-technical change assumed to take place in the Global South, using my research as an example, I will discuss their necessity to engage with the futures of transitions. In this same chapter, I will also introduce an analogy between two transitions one of information and communication technologies (ICTs) and another one on energy. Within a historic parallel, the former is already far advanced and has already revolutionised our societies, and if one looks at them closely, the seeds of the latter (and also through their early implications) are beginning to be seen. Importantly for this study, an economic development perspective is embedded in both, and is of particular relevance for many Global South actors. These considerations also frame the subsequent interest in start-ups, as exceptional entrepreneurial actors.

Chapter 3 elaborates my research methodology, and how I aimed to learn from various developments and actors. I deployed pioneer analysis, as a futures studies method, and I used other foresight techniques, such as horizon scanning. I will also introduce an analytical tool from innovation and development studies, alongside presenting more conventional research methods. Importantly, this chapter also explains how I aimed to steer away from simplistic generalisations, including a discussion on the positionality of scholars of European origin on such topics.

In Chapter 4, I will explain why learning from the off-grid solar photovoltaics start-ups boom in Kenya and Tanzania may be important for understanding transitions in the Global South. I will also refer to the early signs of the energy transition in Chile, to justify the study of an economic pioneer in Latin America, as a country that has a long-standing interest in value chain upgrading.

Chapter 5 presents and discusses the main findings from each sub-study as well as their originality and value, as an effort to explain the different ways in which foresight could assist in exploring the energy transition across various local, national and regional contexts.

Chapter 6 presents four images of the future that address and open up the futures of the energy transition in the Global South. These images are called “Lost Opportunity!”, “Tackling the Youth Unemployment Crisis!”, “Breaking Through!” and “Surfing the Wave!” The glimpses of the future in them aim to provoke ideas of the year 2050 and to assist in conceptualising alternative pathways. When they are interpreted through a political-economic lens, some of them could appear to be more desirable than others.

In Chapter 7, I elaborate on the contributions of this research into each scientific field, identify further research needs and also outline societal and policy-oriented implications resulting from the study.

Finally, I conclude my argument in Chapter 8 where I provide guidance on the study findings, and also ask how locally-innovative efforts could be accelerated, as an issue of potential interest to anyone interested in addressing the transition and the climate dilemma, as topics of global relevance.

2 Generating futures literacy on Global South transitions

Chapter 2 argues that a study interested in the premises, dynamics, and potentiality of transitions, with a view to the future in the Global South, has to deploy a combination of social-scientific viewpoints dynamically to understand a complex and constantly changing world. Generally, by consciously exploring and illustrating where, when, and how different forces interact and looking ahead, one begins to generate futures knowledge.

2.1 Futures literacy through possibilistic-transformative foresight

The future and its possibilities are of interest to most of us. Therefore, an interpretation of how the future is being shaped as well as unveiling our contemporary ideas about the future may help us to discuss futures, as various alternatives of what the future could behold. Besides promoting an anticipatory mindset, futures studies can produce conceptual, theoretical and also practical knowledge about the role that future(s) play in our lives[2]. As already has been implied, a core principle of futures studies is that rather than being confined to a single future, multiple futures can be probed (Amara, 1981). As per Wendell Bell (1997a, 191-238), this makes most futures scholars critical realists, which means that they see that although some (e.g. natural) elements of our surrounding world are

[2] Anticipation studies is another, a much newer scientific field (Poli, 2017), which aims to assist in the examination of the many ways in which we anticipate or "use the future" in the present (R. Miller, 2018). Anticipation can be harnessed to acknowledge the quite complex and sometimes also surprising interplay of natural, human and technological forces. In some sense, all human action, arguably as partly collective and social behaviour, is based on anticipatory models (Tuomi, 2019). At the same time, people operate out of different worlds of reference (Slaughter, 2008, 127). Anticipation assists human beings, organisations, sectors, and perhaps even entire nations to reflect, plan ahead as well as adapt to complex, rapidly-changing environments, and even can help them thrive (ibid.).

almost immutable or (at least) very slow to change, the world is also constantly shaped and framed by our actions, and to some degree our intentions and perceptions are socially constructed (ibid.; see also: Bhaskar, 2010). Furthermore, the future and any glimpses of it, as a potential of the present, are of particular interest because of their "pull" (Inayatullah, 2023). With respect to the possibility of multiple futures (W. Bell, 1997a, 73-114), of late, futures literacy has been propagated as a new civic skill (R. Miller, 2018; Pouru-Mikkola & Wilenius, 2021; Poli, 2021) as an attempt to allow us to better understand the role of future(s) in everything that we see and do. Presumably, efforts intended at developing futures literacy would also require us to develop our anticipatory capacities. As shown by various frameworks in futures studies, there are a range of different approaches that make it possible for us to think more creatively, critically and widely about the future, and also to consider its various alternatives (Minkkinen et al., 2019; Inayatullah et al., 2022)[3].

In some sense, the recognition of alternatives is about possibilities (Gall et al., 2022). In the study of possible futures, and opening them, one benefit is in framing contemporary challenges or problems as opportunities (W. Bell, 1997a, 73-80). One is, for instance, allowed to ask what could be (instead of only asking 'what is'). To paraphrase Wendell Bell (ibid.), the study of possible futures is "an active call for seeing the potential around us and in the world, as well as the possibilities for change, including in ourselves", as a way of expanding human choice. One can claim the possibilities for the future to be somewhat "real", because they are embedded in the present capabilities of individuals, organisations and even nations / societies, as unrealised potential. As a concrete example, humans are able to imaginatively conceive a set of novel conditions before they are even realised. In this regard, creative and unorthodox thinking, novel initiatives and emerging issues that deviate from the mainstream or the norm all are pointing to emergence, the unknown and the uncertain. For Bell, any futures scholar should be aware of many types of latent possibilities, no matter how improbable or remote they may appear. After all, any limitations to future(s) in the present might tell more about the world as it is today, but they need not to obstruct efforts to explore them.

Foresight, as "a systematic, participatory, future-intelligence-gathering and medium-to long-term vision-building process aimed at enabling present-day decisions and mobilizing joint actions" (EFP, 2023) uses many methods and tools. For staying on top of the times, foresight has been recommended to be applied reflexively (Kurki, 2020) for becoming more aware and even conscious of futures (Ahvenharju, 2022). At its best, anticipating with foresight can amount to a mental

[3] As it stands, foresight is advancing in forerunner countries, and being introduced into intergovernmental organisations, as well as new contexts, fields and sectors (Heo & Seo, 2021; Adesida et al. 2024; Villman et al., 2024).

time travel (Cuhls, 2017). In some ways, it is like visiting history. Another similarity can be found between calls to uncover multiple histories (Bhambra, 2014) alongside attempts to consciously unveil alternative futures. Understanding futures better could be a partial answer to complexity in a world that to many feels deeply volatile, uncertain and ambiguous (Störmer et al., 2020). In addition, more attention has been called to the weak signals of change (Ilmola & Kuusi, 2006; Hiltunen, 2010; Rossel, 2012; Lesca & Lesca, 2014; Ahlqvist & Uotila, 2020). A weak signal is defined as a single, marginal, early warning sign of a speculative issue, which requires interpretation, as it is poorly understood or an oddity. At times, such signals may seem obscure, laughable or even preposterous. When scanning for emerging issues (Cuhls, 2019), understanding weak signals has been claimed to be important because if an initial weak signal converges with other signals, it may become stronger. Usually, these signals rarely imply an accurate, true picture or full realisation of an issue and they also do not mean that any subsequent patterns assume a linear trajectory or that the elements described in them were to assume a dominant, hegemonic position (ibid.).

In this study, an element of interest in weak signals concerns their relational and spatial nature. For Ahlqvist & Uotila (2020), the "weakness" in weak signals owes in parts to one's positionality to a signal, as the distance of information to the prior knowledge of the signal perceiver. A novelty that does not fit prevailing categorisations may disrupt existing knowledge (of the perceiver) and challenge existing knowledge (in general) (van Veen & Ortt, 2021, 10). All in all, academic futures scholars advocate for foresight where predominant assumptions and lenses can be challenged, and wider and potentially deeper knowledge about futures is claimed to be generated through them. In this regard, one specific technique is the use of peripheral vision (Schoemaker, 2019), which means attending to the fringes and into signals deemed as irrelevant or meaningless. Interpreting them can help to overcome inattention and unconscious avoidance, help combat distorted views and misguided priorities (ibid.). In this study, in sense-making for fresh perspectives, I attend to pioneers, technology niches and the fringes, and I also move between the local and the global. As an additional feature, foresight also helps in attending to or imagining new actors, new categories and new phenomena in entirely new frontiers. Overall, generating knowledge about multiple futures is a call for the ways of using the future to be constantly developed, and also for understanding new frontiers.

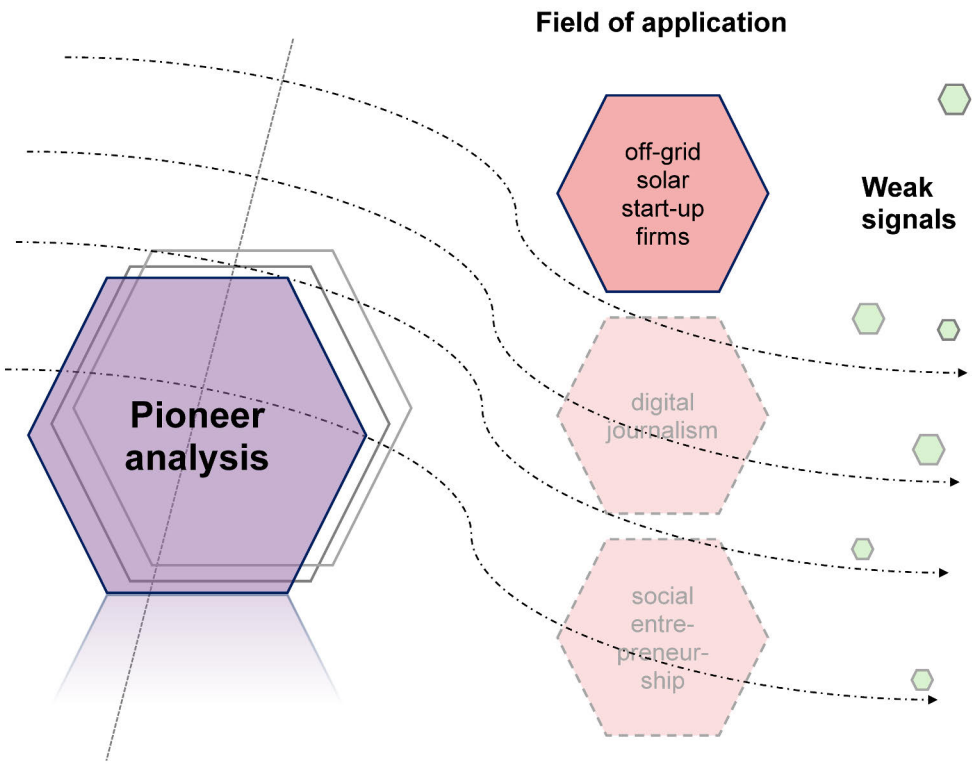

Figure 2. Pioneer analysis as a futures studies approach, also with examples of other fields of application (Kurki, 2020; Ruotsalainen, 2023). The study of pioneers can be combined with the study of weak signals. The original illustration by A. Taylor in Heinonen et al. (2022) has been adapted.

When it comes to pioneers, their role and efforts have only rather recently been scientifically conceptualised in the field of futures studies (**Figure 2**). As a starting point, an appetite to learn from pioneers relates to their futures agency. As a capacity, condition or a state of acting or of exerting power over the future, pioneering is about the human and social component in constructing futures. From a practical perspective, even in highly-constrained environments, at least some agency of change is attributed to actors (Tuomi, 2019, 7). However, one can claim that the mere ideas and actions of pioneers point to futures (Heinonen, 2017). Heinonen & Karjalainen (2019) observe an analogy between the agency of pioneers and weak signals, in how they are pointing to the unrealised future, and then claim that where weak signals may refer to quite numerous oddities, novelties or unstudied phenomena, at any given moment, only few pioneers usually operate at a particular frontier. Where Kurki (2020, 49-51) emphasises their intent as actors, Ruotsalainen (2023) observes that socio-technological transformations are often propagated by them. In studying actors who have at least some agency to shape the future, the idea

is that change, and its potentiality, are revealed. Namely, even if individual efforts fail, the new possibilities revealed by them are in itself valuable to be studied. Consequently, it is necessary to search where and which actors are proposing changes, and of what kinds of changes.

To elaborate further, one can distinguish learning from pioneers as actors (e.g. their capabilities), their ideas (e.g. concepts or innovations), as well as their implications (e.g. a range of speculative impacts from their actions). In my study, all three categories are illustrated, and with a view to transitions, the implications are particularly relevant[4]. From a possibilistic-transformative lens, any assessment of pioneers and the knowledge of futures they can provide should refrain from narrow, singular perspectives. A limitation in other fields that conduct analyses that are oriented at the future is that they often remain oblivious to all the relevant factors (e.g. focus on a single discipline or dimension). If one accepts the role of pioneers as changemakers, then the versatile and wide-ranging influences that can constitute futures should also be acknowledged. Any exercise aimed at exploring and genuinely opening up futures that overlooks emergence threatens to reinforce existing assumptions, frames, worldviews and entrenched practices, as single-truth narratives (Sardar, 1993; Ossewaarde, 2017). One should equally be cautious, if the future is presented as a tool to be mastered or tamed because any anticipatory knowledge is self-referential (Bourgeois et al., 2022). This study makes the particular case that for foresight to improve innovativeness and resilience (Minkkinen, 2020, 19-22), it also should be conscious of the potential(s) of pioneers in the face of uncertain and complex landscapes.

Generally, it is not irrelevant what types of futures we construct, imagine, and dream of. For James Dator (2009), aspirational futures were the main task of futures thinking. If problem-oriented futures work assists in understanding how key trends could impact our world, for Slaughter (2002; 2008), the key to unlocking liveable futures lies in maps that enable the shaping of power. An assumption of power factions to be stable or to perdure, or staying silent about power asymmetries can mask unequal or illegitimate relationships, as ways of "colonising the future" (Ossewaarde, 2017). Taking issues for granted, ruling out openness, and co-opting to a prevailing hegemony carry shades of a lack of criticality. Exploring the futures

[4] An explicit knowledge interest in the field of futures studies is the pronounced curiosity towards futures. This motivation has similarities to the knowledge interest in the patterns of change in fields, such as transition studies, evolutionary economics, and sociology from respective perspectives. Specifically, Bennett et al. (2016) is curious of actors and initiatives who are potentially planting "the seeds of change". The idea of seeds of the future has also been challenged for incrementalism. If evolutionary pathways assume an accumulation of change, such frameworks could shy away from the more revolutionary theories of change.

of a specific topic as well as its possible transformations would require acknowledging material (e.g. modernity), socio-cultural (e.g. inequalities) and political-economic forces (e.g. neoliberalism) alike in entirety. Any attempt to transform also should not portray local actors as powerless in the face of predominant conditions or forces, as it is prohibitive of addressing deeply transformed worlds. However, many contemporary imaginaries remain as quite techno-centred (see e.g. Ruotsalainen, 2023). Equally, even efforts to explore and build climate futures have been undermined by a lack of diversity, heterogeneity and marginal voices (Erickson, 2018). One would have to address power imbalances at different levels, and aim to emancipate actors to be freed from power structures, so that the past and present are left behind in decolonising climate futures (Sultana, 2022).

All in all, any analytical efforts interested in analysing the global energy transition, and its implications, in the Global South, or anticipating its manifestations, would benefit from integrating these standpoints. Active dialogue about the future can be aware and conscious of contemporary power structures, of different goals, imaginaries and futures (E. Smith, 2009). As underscored in critical futures studies, assumptions and interests should be revealed and shared (Ahlqvist & Rhisiart, 2015). Therefore, it also should not be irrelevant of how we do foresight. As a plausible idea, in deliberative foresight, collectives and individuals could be called to have a stake and an elevated agency in opening and shaping (their) futures[5]. If *deliberative foresight* were adopted as a praxis, it could activate multiple audiences, so that all of us become aware of and begin to practise our anticipatory capacities. Marginalised and new groups would be invited to deal with questions that influence the future, as the futures that affect them, also to make them increasingly theirs. Finally, it may be necessary to consider the initial circumstances, lived experience, and the weight of history in different environments to ensure the relevance and usability of futures knowledge (Kwazema, 2021), especially when looking in from the outside. As a particular note for transnational and global foresight efforts addressed at Africa, Greiner et al. (2022, 10) underscore that any futuring should also contribute to unleashing a truly decolonial academic field.

2.2 Energy transitions in the Global South – a call for wider perspectives

Academic studies of transitions in the Global South is an emergent, widening field, and it may be necessary to examine the energy transition, and its early signs with

[5] According to Wendell Bell (1997a, 93–95), one of the nine basic tasks of futures research is to add pluralistic voices and increase democratic participation in imaging and designing the future.

some caution, especially when it comes to substantiating any claims of more extensive systemic change for the future.

The Global South, as a geographical and conceptual entity, characterises a non-homogenous group of countries seen through the global structures and networks of power (Kloß, 2017, Haug et al., 2021). Although deploying the term is not without problems, it allows them to be placed into the international world order and its power structures. In this study, it is primarily operationalised to consider the asymmetries of innovation in a globalised world. In an (unequal) global economic system, different perspectives are necessary to address a lack of problematisation, as concerns how innovation is assumed to take place in the Global South, and assumptions of technology diffusion. Limitations in epistemic understanding (Ghosh et al., 2021) may prohibit some actors from recognising how power operates in global networks of innovation (Liu, 2017) that are assumed to assist in techno-economic change. Often times, there is limited discussion on how progressions from within the global innovation economy are transposed across diverse socio-cultural contexts (Sovacool & Griffiths, 2020). In addition, various inequalities across several domains, entailing colonial pasts, marginalisation, and imbalances of economic power provide a context also to the energy transition, and its specific markets, posing various implications for innovation, and to the role of entrepreneurial actors in the Global South.

Transitions are times of change, which imply a shift from something to something else (Child & Breyer, 2017; Hölscher et al., 2018; see also: Perez, 2016). In fact, they point to the future that has not yet been realised. In the case of societal transitions, as a broader phenomenon, futurist Pentti Malaska wrote of movement in phases of development – from one to another (Pouru, 2018, 19-23, 71-88, 107). The energy transition concerns energy and its wider institutional configurations. Historically, energy transitions were processes of socio-technical change, which consist of gradual, multi-levelled progressions as long, deep, and non-linear affairs, constrained by path dependencies (Sovacool, 2016)[6]. Involving multiple actors at multiple levels, transitions have socio-technical, political and cultural elements (Scoones et al., 2015). In transition studies, an archetypal transition consists of evolutionary processes where bottom-up dynamics (activism, niche technologies, new innovations) meet elements of top-down change (policy processes, strong regime resistance, and landscape-level changes). In other words, because both infrastructural and institutional changes may have to take place before regimes can be challenged or disrupted, transitions are about much more than technological

[6] A family of scholarly approaches across innovation studies, institutional theory, and sociology elaborates their systemic nature, uniting in the multi-level perspectives (MLP) framework (Geels & Schot, 2007; Schot & Kanger, 2018; Geels, 2011; 2020).

substitution or fuel switches (Markard et al., 2012). Authors like Sarrica (2016) consider transitions fundamentally as *cultural* affairs. Due to their complexity, duration, and uneven nature, analysing their futures may have limitations.

Contemporary academic scholarship on energy transitions relates to an analytical and normative call for approaches, supportive theories and conceptual models that would help elaborate shifts to new socio-technical systems, as sustainability transitions (Köhler et al., 2019). In this regard, there may be generic and specific premises on what propels and makes transitions in the Global South truly sustainable.

At first, four generic aspects of energy transitions are raised, illustrating the potentialities of:

1) change in diverse geographies and in recognition of their particular conditions (environmental, techno-economic, socio-cultural as well as political);
2) a (more) sustainable socio-technical system to be established (in light of mounting climate, environmental and other constraints);
3) change processes themselves (the mode and dynamics of change);
4) case specificities (e.g. sector, key actors, limitations)

From a foresight perspective, if one wants to interpret the early signs of transitions in the Global South, and specific contexts, it may be necessary to consider driving and hindering forces, as well as agency. Any study interested in change may not do well, if it looks at the energy sector alone. When it comes to actors, one should be wary of attributing success to any single actor. Especially in the African context, the aspirations of economic transformation, energy access, just transitions, as well as an appetite for leapfrogging form a complex nexus (Murphy, 2001; Simelane & Abdel-Rahman, 2011; Lee, 2019; Swilling et al., 2022). With these caveats in mind, a futures approach allows the consideration of change and issues that have not surfaced yet. As an element of possibilistic-transformative foresight, transition pioneers (Loorbach & Rotmans, 2010) may allow possibilities can be seen before change has been substantiated. Concerning the duration of transitions, transformative thought would be required across timespans (Minkkinen et al., 2019). One could aim to interrogate how different forces, factors and sub-systems will begin to interact with one another. Because uncertainty and complexity increase beyond the short- and medium-term, even considerable systemic change may be imagined in the long-term. Criticality and creativity assist in such considerations (Balcom Raleigh & Heinonen, 2018). To summarise, many outcomes from transitions over time are plausible (and importantly, we have a stake in their actualisation).

Start-ups, lead markets and innovative niches assist in identifying the potential for change in the Global South. Innovative actors tend to initiate and promote change in institutional landscapes where they have agency and power (Loorbach &

Rotmans, 2010; Aklin, 2021). In turn, some analyses of renewable energy technologies also have learned from forerunner environments (Bawakyillenuo 2012; Johnson & Silveira, 2014; Sareen et al., 2023). Where some international policy actors advocate for technological change and innovation as enablers of transitions, to critical scholars such narratives appear as hopelessly naïve, for instance in their techno-optimism (Boamah, 2020). In this study, as an application of pioneer analysis, the interest is in understanding how the actions of pioneers could "open up doors for others to act, trigger benchmarking by followers, and create further possibilities for future change" (Heinonen & Karjalainen, 2019, 62). As a consequence, this raises three issues. First, who are the pioneers, as key actors who hold innovative potential, as possible catalysts, and at what locations. Secondly, what ideas and innovations, such as specific methods, systems, products or services are they offering at markets. And thirdly, what the impacts or implications of their efforts could be.

Focusing on the third focal issue, pioneering activities (in the present) allow specific questions to be raised about the long-term change potential of the energy transition of the Global South more widely (in the future). Contextually, analyses of transitions in the Global South in specific localities must be aware of local histories, the levels of informality, infrastructural heterogeneity, elites, postcolonial realities, roles of different actors (e.g. in public-private partnerships), competing visions[7] as well as transnational linkages, and how such institutional and regime configurations are linked to multi-layered calls for justice (Kraemer-Mbula & Wunsch-Vincent 2016; Munro et al., 2017; Wieczorek, 2018; Winkler, 2020; Koepke, 2021; Späth et al., 2022; Kociemska et al., 2024). One viewpoint to the calls for a just transition concerns the long-standing Global South aspirations to economic development. However, entrepreneurial theories about market protagonists usually ignore such claims or rights-based discourses. The lead market theory simplistically assumes market diffusion to take place through market pioneers, and follower or laggard markets then to follow (Huber, 2008). Besides empirical substantiation to such processes, market uptake is only one part of technological acceptance and legitimacy (see e.g. S.E. Bell, 2020). Besides, from a wider perspective, markets are subject to political and economic forces, regime interests (including vested ones) that resist new ideas, often preferring gradual reform (Kapika & Eberhard, 2013; Bugaje et al.,

[7] Conventionally, such visions have relied on fossil fuels, and are strongly embedded in local and national economic structures and employment-creation. As a topical example, despite major advances in the cost-effectiveness of solar and wind power, as can be viewed from a range of contemporary energy scenarios and their techno-economic assumptions, there are challenges in phasing out coal from the power sector (for instance in South Africa, see: Marais et al., 2022).

2022). As a matter of fact, various interactions take place in the interface of the global and the national level in parallel. If entrepreneurial actors are expediting the uptake of innovations, then other economic and political actors, systems and institutions aim at challenging or governing them, with their interests (Newell, 2021).

2.2.1 The political economy of transitions

From a futures perspective, the Global South, and many African countries in particular, are hoping to shape the historical patterns of interaction and make their voice heard. In the global political economy, when it comes to any innovation, many Global South actors to date have had a rather marginal role in stimulating them. In addition, the role of local innovation is often downplayed in the international technology discourse. In fact, as a prerequisite to any transition pathways, Global South economies are claimed to have a somewhat limited ability to innovate (Swilling & Annecke, 2012).

In response, the Global North has assumed a role where it operates from a somewhat paradoxical position. At the same time, it provides support through official development assistance and climate finance, their particular modalities, programmes and projects for capacity-building and innovative activities in the Global South. However, such activities also face several hurdles, which to a degree are self-imposed. The present international order limits the international flows of know-how, experience and equipment that could flow into the Global South that would expedite uptake of necessary low-carbon (including renewable) technologies to mitigate climate change (Kirchherr & Urban, 2018, 600-604). Already facing important technological disadvantages, the Global South therefore remains critical to the neoliberal orthodoxy, and associated market forces or any other arrangements, which allow the Global North to inform and determine where, for example, manufacturing takes place. In the absence of a wider reform of the international order, project finance, socio-technical solutions and associated ideologies from China and other emerging economies appear as attractive to some actors.

More concerningly, a political economy perspective (Newell & Phillips, 2016; Baker & Sovacool, 2017; Byrne et al., 2018; Furnaro, 2020; Goldthau et al., 2020) hints that the energy transition will produce winners and losers, for instance, within and between different nations across different timescales (Meckling et al., 2022; see also: Sovacool & Hess, 2017, 721-722). Therefore, although solar power may (or may not) be an ‘irresistible’ alternative (Boamah, 2020), an opportunity-focused perspective would emphasise the fact that transitions are also known to generate new economic activity. Accordingly, one could begin to think in more detail how exactly the economy would change, and in what ways. In light of this knowledge interest,

entrepreneurial firms as innovators and in search for new markets are important actors. For instance, looking at them could help to think of how innovative activities within transitions can generate economic value. A priori, it would not be known, how and what economic value could be retained and where, and at what depth and scale. However, one could begin to explore how and where such value eventually will accumulate, study the different types of jobs created, differentiate the internal distribution of surplus within in-country production sites, and how value is amassed in different actors, localities and/or countries involved (Ockwell et al., 2021, 16-20). Some scholars fear that very little economic value will be retained in Global South (Brunet et al., 2022). Then again, one may also envision economic patterns emanating from the transition that would offer possibilities for economic development (and even for decolonisation). In related analyses, ruling out dystopias and utopias, as extremes, could be a useful first step (Wuebben et al., 2023).

2.2.2 The capabilities of latecomer firms

A political-economic question that focuses on the present might ask: 'how can the energy transition, and its innovative patterns, align with the objective of economic development in the Global South?' A possibilistic-transformative foresight approach, in turn, would be interested in opening and seriously interrogating the spectrum of related possibilities. But before examining the idea of such an idea, a historical antecedent is presented to substantiate such a hypothetical claim. As a well-documented process lasting for an extensive period of time, which in some ways still has not stopped, evidence from the information and communication (ICT) revolution[8], is of analytical assistance. Alongside technological change, it saw specific economies, known as the East Asian Tigers, economically develop over the course of the late 20th Century. At the early stages, the ICT sector was at infancy internationally. In tandem with the brewing revolution, a host of East Asian countries and firms started to innovate decisively, growing their ICT sector over several decades. A firm-level perspective captured by Hobday (1995) describes how foreign firms initially possessed a technological advantage and there were no local firms in East Asia that could manufacture. But, over time, interactive patterns emerged. Foreign firms were acting as an example for the local firms who started to accumulate their capabilities. However, the latter had to work hard, and even had to be pushed by their own governments to do so, and in the first place to get started,

[8] Analogies can reveal how our patterns of thought are structured, point to discontinuities over continuities, and challenge what is considered to be "normal". Surprising analogies may unveil the potential of our imagination, and reveal limitations, for example, concerning geographical awareness and our scientific practice.

they had to acquire basic-level capabilities, so that they could engage with such activities.

Although the story is summarised here in a very condensed manner, it appears to be very useful for at least three reasons. First, it is helpful for considering some of the basic obstacles to entrepreneurial dynamics and market-based transitions. In this example, foreign technology-leaders actively engaged with local entrepreneurial firms, and in turn, policymakers saw a strategic opportunity that would create benefits from an on-going long-term process that introduces socio-technical change. Using the anticipatory lexicon, one could even claim that during this particular transition, there was joint agency and orientation to the future by important actors in society over a very substantial time period. Secondly, the accumulation of capabilities took place in the form of learning in the Global South in temporal sequences in a strategic sector. Thirdly, even if this process did take considerable time, as one of its outcomes, local firms started to perform assembly and manufacturing activities. Eventually, this stimulated the diversification of their local economies. In today's perspective, this point remains particularly relevant for African countries where calls for structural transformation are pertinent (Oyelaran-Oyeyinka & Adesina, 2020). And, crucially, this example validates the call for the involved actors to make efforts to forge a pathway of their own (Lee, 2019).

This analogy is interesting also for further justifying the role of entrepreneurial firms as change agents. However, in our context of foresight, with a view of the coming decades, as we will be moving in time towards the mid-21st Century and even beyond, there may be important caveats. Currently, the context to international cooperation is slightly different than in the times of the Cold War in the 20th Century, and claims for political-ideological hegemony. In the mid-20th Century, a strategic partnership formed under state auspices between the U.S. technology leaders and East Asian firms. Under the neoliberal trade dynamics of the previous decades, these might have been difficult to realise, for instance between African and specific Global North firms and countries. In the meantime, the global manufacturing advantage has shifted to China despite re-shoring efforts by the U.S. and also Europe. Additionally, it is not self-evident that acquiring manufacturing competences (or industrialisation) should be priority policy objectives in the Global South (Iraki, 2018). Upon writing this, the wider significance of the on-going shift and the amplification of protectionist tendencies remains unclear. Finally, decentralised renewable energy technologies and the ICTs (as well as the Fourth Industrial Revolution) do share important similarities, which is further illustrated by their technological convergence, the energy paradigm that is emerging may possess unique characteristics and features of its own that differ from any previous patterns seen in times of transitions.

When it comes to agency, academic theorising of latecomer firms in East Asia and later in Latin America has been interested in how local entrepreneurial firms can begin to learn in systematic fashion and to compete in the international/global marketplace (Hobday, 1995; M. Bell & Figueiredo, 2012)[9]. Because these theorisations have primarily been concerned with the acquisition of production capabilities, therefore, they have been applied in Africa only to a very limited degree. In the case of a single firm, production capabilities are those that help it to perform assembly or manufacturing activities. A latecomer firm owes its name to its origins in the Global South, as it searches for entrepreneurial opportunities, even if it were dislocated from the main global science, technology, and innovation hubs and nodes for research and development (R&D) (Hobday, 1995). Innovation capabilities consist of knowledge, skills and actor-networks, as a skillset of an entrepreneurial firm. These capabilities broadly illustrate its ability to innovate, for example, for new business models, and so forth. Acquiring these basic competences is potentially valuable for economic development (Taglioni & Winkler, 2016), recent studies suggest them also to be necessary, if the promises of transitions are to be realised (Ockwell & Byrne, 2017; Lema et al., 2021).

Amidst diverse global financial, capital and technological flows, a question concerns the transnational dynamics of innovation and related interactive patterns. If innovation happens in a systemic (or ecosystemic) fashion, what kinds of evolutionary dynamics and cumulative learning will be necessary? And how could such patterns in the Global South be supported? Across space and time, and between and inside countries, capabilities are not equally distributed. At the onset, at any particular geography (like a market or a nation-state), only loose and weak elements of such a system exist (Chaminade et al., 2018). Usually, innovative activities are centred in the concentrations of human and other types of capital, such as Silicon Valley. Of course, at any specific sector, it could be possible to analytically learn from the accumulation of the said capabilities. Such studies would aim to reveal where knowledge is generated, how it is diffused, and how it is applied. In many Global South markets where the industrial base is low[10], access to networks could be particularly valuable for firms to create, generate and apply new knowledge and technologies (Liu, 2017, 230). Historically, also in the East Asia case, states applied local content regulations to enforce the local firms in productive activities. However,

9 Development economists like Collier (2012) identify a role for latecomer economies in promoting a new energy paradigm for forging new development pathways.

10 A typical Global South economy is assumed to lack a sustainable base for such activities (i.e. local firms, a niche, and have limitations in the ability to promote entrepreneurial activities with innovative technologies). At the same time, foreign technology leaders could lack strategic interest to address the aspirations held at the Global South, and choose to focus on commercial and R&D activities.

such measures also discourage entrepreneurs (Baker et al., 2014; see also: Irwin, 2021). Very importantly, in the very early stages of a transition, promoting local content would be almost pointless due to limited local capabilities and a lack of local firms innovating in a sector. Therefore, if entrepreneurial firms will be critical for the energy transition, an uncertainty concerns how the accumulation of capabilities could be initiated, organised, and actualised in the many Global South contexts simultaneously.

In this light, further questions also need to be answered, namely which types of entrepreneurial firms would be ideally placed to initiate the uptake of decentralised renewable energy in the Global South? And, if such catalysing actors can be identified, how should their role be understood in the usually highly-resistant energy sector? Next, I turn to these questions.

2.3 Start-ups as creative changemakers

A start-up is a type of an entrepreneurial firm that intentionally uses innovation. As a highly-innovative firm and a human institution aiming to create new products or services, at the heart of a start-up is the promise of creative destruction (Schumpeter, 1934). Aspiring, entrepreneurial firms with revolutionary ideas who are not afraid to challenge the establishment are presented in entrepreneurial and technology narratives as almost omnipotent actors, thanks to their ability to assemble and translate specific concepts into innovative designs. With the rise of a global start-up culture, start-ups are addressing unmet needs with unseen solutions at many unexplored frontiers, even under conditions of extreme uncertainty (Ries, 2011). In parallel, the appetite for digital entrepreneurship is growing, also amidst young African entrepreneurs (Delle, 2020). If all start-ups aim at affecting or shaping the future to realise its many alternatives – i.e. to "create" a future, there are some of them addressing global challenges through economic, social and environmental objectives.

When they operate at the forefronts of economy, technology and society, they seem to be pulled by the future. An archetypal start-up story entails boldness, great expectations, endurance and perseverance over obstacles – and in the idealised case, eventual triumph. An entrepreneurial team should be lean and fail as fast and often as possible to rapidly discover what can work, leaving dysfunctional ideas behind (Ries, 2011). A start-up conceptualises an idea, develops it, experiments, and aims to stabilise a business model in the search of a recipe for success, advancing through phases (Picken, 2017). In order to attract customers and convince investors, they may have to pivot; to adapt or turn their business model around, to come up with a suitable solution that makes financial sense at a useful scale, to offer something of value, and of economic value. At the Global South marketplace, alongside other critical

considerations, a start-up must be cognisant of how cost-sensitive many of their potential customers are, as articulated in entrepreneurial theories of frugal innovation and markets at the bottom of the pyramid (e.g. Tiwari & Hestatt, 2012). In principle, lead markets could be conducive for start-ups and help them benefit from complementary capabilities (Tiba et al., 2021) so that they are able to enjoy success when the time is ripe.

From a futures research perspective, start-ups are one type of pioneers who can be claimed to embody futures agency. Start-ups are seen to operate in a liminal space between a 'regime of hope' and a 'regime of truth' (Hogarth, 2017). Critical scholars have explained how their heroic stories, theories, and discourses, with actions and promises, are addressing fictitional expectations in the economy, propagating images of the future (Beckert, 2013; 2016). Overall, the Silicon Valley experimentational culture has been coined as a collective foresight process that generates futures (Tuomi, 2019, 10). However, it is also important to keep in mind that the start-up discourse can divert attention from other issues, such as social injustices (Martinez Dy, 2019; Geiger, 2020; Tarvainen, 2022). The potentiality of start-ups is useful for turning our attention into the long-term. Even if some start-ups were ahead of their time, their ideas and actions that are pointing to futures convey a potential to be explored and shaped. Even when their pursuits do not evolve into a functional enterprise (quite the opposite, the majority of start-up journeys fail spectacularly), the disruptive visions of start-ups, as an alternative to the status quo, signal potentiality. In expressing their expectations, their actions become ingredients of possible futures for the rest of society. In a sense, the uncertainty around start-ups resembles weak signals. Economically, start-ups can assist in the birth of novel niche markets, sectors and even industries (Kurki, 2020). While one can gaze at their competences and at their novel innovations, and can also interrogate the many types of changes that their actions could result in.

When scholars, analysts, and policy actors ponder upon the role of highly-innovative entrepreneurial efforts in the Global South, also for the energy transition, they must be critical (at least) to some of the generic premises of transition theories (Ramos-Mejía et al., 2018; Kumar et al., 2021, Späth et al., 2022; Groenewoudt & Romijn, 2022). This reminder also concerns efforts aimed at anticipatory governance, which is a proposal to govern for the long-term by systematically using foresight across different types of relevant governance architectures (OECD 2019, 3). Alongside financing for the new, rising energy paradigm (Grilli et al., 2018), complementary initiatives, policies, strategies, and frameworks will likely be required to accelerate the uptake of tomorrow's innovations. Taken together, such elements amount to a mission to support sustainability endeavours (Mazzucato & Monaco, 2024). Additionally, any efforts to support the identified key actors would have to overcome an underrepresentation of local voices (and actors) in the

governance of these international flows of knowledge, capital, innovation and technology. For addressing the wider aspirations of economic development, any single policy alone would not be enough (Kivimaa & Kern, 2016), and multiple stakeholders would have to take action (Boston, 2017; Bourgeois et al., 2022)[11]. Therefore, any frameworks designed to support these key actors in the Global South should have clarity over concepts, objectives, mechanisms and expected outcomes. In the event of prescriptive support, clarity would especially be required of how they are rooted locally (Bogge et al., 2024) as well as the division of roles between national and international actors partnering in Global South contexts (Georgallis & Durand, 2017; Poole, 2018)[12].

Finally, if start-ups are indeed critical private sector actors in the Global South, it would important to assess their potentiality against the evolving ideological context of states and markets. As articulated in this last section, their disruptive promises do not limit us from thinking of the role of markets in catalysing change in wider systems in different regions of the world.

[11] Already early scholars like Wendell Bell (1997a) noted that different kinds of anticipatory knowledge can influence decision-making and politics. Conceptually speaking, inclusion, participation or even co-creation may not be enough for de- and re-constructing futures (Andersen & Andersen, 2017; Inayatullah et al., 2022). In the event of practising deliberative foresight, a co-productive stance should overcome implicit or tacit processes of marginalisation and actively recognise, encourage and integrate bottom-up and top-down dynamics that assist in further imagination.

[12] In the 2000s, an important mode of policy engagement for Global North actors at Global South contexts has been development policy, as one part of their foreign policy, where some programmatic tools have channelled support to innovative activities (Stokke, 2019).

3 Analysing the pioneers of the energy transition in the Global South: methodology and materials

In chapter 3, I elaborate on the research design of my study about the frontiers of the energy transition in the Global South. Assuming a possibilistic-transformative foresight approach, I applied pioneer analysis as an overarching framework (Heinonen, 2017; Heinonen & Karjalainen, 2019). Then, as exploratory research in a multi-method research framework, I primarily deployed qualitative methods to study and map for long-term change potential at various forefronts. I deployed specific foresight methods that were adapted so that a host of pioneers (benchmarks, start-ups at lead markets) and their capabilities could be identified and analysed, which is depicted in **Figure 3** and also detailed in **Table 2**. As a primary case study (Yin, 2017), the off-grid solar photovoltaics start-up boom in Kenya and Tanzania proved to be instructive of the very early marketplace dynamics of this transition. I adapted a set of internationally recognised methods from innovation and development studies (M. Bell & Figueiredo, 2012; Oslo Manual, 2018) to study firms. For shedding further light on pertinent issues of economic development in East Africa, a set of comparative insights was drawn from Chile, which typically is portrayed as a pioneering economy in Latin America and whose economy has historically been shaped and contested by neoliberal policy influences.

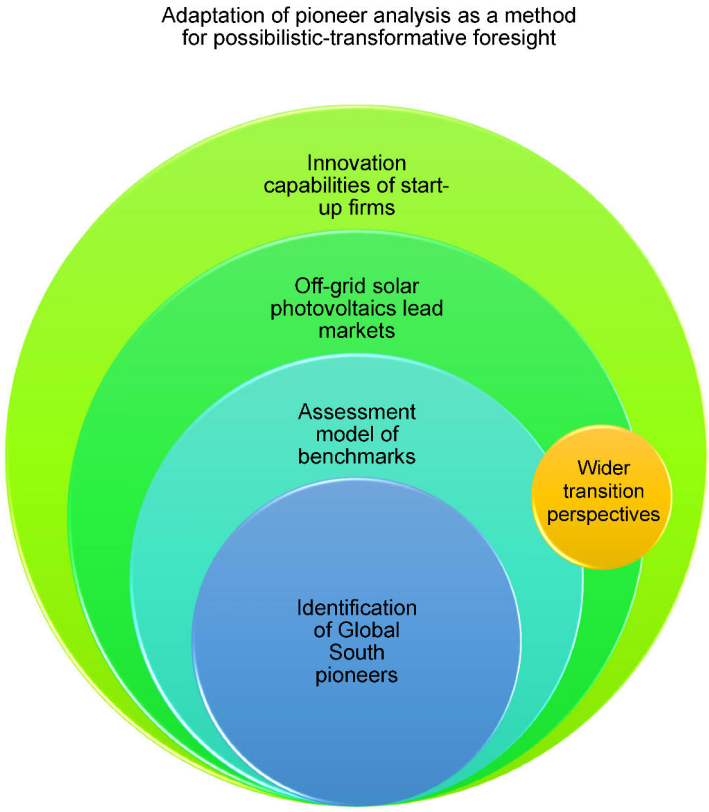

Figure 3. Methodological design of the study. Attending to the forefronts of the energy transition in the Global South, as possibilistic-transformative foresight, was exploratory research that deployed pioneer analysis with different assessment methods. After identifying start-ups as key actors in the transition, methods from the field of innovation and development studies were adapted to study them.

An aim to analyse the transition as a driving force that affects the Global South stemmed from an interest in its widening transnational dynamics, for its techno-economic aspects to align more closely with some national and local socio-political realities. As the study advanced, pioneers and associated weak signals, as the very early signs of the transition, revealed how they were pointing to alternative futures. A specific interest in my study pertained to long-term economic change. A possibilistic view to techno-economic change and its associated, innovative dynamics was accompanied by empirical research about firms, as market pioneers, to explore the impacts of the transition. As explained in section 2.1, what is possibilistic also points to the transformational (Wiek & Lang, 2016). For characterising the patterns of power distribution and related transformative aspects in evolutionary change is usually quite challenging to capture by solely numerical analyses (Bob-Milliar, 2022), which required careful consideration.

Table 2. The methodology in each original sub-study to analyse the energy transition in the Global South: aim and motivation, study methodology, data collection, and data analysis.

Article no.	Aim and motivation	Study methodology (and main method)	Data collection	Data analysis
I	Identify who are the pioneers of the energy transition	Adaptation of pioneer analysis	Qualitative expert survey (n=39)	Descriptive statistics Thematic coding of survey responses (cluster analysis)
II	Learn how a pioneering renewable energy project points to alternative futures	Multiple case study of four benchmarks in sector and industry	Policy and industry documents Media reports Semi-structured interviews (n=12)	Design of a new assessment model that analyses pioneering initiatives
III	Learn about the off-grid solar photovoltaics start-up boom in East Africa	Innovation capabilities of off-grid solar photovoltaics (PV) firms	Database of entrepreneurial firms in Kenya and Tanzania (n=94) Interviews of highly-innovative firms (n=16) and sectoral experts (n=32) Market, sales, finance and investment data	New four-level typology of firms' innovation capabilities Estimated market value of products: cash vs pay-as-you-go products
IV	Explore the energy transition in Chile, an economic and solar energy pioneer in Latin America	Participatory foresight	Futures clinique with national experts (n=30) • Futures wheel • Futures table (PESTEC analysis) • Black swans (surprises) Market and policy documents Expert interviews (n=5)	Thematic coding of workshop discussions with national experts Descriptive document analysis
V	Explore and open long-term market change potential	Images of the future	Re-use of article III datasets Horizon scanning (n=212) Observations at hybrid or virtual stakeholder forums (n=15)	Descriptive coding Cluster analysis Impact-uncertainty matrix Intuitive logics scenario technique

3.1 Pioneer analysis as a foresight method

This section describes how the study moved from identification to interpretation of some of the global pioneers of the energy transition.

As the first step, as a scene that started my empirical research, a survey was designed to identify pioneers by building on an existing scenario set (Heinonen et al., 2017; see also: Rowe, 2017). The aim was to search for real-life actors around the world who are already spearheading renewable energy, environmental innovation and climate activism, such as firms, social movements, organisations or key individuals. An international online survey was sent with two other researchers, targeting 160 recipients, consisting of futures researchers, foresight practitioners[13], analysts, entrepreneurs, energy and innovation experts, which is documented in article I. Responses from 14 countries resulted in a 29% response rate (n=39) (**Figure 4**).

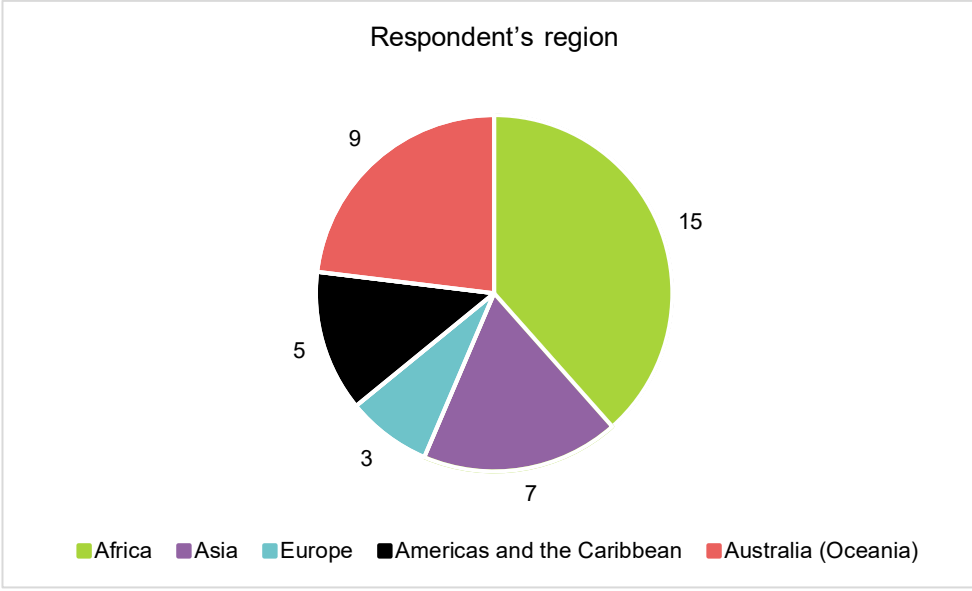

Figure 4. The respondents (n=39) to an international expert survey about energy transition pioneers.

The primary aim of the survey was to establish an overview of the actions, circumstances and challenges of these pioneers. The survey that was circulated across different regions also generated some insights of specific localities because

[13] From the internationally-leading foresight networks Club of Rome and the Millennium Project.

the respondents were asked to name different types of frontrunners as local pioneers. The survey design deployed interrogative techniques that encouraged the experts to depart the present moment and to think of alternatives freely. As an important detail, addressing futures ought to overcome the challenge of presentism, as a bias, starting from the data collection.

As a further explanation, the survey mostly contained open-ended questions, so that these international respondents would feel empowered to use their mental and creative capacities, as much as possible. An existing scenario set was shared with the survey as instructive material, to orient a respondent toward alternative futures (that do not yet exist). Without deploying them for emotional, cognitive and psychological support, it might not have been possible for a respondent to detach from the present. Additionally, it could have been a challenge for a respondent to begin to think of their pioneers as the possible key actors of the future. In asking the respondents to think widely, the purpose was to stimulate a mindset shift from a probabilistic to a possibilistic mode to address possible, probable and preferred futures alike. In thinking about change, one survey question specifically interrogated desirability. As an interrogative technique, some questions in the survey created a contrast between the scenarios (of the future) and the present-day situation. When the respondents were asked to deploy critical and imaginative capacities alongside analytical ones, it could be claimed that they were also exercising futures literacy. Namely, if systems literacy recognises cause-effect relations i.e. systemic causalities, then integrating long-term aspects through a non-linear mode was an attempt to take systems complexity seriously, akin to a foresight exercise.

The above survey results as well as academic literature place Kenya as a lead market in decentralised renewable energy technologies. Therefore, it seemed interesting to explore the forefronts of the transition at a conducive Global South landscape. Building on this interest from a futures research perspective, article II assumed an entirely different research strategy. In this sub-study, four benchmarks in the renewable energy sector in Kenya, were analysed primarily based on a document and media analysis. Additionally, a small number of context interviews assisted in describing and verifying these case studies. At first, these initiatives were selected, leading into the choice of a utility-scale wind farm, an innovation hub for renewable energy, a philanthropic initiative, and a business model for off-grid solar energy. As selection criteria, all of them were internationally recognised approaches, initiatives and projects. Then, they were described. Each project or venture, as quite different by nature, was characterised by how they had been conceptualised, designed and were operated (in the present). Finally, the actual analysis graded each of them in an assessment matrix in four dimensions, which the sub-study developed. The assessment in two steps asked in what ways were they pointing to futures, and whether they appeared to be (or not) transforming. As a limitation, the analytical

phase was largely conceptual. In the study, it was of particular interest to interrogate the potential implications or consequences of these initiatives, as they reveal 'what can change' (in the future). In evaluating the innovativeness and the limitations of present actions, one was able to further ask 'what if?', as a method of documenting and exploring change.

In a nutshell, the assessment model aimed to interrogate whether the present benchmarks are also catalysing change.

3.2 Methods from innovation and development studies – the role of local capabilities

After the off-grid solar photovoltaic start-ups in Kenya and Tanzania had been identified as market pioneers, they were examined in article III in more detail (see also: 3.4). A start-up boom in decentralised renewable energy is a rare phenomenon, which also meant a choice in outlining and choosing from the different ways in which these innovative actors are pointing to futures. Although their technological novelties and a speculation with the various kinds of potential future implications could have been an interesting topic of study, the sub-study instead chose to focus on the capabilities that could explain and justify their innovativeness. As a researcher, I turned to methods in innovation and development studies that could help me understand what makes firms operating in Global South markets innovative. To achieve this analytical goal, I compiled a database of entrepreneurial firms active in the Kenyan and Tanzanian markets (n=94) primarily drawing on publicly available sources, such as biographies, business and investment data, literature, industry and technology media, policy and technology reports, websites, and so forth, assisted by a database that was shared by a development partner from the Global North. Apart from some retail firms, three out of four firms in the eventual sample were at most ten years old, illustrating how youthful the sector was.

I adapted descriptors from Bell and Figueiredo (2012) and the Oslo Manual (2018, 103–126) to create a typology that measures firms' capabilities. After first organising my data in the sub-study, the firms' innovation capabilities were then constituted from three dimensions: knowledge (age, evolution, ownership, team, technology); skills (business model, characteristics, innovation, value proposition); and actor-networks (background, finance, geography, partnerships) with the aid of previous theorisations. As a result, any firm in the sector could then be looked at through its activities and be placed into one of four levels based on its capabilities. At the lowest level were firms that revealed limited capabilities to innovate, and at the highest level were firms that demonstrated an ability to solve highly complex problems and deploy emerging technologies. These levels formed a continuum rather than distinct, rigid categories. The purpose in differentiating firms was to discover

what those with a more basic or a practical set of knowledge and skills are able to do; as compared to leading firms who apply specialised, codified, frontier knowledge, and seemed to possess quite imaginative skills. After this, firm, market and investment data were analysed.

An analysis of the firm-level data suggested that the possession of capabilities to perform complex innovation with an environmentally-friendly technology could also be of (higher) economic value. To substantiate the claim, Article III also examined global off-grid solar market reports between 2014 and 2020 up until the start of the coronavirus pandemic (COVID-19). These regularly published reports from the Global Off-Grid and Lighting Alliance (GOGLA) and Lighting Global offered an insight into finance data, product sales data as well as industry trends. From this data, it was possible to extract what number of industry-verified products were sold, and to estimate their value. The empirical data analysis in article III proposed that technologically advanced solar PV products are more valuable than traditional ones, such as simple solar panels, sold in cash. However, where a more innovative product might derive higher value from sales, it also required a firm to have quite advanced capabilities to be able to create such services.

Another, complementary proxy that could be used to monetise the economic value of firms' innovativeness was derived from the investment attracted by the studied firms in these two lead markets. At the lead markets of a vibrant sector, a number of different types of financial actors by form and volume (crowdfunding, international development finance, social impact funding, venture capital as well as their combinations) had emerged to catalyse the journeys of entrepreneurial firms. The sub-study documented multiple sources of investment data. Start-up firms publish information about their funding rounds, as capital injections, and could be verified from Crunchbase and Owler. Data received from the development partner provided information of early seed finance received through programmatic funding. Venture capital databases provide details about the funding rounds and sources of capital for every round of investment. This sub-study, and its datasets, later proved to be instructive to the argument of this dissertation.

3.3 Imaginative-analytic foresight techniques

Next, my attention turned to a different geography, renewable energy market and a case, again also assuming a different methodological approach. In article IV, participatory foresight techniques were used to learn about market developments in another continent. As a specific type of a futures workshop, a futures clinique was co-organised with a local partner organisation in Santiago de Chile in 2016, engaging national experts (n=30) with an aim to query the long-term implications of the transition as well as its discontinuities in Chile, Latin America. Futures clinique is a

co-creative foresight method, where a broad group of stakeholders from diverse backgrounds explore a subject matter (Heinonen & Ruotsalainen, 2013). Usually, the participants are guided to study prominent ideas through questioning and immersion with dedicated exercises. In this case, a set of national innovation and energy experts were instructed to explore how an energy transition, based on the uptake of decentralised renewable energy, as a possible, yet at the time an improbable scenario, would manifest, if it was realised. If such a pathway were to open, what would be some of the implications, and how might Chile, on the whole, look like and be shaped in this future?

In the futures clinique, the participants worked in phases and in groups using a combination of methods:

- the futures wheel, as an ideational technique (Glenn, 2009);
- the PESTEC table, as one version of the futures table that can be used for morphological analysis for systems mapping. PESTEC stems Political, Economic, Social, Technological, Environmental, Cultural; and
- the imagination of black swans (cf. X-events), as so-called low probability-high impact events that hypothetically could take place in the future

Essentially, the experts were asked to probe a future that had not yet been realised and elaborate on its potentiality. Divided into small groups in the clinique, they were instructed to discuss the energy transition with a view for the future, as a socio-technical process within their present (national) institutional landscape. After the clinique, a small number of innovation, policy and renewable energy experts (n=5) were interviewed on related themes. However, the data analysis that followed focused solely on the group work results of the clinique, which were analysed qualitatively with another researcher. Emerging themes were abductively coded from the debates. Abductive coding means combining deductive and inductive logics (Vila-Henninger et al., 2022). In this case, existing theory about the energy transition provided guidance e.g. to the generation of the codes in the coding process, as data analysis. Then, the actual workshop data i.e. the arguments, questions and viewpoints of the Chilean participants was used to challenge pre-existing conceptions and to generate more refined understanding, resulting in inductive codes. Thereby, the transition in Chile, ahead of some other countries and markets in the region economically and in solar power uptake, was assumed to shed light on issues that could emerge elsewhere, especially with a view to similar aspirations in the many different regions of the Global South.

Horizon scanning is at the heart of foresight. Alongside learning through the pioneers, it also felt necessary to aim to keep up with the changing times. Horizon

scanning studies emerging issues, and their weak signals, to identify things potentially to come, ranging from opportunities and threats (Lesca & Lesca, 2014; Cuhls, 2019). In this study, after having identified off-grid solar photovoltaics start-ups in East Africa as key actors, horizon scanning aimed at placing these identified forerunner activities against wider forces and related developments. Compared to a market study, which typically would have limitations in its treatment of long-term uncertainties, a futures study is keen to understand such signals. In practice, I conducted horizon scanning as a primarily desktop-based activity so that I could attend to emerging issues and weak signals of the energy transition that could affect such early signs of market-aligned transitions in the Global South. In article V, a set of collected signals (n=212) acted as data points, which were classified by type, as either trend-like or as a weak signal, then by level (global, local/regional or sectoral), and interpreted. Blogs and technology media informed of the start-up discourse in Africa. Supportive signals from rural electrification sector and decentralised renewable energy industry news, reports, and newsletters were informative of trends. In contrast, national and international media stories, as far more mainstream media sources, revealed contradicting views on political-economic issues related to technological change (see also: 3.6).

From the datasets, and especially from the scanning, a set of driving and hindering forces that affect markets in the energy transition were identified and clustered, as explained in article V. This time, the PESTEC analysis (mentioned above) assisted in clustering the forces i.e. to organise the data. Primarily from the signals, clustered forces (n=83) were placed into an impact-uncertainty matrix (Chermack, 2011), as a tool that helps in analysing emerging issues through what can (or could) change. When any force is placed into the matrix, it can be assessed to have low, medium or high impacts; and be either a little, somewhat, or highly uncertain. In assessing them, as a subjective assessment exercise, ten appeared to entail both high impacts and high uncertainties, raising further interest. In this phase, some of these forces appeared to be connected. In my analysis, I was interested in identifying forces, which could be seen as critical to start-ups, as agents of change, and their hypothetical potential in the Global South. The datasets of previous sub-studies contributed to theoretical understanding. As a result, two uncertainty clusters were formed: one with elements primarily related to innovation, and another cluster consisting of policy and political issues. These clusters were also named. As a final step, they were used to distil images of the future to open the long-term economic impacts of the Global South transition (see Chapter 6).

Images of the future are presented in Chapter 6, as a result of this dissertation. They have been informed by article III about capabilities of start-up firms in the off-grid solar PV sector as well as the scanning results in the final article (Article V) and allude to the implications of the global energy transition in the Global South, as a

basis for scenarizing futures. In empirical futures studies, the image of the future represents "the state of affairs prevailing at some future time" in a structured (or even metaphor-like) manner (e.g. Minkkinen, 2020, 18-19)[14]. Although they are almost scenario-like, my images do not have a detailed narrative or a pathway to their end-states, and thereby they rather resemble vignettes (Rhisiart, 2013). Additionally, the presented images should not be seen as static or fixed, but more like stepping stones for novelties, and for pursuing deeper, transformative frames (Minkkinen et al., 2019, 7). As a reminder, moving away from singular predictions is important because as the time horizon expands, so does uncertainty (van Asselt et al., 2007). However, each of my images provides a short storyline that alludes to their causal mechanics, such as interactive patterns and sectoral dynamics, which could result in different long-term economic implications by the year 2050. For further relevance, these images could be assessed and validated in an expert roundtable.

3.4 Positionality, research ethics and qualitative data

To assess complex phenomena across specific geographies, where power operates in multiple directions, as instrumental as data collection and analysis from various sources are for research, the reliability and validity of findings also must be assessed against relevance and credibility (Silverman, 2020). In other words, different voices should be heard and listened to address alternative futures in any efforts of possibilistic-transformative foresight. As explained, semi-structured context interviews with energy and development experts internationally and through field work (n=12) were conducted to frame and triangulate the research. In them, stakeholders were asked to openly share their insights. At the initial stages, two futures workshops had been organised with local organisations in Nairobi, Kenya, and a third workshop in Dar es Salaam, Tanzania between 2015 and 2017, as spaces for deliberation (Jungk & Müllert, 1987). These generated an overview of some of the actors' expectations as well as insights of the early seeds of the energy transition. Although these workshop interactions were independent of the actual sub-studies, they deeply shaped my research questions. Background interviews for article III assisted in framing subsequent research and the eventual data collection. In contrast,

[14] Images of the future (W. Bell, 1997, 95-97) are a theoretical and conceptual confluence in futures research, which can be distinguished from imaginaries. However, both concepts suggest that once they are collectively shared, and when actors, groups or organisations with the necessary capabilities use them to initiate action(s), they may gain power. Related ideas are presented in the works of early futures scholars (W. Bell and Mau, 1971; Polak, 1973) and political scientist Harold Lasswell's ideas of development analysis.

specific participatory methods deployed in Chile by a wider research team with detailed preparation in article IV led to the thematic analysis of collected research data. Overall, in such workshops, opportunities and risks were scanned to enhance contextuality, making them not too dissimilar from innovation sessions (Melkas et al., 2016). In this sense, one may consider the study to have been motivated by deliberative foresight.

I reflected my own positionality throughout the research journey in this exploratory study, as a scholar whose origins are in the Global North, as an additional layer that cast a light upon this research topic. Any scholar should be aware of how Western perceptions have undermined Southern voices (Giwa, 2015). Also, historically, Eurocentric views have had severe limitations, for instance, when they have been cast upon Africa (Koivunen, 2006; Bob-Milliar, 2022). At the same time, one also must be wary of overtly simplistic or naïve claims, such as propositions of antagonistic power dynamics. As a research strategy, the perception of climate and technology leadership of the Global North is problematised across articles II-V. In some cases, European and international actors may appear to have a dual role, as quite resourceful actors who are able to 'inspire' (Stokke, 2019) through their techno-economic capacities, and when they set agendas, formulate policies and promote programmatic approaches. In practice, I had to actively reflect and re-calibrate what and how to represent, and I also had to question some of my privileges (Choquez-Millan et al., 2024; Mkwananzi, 2025) as a researcher, such as access to expert networks or specific forums that could be seen venues for dialogues that allude to 'futures' or the ability to retrieve online data, which is not to be taken for granted.

As a learning journey, I emphasise the importance of being actively conscious of one's own role in the research process through humility. In support of theorisations, interpretive lenses, methods and data chosen, I used journaling for my research. As an eventual research strategy, I focused on the transnational level, as a decision that also was carried over to methodological choices and shaped practical data collection. Typically, I relied on multiple data sources, and aimed to combine expert interviews, participant-observation e.g. at international (and sectoral) stakeholder forums with more desktop-based data collection strategies. The neoliberal discourse is also present in international development and informs the off-grid solar PV sector in Kenya and Tanzania. In assessing data sources to this particular case study, with associated market promises and technology claims, I also treated them as symptomatic of policy discourses. For identifying start-up firms, alongside expert opinions, I reviewed a range of publicly available materials (see 3.2). As earlier reported, article III as perhaps my most data-driven study on the capabilities of firms was sparked by a small subset of project data, initially shared by a Global North funding body.

As a single scholar, I classified my data throughout my research. Preceding the mentioned article III, 14 additional interviews with some of these highly innovative off-grid solar photovoltaics firms and 32 interviews with relevant sector experts and international development actors primarily between 2017 and 2020 were instructive, so I could build a picture of an exceptionally-innovative sector, elaborating its rapid evolution. In these interviews, either recorded and/or transcribed, the research aim was explained to the interviewee(s). In other, more informal conversations, hand-written notes were occasionally more appropriate as per the nature of the dialogue. Using snowballing technique, some discussants identified further experts. A passage in article III alone refers to interview material directly, and in this case, only generic characteristics concerning the interviewee, as an informant, are provided. All stored interview material has been anonymised with assigned codes. In contrast, the names of firms are mentioned in this same study. Finally, as a subset of data for article V, participant-observation virtually at stakeholder forums resulted in descriptive notes that aim to capture key themes and issues from these events.

In data analysis, every article contains some descriptive analysis. Many articles present some elements of thematic analysis or cluster analysis, which also typically assisted in organising the collected data. In every sub-study, existing theories informed further analyses, also in light of policy documents. Background interviews typically generated information about the phenomenon in question. Media and policy documents were typically used for descriptive purposes, and they were not coded.

In article I, after descriptive statistics of the survey results, answers to open-ended questions were thematically analysed (Note: with the help of an assistant to the research project). In article II, I invented a novel assessment model that assumed a futures research point of view to describe how sectoral benchmarks were pointing to possible futures. In article III, the capabilities of firms were assessed by adapting from state-of-the-art theorisations in innovation and development studies (M. Bell and Figueiredo, 2012; Oslo Manual, 2018) to inform the labelling of descriptors and how the capabilities should be studied. Although some of the background interviews for article III with the sectoral experts and firms were thematically coded, partially informed by innovation and transition theories, these codes were neither reported nor used for the eventual typology on firm-level innovation capabilities. However, their themes contained various elements of ecosystem-building, market theory as well as spoke to divergent expectations in the off-grid solar PV niches especially in Kenya and Tanzania, and also other African countries. As mentioned, the coding of the group work results in article IV was abductive. The interviews for article IV were not coded. In article V, which combines multiple datasets, the impact-uncertainty matrix adapts from the ‘intuitive logics’ scenario technique used by foresight practitioners (Wright et al., 2013).

3.5 Self-assessment of the applied methodology

A validity criterion to assess the quality of scientific futures research, proposed by Kuusi et al. (2015a), is applied as a self-assessment, as shown in **Table 3**, where 1 = lowest score, 6 = highest score.

Table 3. Self-assessment of the study methodology as per the validity criteria proposed by Kuusi et al. (2015a, 75; see also: 2015b).

1: Wide scope of possible future paths	2: Most relevant futures paths	3: Covering interpretation of past 'facts'	4: Effective interpretation of past 'facts'	5: Many people understand the map, e.g. simple visualisation	6: Relevant experts understand the map
4	5	6	5	4	4

As possibilistic-transformative foresight, the research considers transformations, and within this context, the research process has narrowed down its focus to entrepreneurs as plausible agents of change (4). This can be justified by effectively exploring the most relevant futures paths in a credible manner. In fact, on the mode of a possible transition in the Global South, Cloke et al. (2017) identify a top-down, technologically-driven framework as the dominant one so far (in spite of emancipatory desires). Therefore, this path needs to be examined, while acknowledging its socio-cultural roots (5). The literature review covers a wide array of academic and grey literature of past and present developments (6). The study also reflects and interprets their theoretical lessons (niche-theory, social construction of technology) (5). With respect to the final criteria, the study and its images of the future have been examined externally and academically prior to the publication. These images aim to communicate the study findings to different users (4). As a further step, these images are recommended to be discussed with different types of audiences, so that various stakeholders and experts can understand the study, and its nuances (4).

3.6 The limitations of the study

The choice of 'level' affects the images of the future of this study and results in some trade-offs. Problematically, in elaborating what makes entrepreneurial firms (such as start-ups) attractive to finance, a related emphasis on technological capabilities hides local entrepreneurial firms' realities and the informality of Global South economies. Overall, the political-economic lens to economic development is about

a transnational perspective. However, for in-depth country case studies, a different research design would be required with further co-creation and extensive data collection at local level. A study interested in pioneers, as extreme cases, also has some limitations in generalisability, but similar types of patterns (as well as techno-economic pathways) could appear at laggard markets (Beise, 2004; Tiwari & Herstatt, 2013).

Concerning validity, there are different aspects that affect the detection of meaningful signals from noise in change-related issues. Policy documents alone cannot offer insights of implementation, and market or industry reports (domestic or international) also should be scrutinised. Some level of technology hype is to be recognised as a feature of any nascent field. Reliability-wise, for example during the COVID-19 pandemic, publishing activity in the off-grid solar sector was temporarily halted. Any press releases, media or news reports must be examined. In Kenya and Tanzania, some limitations in national press freedom may shape topical coverage and critical reporting, and should be acknowledged (Reporters Without Borders, 2025). Overall, data verification is important for any study interested in these topics.

4 Off-grid solar photovoltaics start-ups in the East African lead markets

In this chapter, the application of pioneer analysis is demonstrated through an empirical case study. As an initial framing, I use a past – present – futures framing in the following manner. First, based on a literature review, I begin with a short history of the evolution of the off-grid solar photovoltaics niche in Kenya and Tanzania, for understanding the role of entrepreneurial firms for the uptake of decentralised renewable energy in East Africa. For justification via cross-country reports of experiences elsewhere in sub-Saharan Africa, see Bawakyillenuo (2012). After this, I will describe contemporary issues. Finally, these developments, their decentralised nature and market characteristics can be viewed as a cluster of weak signals, as an extreme case of the global energy transition.

At the end of the chapter, assuming a foresight perspective, I draw attention to the wider potential of these entrepreneurial actors, as well as a budding ecosystem of innovation, finance, markets and technology, and associated economic change, to articulate a long-term perspective, illustrated in **Figure 5**.

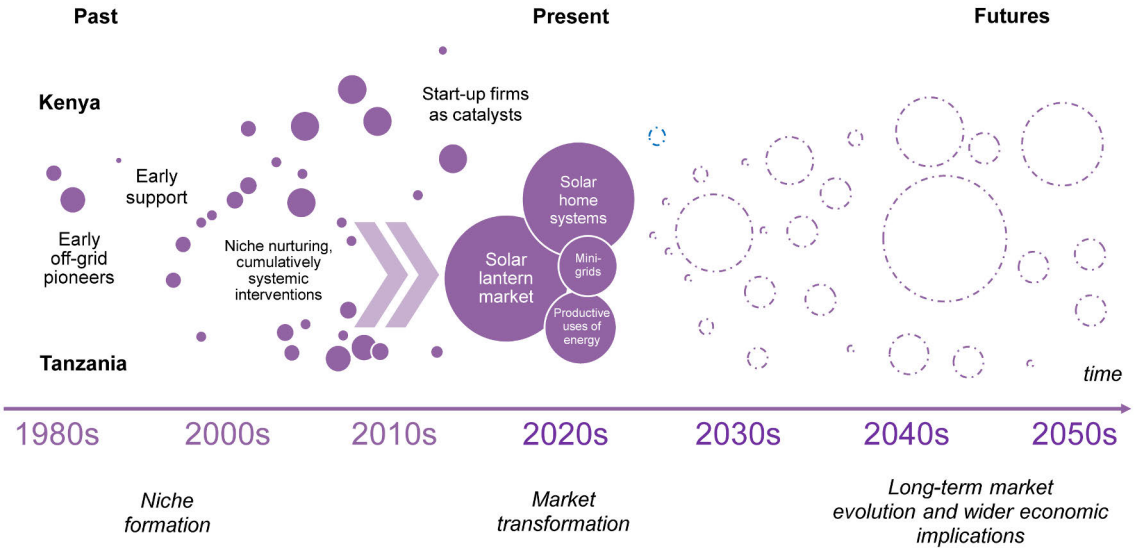

Figure 5. The evolution of the off-grid solar photovoltaics sector in Kenya and Tanzania, and the role of start-up firms at the market transformation phase. In this study, long-term market evolution and implications on economic development, and their futures, are of particular interest. Illustration by the author.

4.1 Evolution of the off-grid sector in East Africa from the 1980s onwards

As a starting point, off-grid solar photovoltaics are systems, products and services that can operate autonomously from the electricity grid. This sub-section draws heavily on Byrne (2011); Ockwell & Byrne (2017); Byrne et al. (2018) as well as Ockwell et al. (2021). Lighting Africa, Lighting Global and Global Off-Grid Lighting Association reports offer further guidance.

Historically, the evolution of the solar photovoltaics niche in Kenya has diverse features and many phases, and somewhat similar progressions have been observed slightly later in Tanzania, as suggested by Ockwell & Byrne (2017). As a technology or physical equipment, the first signs of solar photovoltaics in East Africa appear in the 1970s. In Kenya, traces of a solar home systems market surface in the mid-1980s, although at the time, largely on a project basis. In those days, the commercial uptake of solar technology was still at infancy, but some actors in Kenya started to characterise its adoption and propagate a narrative of an entrepreneurial, private sector-led story. More systems-based explanations are cited in contemporary literature, emphasizing the necessity of niche-building efforts. In the latter account, many experimental, innovative and decisive actions orchestrated over lengthy periods of time have built up capabilities in solar photovoltaics as well as other decentralised renewable energy technologies in Kenya and Tanzania. Generally, entrepreneurial heroics and niche-nurturing dominate as two contrasting narratives that frame technology uptake (ibid.).

Building on academic literature, at the initial stages, there appears to have been little, if any market activity in these countries. Therefore, the basic tasks for any actor involved with the technology concerned addressing issues such as awareness-raising, education, and acquiring technical competences. Drawing again on Ockwell & Byrne (2017), during the early decades of solar photovoltaics, especially in the Kenyan case, a combination of efforts involved small-and-medium-sized enterprises (SMEs), non-government organisations, and international development actors, and the role of international partners was also to channel financial support, so that the identified challenges could be dealt with. In the early niche-building efforts, this coalition of actors with other experts also interacted repeatedly with national policy-makers to outline the benefits of the technology, as a way of establishing a base for the nascent solar photovoltaics sector. Such experimentations provided varying results. In the 1990s, more systematic capacity-building efforts continued with further, programmatic support from international development actors.

4.2 Kenya and Tanzania – an evolution from electricity access to niche-building efforts

In the past, like in many countries, national regime actors in Kenya and Tanzania have predominantly focused on grid-extension and have left the promotion of off-grid solar photovoltaics for electricity access, rural electrification, as well as decentralised renewable energy uptake to grassroots actors. As a consequence, alongside the early signs of a solar home systems market in Kenya and in Tanzania, a range of capacity-building efforts to raise awareness, address service delivery, maintenance, provide finance as well as educate consumers characterised the early decades of solar power. Overall, despite lengthy hopes, the uptake of solar products and related services has remained slow in the African context because of technical, financial, social, implementation, and institutional / policy constraints (Friebe et al., 2013; M. G. Smith & Urpelainen, 2014). One challenge has been the design of delivery and service models that low-income consumers can access and afford.

In the early 2000s, a solar home system market emerged in Kenya, and at the end of the decade, in just a few years the PV market in Tanzania grew to a value of USD 2 million or more. Yet, at the end of 2000s, solar energy still had quite a modest role in Africa and internationally. It was around this time, when solar panel manufacturing started to shift from Europe and the U.S. to China (Huang et al., 2016). Interestingly, in these two East African countries, it appears that as a partial result of perseverant actions by international actors, also by combining consumer education with private sector development, some success was being achieved in the solar photovoltaics niche (Ockwell & Byrne, 2017). At least in some ways helped by a systemic approach, and a range of activities addressed at the promotion of solar photovoltaics, what could be characterised as an off-grid lighting and appliances niche started to emerge. At the same time in international development policy, more focus started to be on improving access to lighting, and the promotion of small solar-powered lanterns, or so-called pico-solar products (Lighting Africa, 2022).

Such evidence compellingly suggests that the role of financial support from international development partners for capacity-building efforts sustained over time cannot be overlooked in Global South contexts. In the 2010s, these actors were channelling official development assistance (ODA) as well as started to explore new ways to provide climate finance. This way, they were hoping to address a dual objective: poverty-eradication as well as combatting climate change. In the dawn of the 2010s, some policy reports were articulating the problem definitions concerning solar PV uptake using market-related terminology.

Between 2008 and 2013, China's then newly-established solar photovoltaics industry caused the world prices of solar panels to drop by 80 percent (Huang et al., 2016). Perhaps it is no coincidence that around this time, the signs of entrepreneurial activity with solar photovoltaics in East Africa also appear in more frequent terms

across various sources. An appeal in providing solar home systems in entrepreneurial mode also coincided with a growing reluctance in international development circles to rely on philanthropic approaches, especially in cases of technology uptake. In my own research, industry reports, sectoral media and interview material suggest that a number of private sector actors as well as development analysts started to see the lack of dynamism in project-based models, as a related problem. In the case of off-grid solar photovoltaics at these pioneering markets, a more market-based approach began to be advocated as a more appealing avenue. Literature, various reports and policy documents hint at some gains in regime-level acceptance of solar power uptake, they also present niche actors to perceive the decision-makers in Kenya and Tanzania to have a somewhat limited understanding of the dynamic efforts in the marketplace. As a further point, the national energy policy formulation in Kenya in the early 2010s largely overlooked the global fall in solar PV prices already in motion (Rose et al., 2016).

4.3 Start-up phase in the 2010s – the pull of the future

As the 2010s were starting, mobile phone penetration had increased swiftly in East Africa, and spectacularly, Kenya and Tanzania had emerged as global frontrunners in the use of mobile payments. In both countries, mobile money was being used for daily economic transactions (Onsongo & Schot, 2017). As a source of further excitement, the digital revolution hinted at even more transformative pathways. In the solar sector, as the first sign of an entirely new phase, M-KOPA Solar, a British-Kenyan firm, founded in 2011, introduced to customers how they could use solar photovoltaics by using their mobile phone. Such companies allowed the users of compact solar-powered systems to subscribe to a company service by paying in small instalments with the features of their new mobile devices. A financial innovation, coined as the pay-as-you go model, as a subscription into new energy services or for eventual ownership of products, caught on and became internationally heralded, for enabling low-income customers to access energy services (Rolffs et al., 2015). In only three years, its systems for lighting, mobile charging and powering a radio were claimed to attract nearly 250 000 customers. Such promises seemed to be enough to catalyse a wave of innovative firms to enter into these lead markets, and beyond. A narrative of heroic solar entrepreneurs providing access to clean electricity, translating a global challenge into an economic opportunity, had winds in its sails.

Excitement of these novelties was on the upswing also in policy circles. In some analyses, over 80 million people in East Africa were identified as potential beneficiaries of mobile-enabled energy services (Gauntlett et al., 2016). Some new firms entering the sector, using the pay-as-you-go model, were applying design

thinking to discover more about their potential users. In addition, other firms were introducing new, technologically advanced services that use rudimentary machine learning, as documented by case studies (Bisaga et al., 2017). As the decade went on, the turnover and sales of entrepreneurial off-grid solar PV firms from their products and services was increasing. Expectations were rising even in the solar mini-grid segment, which had been ever-reliant on project funding (Ogeya et al., 2025). Finally, some companies were entering the 'productive use' segment where solar energy is used for agriculture, cooling and other economic activities. Curiously enough, in the mid-2010s, numerous academic research gaps still were stated to persist in understanding the full dynamics and potential of solar photovoltaics (PV) in the Global South (Hancock, 2015).

4.4 Innovation-led development policy targeting the SDG 7

In a seemingly short time period, the off-grid solar photovoltaics niche in these pioneering markets matured, so that surrounding discourses even began to speak of a nascent industry, as a new opportunity for entrepreneurs and investors. At the end of 2010s, the global investment for off-grid electricity access start-ups reached new heights, and Kenya and Tanzania were amongst the lead markets (Malima et al., 2024). It is perhaps not a coincident that the role of entrepreneurs and business leaders was being depicted in international development policy as so crucial that they were expected "to lay out a clear vision for a sustainable future and shape a new era for business", as hinted in 2017 by the United Nations Global Compact (see also: Groenewoudt & Romijn, 2022). At the clean energy sector, with a growing number of actors, the ecosystem was growing. Although it is challenging to establish a direct causation, it appears that the described market dynamics at the off-grid solar PV sector were also influencing the 'theory of change' to support the attainment of the Sustainable Development Goal 7 (SDG 7), aimed at expediting universal access to affordable, clean, and modern energy services.

Because local finance can be limited in Global South environments, the surge of intermediaries into the decentralised renewable energy space seems very promising for entrepreneurs and start-ups. Alongside the provision of business support and awareness-raising, international programmes such as EEP Africa (2022) were also stating social and environmental goals, as part of their newly-targeted activities. The early pay-as-you-go pioneers started to expand to new markets, including West Africa in the late-2010s, as a seeming testimony to the sector's triumph. However, soon enough, less positive news began to emerge. Concerns of commercial profitability were voiced, when German-originated firm Mobisol, another early pioneer, sought for insolvency. Mobisol had established an academy in Tanzania to

train local technicians on solar technology and had also been vocal about the issue of electronic waste. Then, the eruption of the COVID-19 pandemic meant an even more dramatic turn. As a start to the 2020s, this global and regional crisis disturbed almost all firms' operations, also in this sector. Certain prominent off-grid solar firms managed to apply for relief funding from development banks, while most African governments did not provide any emergency measures to renewable energy sector actors (McCarthy Akrofi & Antwi Sarpong, 2020). Additionally, data privacy and circular economy started to enter the industry debates as new issues.

4.5 Value accumulation and missing production capabilities

What the future will hold for the off-grid solar photovoltaics sector in East Africa, and beyond, remains uncertain. If the Kenyan market is already very mature, and that of Tanzania could be some way behind, there are many less mature markets (Malima et al., 2024). Furthermore, despite undoubted success, at least three issues remain as reservations for the market-aligned dynamics of this technology, listed next:

First, despite niche diversification, a start-up boom and the growth of a nascent ecosystem, the most innovative journeys of this future-oriented industry have primarily been facilitated by technologies and competences originating from outside of Africa (Byrne et al., 2018). Amidst a flurry of innovation and excitement, it has remained unclear to which extent different types of foreign direct investment attracted by the sector will be able to also promote local linkages and assist in the development of local business and their capabilities (Malima et al., 2024). Secondly, in theory, any entrepreneurial firm, local or foreign, should have a chance to benefit from an expanding ecosystem. However, in the 2010s, the majority of finance was attracted by only a handful of leading firms, again, all of them from the Global North (GOGLA, 2022). As a result, critical scholars were becoming wary that the efforts to transform access to clean energy into an economic opportunity are not paying adequate attention to value accumulation (Ockwell et al., 2021). The most fearful ones even claim that instead of addressing policy priorities of the Global South, the Global North support is dictated by their domestic priorities, at the service of their own innovation policy. Thirdly, the Global North actors may have failed in fully integrating Global South priorities into their strategies and programmes. As a particular example, at the end of the 2010s, there was only one local solar module assembly plant and a battery manufacturer in the entire East Africa; and both of them

were located in Kenya (e.g. Ockwell & Byrne, 2017)[15]. Somewhat exceptionally, in 2018, M-KOPA Solar, the earlier mentioned pioneer, announced that it would start procuring some of its solar panels from a Kenyan manufacturer. A few years later, in the early 2020s, it was a Global North philanthropy that announced a renewable energy manufacturing initiative addressed at African countries[16].

4.6 Problematising the neoliberal orthodoxy

In the case of sub-Saharan Africa, with the exception of South Africa, most economies have limited industrial bases. Therefore, a comparative case study may help in addressing some of the mentioned issues that are related to the energy transition from an international perspective. Around this same period in Latin America, Chile's high-income economy had assumed the position of a regional leader in decentralised renewable energy, particularly in solar energy. As an important difference to East Africa, the solar photovoltaics niche in Chile is not necessarily known for off-grid or pico-solar products. Politically, in the 2010s, Chile had elevated its clean energy ambition, and formulated quite advanced targets for renewable energy, which it also expressed in its long-term energy plan (Alvial-Palavicino & Opazo-Bunster, 2018). As a related aspect, for investors, its renewable energy markets were being presented as some of the most attractive in the world. But, from a national perspective, the country was also expressing high hopes of value chain upgrading from solar photovoltaics, as can be read from several policy and political statements as well as related initiatives.

To date, Chile's conducive market environment has invited solar power projects, where project developers successfully deploy solar photovoltaics at record low costs. However, from an innovation perspective, although Chile is considered as a more advanced economy than Kenya and Tanzania, it does not have local companies along the wider solar value chain nor the human capital in place to aim at upgrading (Haas et al., 2018). As the history of Chile would tell, neoliberal ideology is deeply embedded into the weaving of its political economy (Furnaro, 2020), and apparently, some of such dynamics are also pertinent to the energy transition. Certainly, such

15 In the case of off-grid solar photovoltaics, production capabilities primarily point to solar panels, specific components, batteries used by such devices, or other auxiliary products benefiting from these technologies.

16 The issue is not entirely new, as in the past, there have been partial efforts to attend to the issue. According to Ockwell & Byrne (2017, 97-99), development-partner funded efforts in the early 2000s aimed to develop the local manufacture of battery charge regulators for solar home systems in Kenya, but were unable to compete with China. In 2011, an assembly plant of solar modules and solar kits was established, resulting from a joint venture between a Dutch investor and a Kenyan holding company.

issues as well as capabilities may vary from sector to sector. For instance, in lithium, one of the essential minerals for the global energy transition, Chile is a major international producer and exporter. However, in an industry controlled by two multinational firms, there is hesitation of allowing market forces to reign freely due to past accusations of corporate misconduct. Additionally, the environmental impacts of lithium mining are being placed on scarce and already privatized water resources as well as causing harm to Chile's indigenous communities.

4.7 Concluding remarks

To conclude this chapter, the case study of the off-grid solar PV pioneers in Kenya and Tanzania was presented as important evidence, if we wish to understand decentralised renewable energy uptake in the Global South.

At first sight, such seeds are pointing to a decentralised renewable energy future, as a rather prominent technology story that stands out as unique compared to many other contexts. A magnitude of efforts built a sustainable base, then a small niche evolved into a sector, created new markets, and even erupted a start-up phenomenon. The emergence of innovative products and services in East Africa also suggests that higher shares of economic value are accumulated through creative processes. However, alignment with local needs and national priorities has not fully been solved, and the tales reported from Chile allude to more widely-held aspirations. Although the studied cases and sectors differ by characteristics, productive capabilities are of national interest in both regions. In the African context, they specifically relate to deeply-held aspirations for industrialisation.

At the same time, some important shifts have started to take place that may affect international collaboration. Towards the mid-2020s, the European Union and the U.S. had entered a race vying for technology leadership, in selective parts concerning climate technologies, and were re-shoring some of their productive activities to address the competition from China. After a cascade of crises, the political, economic and social mood globally has put pressure on decision-makers. As one of its many consequences, this was adding pressure on the budgets for international development in many Global North economies. And, while the Iran War in 2026 was raising questions of dependencies on fuel imports in many markets, it was also posing challenges to certain economic activities, and placing an additional strain on international cooperation, and its conventional modalities, which were discussed earlier in this chapter.

5 Key findings

This chapter elaborates on each original study in the dissertation, and how they have helped to answer the sub-research questions of the entire research. For each article, the context and motivation, aim, research question, hypothesis, methodology and data, key findings, conclusions, and originality/value are provided in **Table 4**. All articles, including my primary case study discussed in articles I, II, III and V, aim to demonstrate how a transition can be imagined in a range of local, national, and regional context(s), assisted by foresight, explained next.

Table 4. The main elements of each original sub-study, and their originality and value.

	Article I: **The pioneers of renewable energy are around the world – what can we learn from them?**	***Article II:*** **Using deliberative foresight to envision a neo-carbon energy innovation ecosystem – a case study of Kenya**	***Article III:*** **Moving forward? Building foundational capabilities in Kenyan and Tanzanian off-grid solar PV firms**	***Article IV:*** **Foresight for Chile's energy transition – unleashing societal trans-formations**	***Article V:*** **Not all start-ups are born equal – four images of the future of the off-grid solar photovoltaics start-ups in Kenya and Tanzania in 2050**
Sub-research questions	1, 2, 3	1, 2, 4	2, 3, 4	1, 2	1, 2, 3, 4
Context and motivation	The global energy transition could imply major transformations in this century. It could be useful to already begin to learn from pioneering actors and actions that promote new practices.	The efforts to plan for a renewable energy system must be far-sighted and deliberated. Such debates must attend to broader institutional and socio-cultural aspects as well as aspirations.	The off-grid solar photovoltaics (PV) sector is a nascent industry where investment in start-ups grew from USD 20 million (2013) to nearly USD 400 million (2018), targeting solar home systems and mini-grids.	Chile is a pioneer of economic development in Latin America, which has ambitious renewable energy targets. Political and economic considerations inform related strategies.	Amidst protectionist headwinds, Europe aspires to be competitive, and promote international partnerships. At the same time, the Global South calls for decolonised frameworks.

Aim of the study	The aim is to identify local pioneers and to learn from their motivations, actions, needs and challenges. A contrast is created between the present and possible scenarios, and associated transformations.	The aim is to describe leading renewable energy and innovation practices in Kenya, and to learn from strengths, weaknesses, as well as to explore their (hidden) potential.	The aim is to learn how capabilities have been accumulated in the pioneering off-grid solar PV sectors of Kenya and Tanzania, and to describe niche and market dynamics.	The aim is to explore how foresight can be used to analyse energy transitions, and to illustrate its potential to study radical and discontinuous change.	The aim is to show differences and elaborate a range of economic implications, which could open up in the Global South in the long-term from the green transition.
Research question(s)	Where, how and what kinds of change concerning renewable energy and environmentally-minded practices around the world can be found?	What are the dynamics of key renewable energy initiatives in a pioneering environment from evolutionary and ecosystemic perspective?	How have firms in the off-grid solar PV sectors in Kenya and Tanzania accumulated their innovation capabilities?	What could change in Chile as a result of the energy transition institutionally and socio-technically by the year 2050?	Drawing on firms as key actors in lead markets and critical uncertainties, what kinds of futures are they pointing to in the Global South?
Hypothesis	Change can start from anywhere, but often times, it starts on the fringes of hegemonic regimes.	Foresight and long-term dialogues could inform the direction of transitions in the Global South.	Capabilities of firms may be important in explaining the success of entrepreneurial efforts.	National energy strategies for transitions are pinned by political-economic interests.	Recognising power dynamics could help in understanding differentiated premises of transitions.
Methodology and data	Qualitative survey was sent to international foresight, energy and innovation experts (n=39). Aided by transformative scenarios, they identified pioneers in their local and regional context(s).	Four leading initiatives were described from media, policy documents, interviews, and a futures workshop, and assessed with a new assessment model and scenarios.	Novel four-level typology of innovation capabilities of off-grid solar PV firms (n=94) was developed, and contrasted against longitudinal off-grid and lighting sector market, finance and investment data.	Global scenarios were localised in a futures clinique with ideational-analytic techniques with national experts (n=30). The results were abductively coded.	Observation in sectoral forums (n=15) and interpreting horizon scanning signals (n=212) assisted in identifying critical uncertainties.
Key findings	A wide range of actors can advance innovative and	Any renewable energy initiative, project or service also	Many locally-originated firms reveal basic capabilities, and	A more decentralised energy system demands a	Four images of the future differentiate the type and depth

	novel solutions. The initial scenarios had only some forerunners, but a number of real-life pioneers could be identified from the survey, as suggested by the scenarios.	affects an innovation ecosystem locally and nationally. Such modalities and their impacts can be mapped.	some Kenyan firms also reveal advanced levels of capabilities. The leading start-up firms that attract major investment are of international origin.	more regionalised mindset. Knowledge is necessary for developing value chains. Related plans also will likely encounter surprises.	of economic implications (new services, new jobs, local innovation, and assembly), alluding to economic transformation.
Conclusions	The identified actors and initiatives, as pioneers, have momentum in the present, and solve different problems than those that appear in the future (whose problems already may have been addressed).	Individual initiatives in a conducive environment present diverse learning opportunities that merit explicit consideration as well as a view on evolutionary change.	Although many highly capable companies are of foreign origin, they also can present opportunities for local firms to learn. A base of capabilities is a prerequisite for any innovative learning patterns to begin.	The future horizon is constantly moving. Knowledge is important also from a national perspective, transnational partnerships and efforts to upgrade value chains would suggest.	Decentralised renewable energy and the energy transition in the Global South are at infancy, but pioneers show how capabilities and regime support influence long-term gains.
Originality and value	Pioneer analysis is a novel foresight method that helps to study the seeds of possible futures. In this specific case, the identified actors point to the global energy transition.	Alongside a novel assessment model, the introduces deliberative foresight, as a concept, which could help in the anticipation of emerging issues through co-creative dialogue(s).	The latecomer theory has rarely been applied in Africa, where many countries have limited assembly and manufacturing bases. Here, it was applied to study a sector with an environmentally-friendly technology.	Any country in the Global South that aims to become a knowledge and technology innovator must experiment, reflect, perform science-driven innovation and practise foresight.	Futures in the Global South can be systematically studied and elaborated further. From the seeds of possible pathways, it is also possible to identify and discuss preferable ones.

5.1 Article 1: The pioneers of renewable energy are around the world – what can we learn from them?

Karjalainen, Joni & Heinonen, Sirkka (2018) The Pioneers of Renewable Energy are Around the World – What Can We Learn from Them? *Journal of Futures Studies* 22 (4): 83-100.

Article I claimed that to understand the potential for systemic, transformative and whole-of-society change, there should be pioneers as catalytic actors who are expected to intervene. In applying the perspective of pioneer analysis to the global energy transition, as a foresight method, one would be interested in searching for the kinds of pioneers as actors who already pursue and experiment with alternative ideas and novel initiatives outside the mainstream. As alternatives to present regimes, such initiatives might be found at the fringes of existing socio-technical system(s). Many of these pioneers in the present may be critical of the status quo, but they do not necessarily constitute a single, homogenous entity. Rather, they present a diverse group of actors with potentially quite varied ways of being, doing and thinking. As a hypothesis, the aim of the study was to identify and learn from a range of pioneering efforts at the forefront, placed at different levels to explore where, how and what kinds of change could potentially emerge.

A qualitative expert survey was designed to learn from such efforts with the help of socio-cultural energy scenarios, which had been built on the basis of weak signals of change. As an objective, the idea of pioneer analysis was adapted for identifying forerunners of the energy transition around the world. Through the survey, it was assumed that it is possible to get an overview of their actions, their proposed models as well as the challenges that they encounter, and indirectly, of their visions of the future. As what they aim to do challenges established norms and regimes, each mode of pioneering faces change resistance. If the identified challenges could be resolved even partially, other actors might be able to join their efforts, and make further contributions at the forefront. As a result of the study, responses to mostly open-ended questions on such topics amounted to over hundred pages of raw text, which were first described, and then thematically coded into clusters.

The aim of the survey was neither to test the accuracy of scenarios nor to forecast – but to gain glimpses of the future. The survey responses present spirited and visionary individuals, innovative companies, resilient communities as well as ecological and social movements from around the world who aspire to preserve the world for future generations. Out of the many examples, experiments and initiatives mentioned, the respondents from East Africa declared off-grid solar energy entrepreneurs as an example of a particular type of pioneers. A respondent from

Tanzania suggested that *"there is already a way in which the start-ups are driving the society"*. Another one from Kenya claimed that *"radical start-ups and green do-it-yourself engineers will most probably increase as people get more fed up with existing systems"*. Then again, far more details seemed necessary to study these actors more closely.

Arguably, in such actions, it is possible to see the very early signs of change – or even the seeds of transformations. Such evidence can also provide depth, context and detail to other foresight efforts. Here, a focus on key actors enrichened more generic descriptions in initial scenarios. Overall, the survey results suggest that all pioneers create awareness, form networks skilfully, and lead by example, to advance their cause. As specific types of pioneers, the responses primarily attributed the agency of start-ups with business models, technology, and innovativeness. Inviting start-ups, as new economic actors to disrupt a sector, is a particular mode of how the private sector can innovate. In theory, if all of the identified actors were to begin to work together, their actions and networks could begin to resemble a widening ecosystem, where they would be interacting to address a specific objective, such as the energy transition, each in their own, unique way. Eventually, they would also enforce new norms and incentives, and propel policy and regulatory change, as elements that could expedite the transition.

5.2 Article 2: Using deliberative foresight to envision a neo-carbon energy innovation ecosystem – a case study of Kenya

Karjalainen, Joni & Heinonen, Sirkka (2018). Using deliberative foresight to envision a neo-carbon energy innovation ecosystem – a case study of Kenya, *African Journal of Science, Technology, Innovation and Development* 10: 5, 625-641.

After drawing the attention in Article I to many types of pioneers around the world, *Article II* focuses on one country. As already mentioned, Kenya in East Africa, as part of the African region in the Global South, is presented as a pioneer to the uptake of in decentralised renewable energy, hosting diverse actors, networks and niches, each with their particular dynamics. Every niche, as a sub-sector, also has specific norms, policies as well as knowledge and financial flows. Therefore, to better understand their potentiality, the study selected four case studies, each from a different niche: the Lake Turkana Wind Power Project, in Northern Kenya, as Africa's largest wind farm; a hardware hub i.e. a makerspace for experimentation with sustainable energy; a philanthropic solar power initiative; as well as an innovative off-grid solar photovoltaics business.

Each initiative was assessed with an assessment model that elaborated how they were pointing to the future. One element of the assessment was their transformativeness. In describing the cases, although each case was observed to present quite different dynamics. a common denominator to all four of them were their inter-/transnational linkages. When it comes to modern renewable energy technologies, Global South contexts are typically, to various degrees, reliant on the provision of finance, technology and knowledge from external sources, and these initiatives were no exception. Out of the cases studied, the exceptional dynamics in off-grid solar photovoltaics business proved to be of particular interest. Although the actual assessment was largely conceptual, withstanding diverse dynamics, none of the assessed cases received a full score. In theory, each and every project or initiative can catalyse further action or generate different types of spill-over effects, but they are not automatically realised. The results hinted that such initiatives could be conceived, designed or operated even more holistically.

A future-oriented element in the assessment is a move beyond a 'project mode' where present delivery mechanisms are not taken for granted. In practice, for actors who are working to address the uneven progress of the transition in the Global South, leveraging learning opportunities from pioneering initiatives at various Global South contexts could be required. A search for 'ideal' dynamics is also about collaborative modes between the Global North and Global South actors, even if the study did not focus on them in detail. The study hints at a necessity to study local efforts to develop national ecosystem(s) further, including long-term mindset and pathway-creation aspects. One further possibility would be to map actors and networks in a systemic way to support, for example, Global South regimes to visualise their nascent innovation ecosystem(s). Internationally, in such a hypothetical map, some elements can be easily detected, but completing such an exercise would be a task potentially suited to local and national research institutes and policy-makers.

5.3 Article 3: Moving forward? Building foundational capabilities in Kenyan and Tanzanian off-grid solar PV firms

Karjalainen, Joni & Byrne, Rob (2021). Moving forward? Building foundational capabilities in Kenyan and Tanzanian off-grid solar PV firms. In Andersen, M., Hanlin, R., Lema, R. & Nzila, C. (eds). *Building Innovation Capabilities for Sustainable Industrialisation: Renewable Electrification in Developing Economies*. Routledge, pp. 181-204.

Article III attends to a start-up boom in the off-grid solar photovoltaics sector of Kenya and Tanzania in the 2010s. As a backdrop, like described in Chapter 4, it has

taken over about 30 years in East Africa to establish foundational capabilities in solar photovoltaics, which eventually, has helped their off-grid solar PV markets to rise. Prior to the start-up boom, both countries had been frontrunners in mobile technology, mobile payments and digital finance. A burst of entrepreneurial off-grid solar activity with off-grid solar lighting devices and services saw several firms to innovate in these lead markets. The study learns from these world-leading patterns in decentralised renewable energy (DRE), which also were raising waves in business as well as global development circles.

As a difference to the previous sub-studies, the study adopted an innovation and development lens. As a scientific novelty, the study adapted latecomer firm theory, which aims to explain how Global South firms can compete in international markets. Typically, the theory has been deployed to identify ways to support local firms' aspirations to manufacture to move up in value chains. Here, the aim of the study was slightly broader, namely to document how innovation capabilities have been accumulated in the off-grid solar photovoltaics (PV) sectors in Kenya and Tanzania over time. Methodologically, in a decade of intensified investment for off-grid electricity access start-ups, the study analysed the capabilities of firms in these two lead markets against promises of market growth. Through a sample of entrepreneurial off-grid solar PV firms, the study introduced a new categorisation that places firms into four levels based on their innovativeness.

As a snapshot of lead markets, the findings revealed many local firms to show signs of innovative behaviour, where some of them were interacting with international firms and supportive actors, with imitative behaviour . Other local firms had decades of experience at their home market, but limited expansive potential. Apart from isolated solar photovoltaic module assembly lines in Kenya, local firms did not really reveal productive capabilities. At the same time, start-up firms, many from the Global North, were in the international limelight deploying advanced business models and emerging technologies. By applying frontier knowledge, demonstrating their skills and using their actor-networks, they were able to attract significant investment, experiment and aimed at venturing into new markets. Such findings suggest that innovation capabilities increase a firm's scale-up potential, and are also of economic value.

The more detailed data offers insights about the founding teams of start-ups, their backgrounds, origins, and levels of past experience. The technological competences of a firm seemed to positively affect scalability, which may explain why start-up firms are conducive to funders and development partners alike. A related insight hinted at value generation being associated with design thinking tools that already help some firms to build innovative energy solutions that are geared for the future. Some concerns are raised of the ability of local early-stage firms to access fit for their needs, for instance, as small enough to nurture them at their incipient stage.

Although commercial viability was precarious, the study speculated with the idea of clean energy markets potentially emerging as business opportunities in the future.

The study contributes to innovation and development literature. First, a 'pre-latecomer phase' where foundational capabilities are nurtured is claimed as an important predecessor to entering an 'early latecomer' phase where more complex, innovative activities are performed. This hints at a 'pre-latecomer story', as a lesson to other countries with currently limited industrial bases, with insights on how to potentially start and foster efforts for sustainable industrialisation. Secondly, by looking at entrepreneurial firms, it suggests to document how innovation capabilities with environmentally-friendly technologies can be accumulated. It also hints at a necessity of increasing the possibility of more Global South firms appearing with innovative activities as well as allude to efforts to nurture production capabilities, such as solar photovoltaic module assembly, as a potential prescription. However, it is not possible to predict whether so-called latecomer firms with more complex capabilities appear or not.

5.4 Article 4: Foresight for Chile's energy transition – unleashing societal transformations

Karjalainen, Joni, Vähäkari, Noora & Heinonen, Sirkka (2020). Foresight for Chile's energy transition – unleashing societal transformations. In Noura, Lucas (ed.) *The Regulation and Policy of Latin American Energy Transitions.* Elsevier Science: Amsterdam, Oxford, Cambridge, MA, pp. 263-282.

Article IV changed the question-setting and the continent, to focus on the seeds of the energy transition in Chile, Latin America, and its neoliberal political economy. Assuming a wider, more society-level perspective, it was interested in what could change in the coming decades in Chile, as a result of the energy transition. As a hypothesis, as transitions are times of change, it was assumed that the exploration of emerging directions and discontinuities could be important for national energy strategies, which usually are informed by political and economic interests. As a global force, the transition can shape other strategies, also regionally. Although various focus areas could be chosen to explore what the transition could propel, in this study, the attention was on energy, organisations and values. As a starting point, any expert would have to be encouraged to free their mind from the present and allow to imagine future change(s). After all, the future does not need to look anything like the past.

Methodologically, the energy transition and its socio-cultural interface were interrogated through a participatory approach. At a futures clinique, organised in Santiago de Chile, national experts from diverse sectoral backgrounds convened to

address two objectives. First, to explore the kinds of avenues that might open up from the transition, and secondly, to analyse them. As an approach, the cultivation of foresight, related methods and tools were assumed to have potential to elevate planning processes and related innovative activities. In foresight, successful co-creation should take place in an argumentative and deliberative space through dialogue for trust-building between multiple actors. As the transition is in motion, such endeavours would have to open many types of futures, even unlikely ones.

After the futures clinique, the expert dialogue was analysed thematically with a co-author to the study. As a result, two directions seemed to emerge. In one scenario, local and national actors struggle to retain economic value nationally, and are dependent on foreign actors (less desirable). In the other direction, Chile's profile as a regional knowledge and technology innovator is heightened, and it owns its transition in the truest sense (a desired scenario). As this result points to innovation, it suggests a slightly wider framing to standards economic theory, where value chain upgrading has classically been prescribed to policy-makers for increased value retention. Namely, even for a country like Chile that has a specific type of economic structure, it could be quite difficult to move up the value chain in a technology like solar photovoltaics without a sufficient number of local actors or adequate human capabilities. Such struggles to retain national value with a chosen technology should partially inform the strategic planning of any country assuming to make economic gains from the transition.

5.5 Article 5: Are all start-ups born equal? Images of the future of the off-grid solar photovoltaics sector in Kenya and Tanzania in 2050

> Karjalainen, Joni (2026). Are all start-ups born equal? Images of the future of the off-grid solar photovoltaics sector in Kenya and Tanzania in 2050. *Unpublished manuscript.*

Article V is about images of the future until the year 2050 that recognise how start-ups operate in a changing, turbulent world, swayed by political-economic interests, crises as well as geopolitical shifts. At a set of high-level policy frameworks, the European Union has declared to act as a climate leader and advance the green transition in its international partnerships, but at the same time, it also strives to promote its competitiveness against the U.S. and China. Meeting such objectives can make the Global North development policy rhetoric look like muddled waters. As a hypothesis, the study assumed that an active recognition of power imbalances is necessary to improve the success of innovation programmes in the Global South.

The aim of the study was to query the contemporary frameworks of market-led transitions. Empirically, the study built on the findings from article III that documented the start-up boom at the off-grid solar photovoltaics sector in Kenya and Tanzania in the 2010s. As a novelty, the study introduced two new and original datasets. Participant-observation at key stakeholder events between 2020 and 2022 (n=15), which deployed a hybrid format or were organised fully virtually, had mapped expectations at the international off-grid solar sector, informed by high-level Europe-Africa business/policy forums as well as by a related side event at the international climate negotiations (COP). The horizon scanning of emerging issues and weak signals (n=212) relevant to the off-grid solar PV sector, and of decentralised renewable energy uptake more widely, enabled change to be conceptualised. Altogether 83 forces were identified, and as the last step, the impact-uncertainty matrix assisted in the identification of two uncertainty clusters.

As a result, the accumulation of capabilities as well as strategic regime support helped to identify four images of the future that assume a view at long-term economic change. These images, presented in Chapter 6 as a result of the entire dissertation, differ from one another in terms of what could result from the transition, as set by the example from off-grid solar photovoltaics lead markets. As an empirical contribution, through these images, any practitioner can begin to conceptualise the market dynamics of the energy transition in the Global South, also with a specific technology. As a contribution for decisionmakers, these images document why a technocratic mindset propagated by some international development policy actors may fail to appeal to Global South decision-makers.

Overall, it would seem as important to learn what can either advance or hinder capability-accumulation with climate-compatible technologies at lead markets. At the same time, developing local innovation ecosystems could enhance the Global South chances for making economic gains, but Global North firms and public sector actors might also have to be instructed to assist patiently the accumulation of locally-innovative entrepreneurial activity. Ideally with a view to the decades to come, a conducive mix of political and economic incentives would assist a growing amount of capabilities as well as economic value to accrue at least in selected markets. As a macro-framework, Lema et al. (2021) have proposed the coupling the objectives of renewable electrification and sustainable industrialisation in the Global South markets together more tightly. In the absence of deeper alignment with political-economic motives, it is not entirely clear how environmentally sustainable technologies are assumed to diffuse.

6 Four futures of the energy transition in the Global South

Four images of the future that explore the seeds of the energy transition in the Global South summarise this exploratory research. This set of images is informed by the findings of each sub-study, the underlying datasets, and especially based on the primary case study in Chapter 4 of an off-grid solar photovoltaic start-up boom in East Africa. Assuming the same critical uncertainties, expanding from the images of the future at the off-grid sector, more generic images of the future are presented, which concern the wider energy transition, and its dynamics, as a whole. Overall, capability-accumulation and strategic regime support were identified as the two axes that inform the journeys of entrepreneurial actors in the decentralised renewable energy markets of the Global South. If uncertainties about capabilities of firms concern the economic realm, then the latter uncertainty, of strategic regime support, has a more political characteristic. As a timespan that offers a more dynamic, granular view to the energy transition, the images have been set to the year 2050, as next depicted in **Figure 6**.

1) The *innovation capabilities* of entrepreneurial firms, such as start-ups, are acquired through learning. These capabilities allow start-up firms, as micro-level market actors, to innovate in a specific market. Production capabilities, as their sub-set, allow firms to assemble and manufacture a specific technology, such as solar photovoltaics or battery technology. Although it might take a substantial period of time, the ability of firms to accumulate capabilities in a specific market also points to the accumulation of economic value. At one extreme, local entrepreneurial firms would not really be able to accrue capabilities, which also would diminish the retention of value. At the other extreme, a number of firms would succeed in accumulating capabilities, at a very fast learning rate, and in turn, this might help widen the local and national knowledge base.

2) *Strategic regime support* is about the predominant mindset of hegemonic actors and decision-makers in how they perceive and approach the energy transition. At one end, when it comes to some regimes of the Global South, including those in emerging economies, they may be quite resistant to the transition, its principles, and its paradigm. If the Global North actors also lack a strategic view, this would make the overarching framework, support and policies quite disjoint (or weak). At the other end, some Global South regimes already may wish to assume leadership over the transition, with a view to economic and other assumed benefits. They may choose to begin to explore decentralised renewable energy and distributed energy planning solutions, and also their digital interfaces. If certain Global North regimes were to instruct their technology actors at the technology frontier to support local firms, this could constitute a transformative mix, as a novel mission.

Assuming at least a base of capabilities, in any market or locality, a transition would advance only through interactive and quite complex, causal patterns, as stage-wise developments. Alongside entrepreneurial efforts, innovative activities, support programmes, long-term policies and initiatives would have to stimulate processes of socio-technical change. As a further consideration, capability accumulation and strategic regime support, affected by political-economic forces, are assumed to evolve quite slowly. Changes in either dimension would also not be automatic. As suggested by these images, they affect the agency of start-up firms to act purposefully in the decentralised renewable energy marketplace. Together, they also would inform the possible futures of the energy transition in the Global South, and related transformations.

Inspired especially by the case study of off-grid solar photovoltaics in East Africa, the set of four images does not intend to focus on any single market or country. As a note, although they differ in economic implications, they do not assign specific, e.g. quantitative estimates of monetary value to be accumulated. Overall, their purpose is to assist in widening and deepening the futures of the energy transition in the Global South. In other words, decentralised renewable energy is placed within a political economy for envisioning more transformed worlds. In doing so, the presented images aim to illustrate the prerequisites for change and help us imagine how the energy transition could evolve. Finally, some contextual features have been included into each image in the nexus of national as well as transnational dynamics, so that they would feel lifelike.

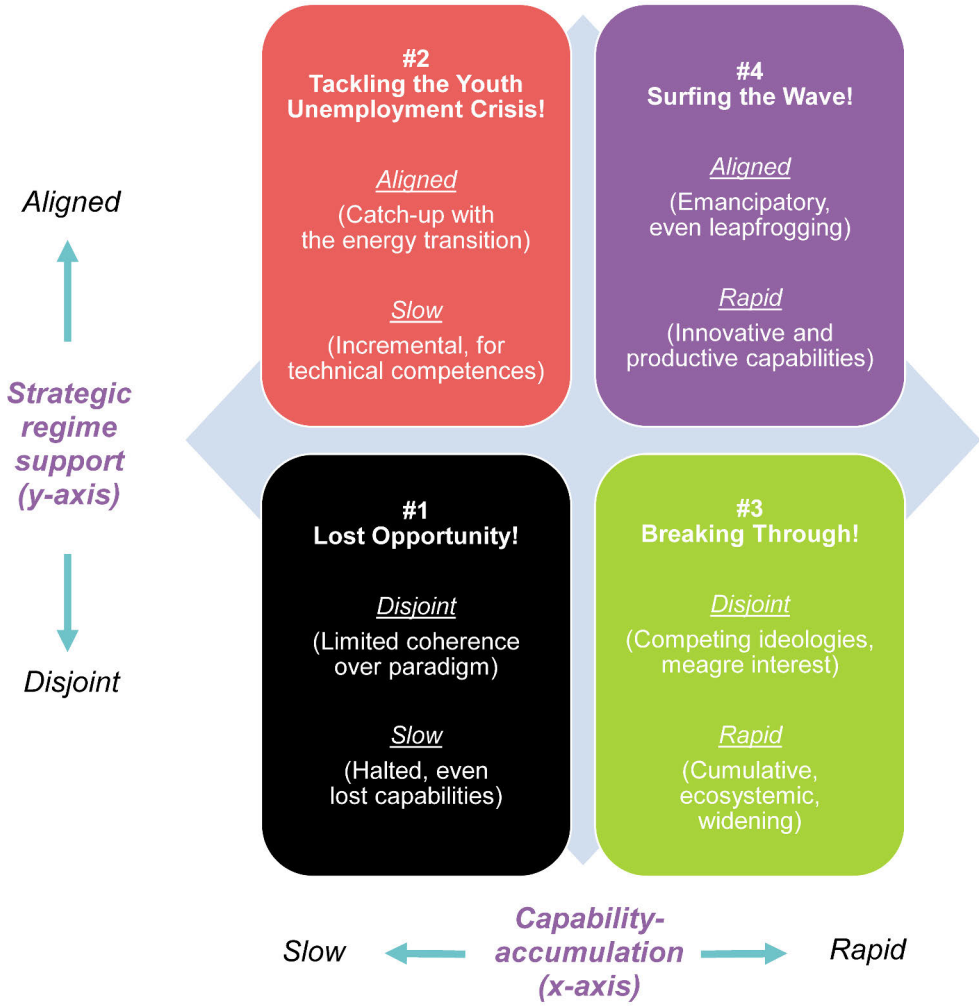

Figure 6. Images of the future 2050 of the energy transition in the Global South, drawing on evidence from the lead markets of decentralised renewable energy, and on the off-grid solar PV start-up boom in the East Africa.

6.1 Image of the future 1: Lost Opportunity!

Table 5. Image of the future 1: Lost Opportunity!

Capability-accumulation	*Strategic regime support*
Slow	*Disjoint*
Halted, even lost capabilities	*Limited coherence over paradigm*

In the *"Lost Opportunity!"* image of the future, a set of Global North actors spearhead the energy transition, but their global power is waning. By 2050, especially China and India have considerably grown in political and economic power. Conventional, centralised fossil fuel generation and related infrastructures supplied their development pathways. In their footsteps, Global South regimes treat the green transition with lukewarm interest.

Although the costs of solar photovoltaics have fallen further, they primarily complement the electricity mix and related services cater for public institutions or upper-class households. Technologically-leading powers rarely interact with their Global South counterparts. Only philanthropic initiatives have supported innovation with decentralised renewable energy.

In the mid-21st century, the global society is a ship lost at sea. In a protectionist and regionalised world, the Global South is free from official development assistance, but climate finance also has run dry. Entrepreneurs, activists and civil society look at the global turbulence in disbelief.

6.2 Image of the future 2: Tackling the Youth Unemployment Crisis!

Table 6. Image of the future 2: Tackling the Youth Unemployment Crisis!

Capability-accumulation	*Strategic regime support*
Slow	*Aligned*
Incremental, technical competences	*Catching up in the energy transition*

In the *"Tackling the Youth Unemployment Crisis!"* image of the future, the decentralised renewable energy sector has evolved and matured by 2050. Global North and Chinese firms lead the sector, and the Global North has re-gained some of its manufacturing capacities. Regional and global crises have occasionally caused further turbulence.

Global North and Chinese technology firms are vertically integrated and supported by innovation ecosystems. They control their value chains to deliver high-quality services. Low-carbon technology transfer has been undermined by the global trade regime and the hype of the Fourth Industrial Revolution (4IR), such as machine-learning and artificial intelligence technologies.

Apart from individual assembly lines, most of the Global South still lacks production capabilities. Aspiring entrepreneurs rely on aging technologies and learning opportunities from transnational interactions remain sporadic. Global North support to the Global South in the transition has been limited to green hydrogen.

6.3 Image of the future 3: Breaking Through!

Table 7. Image of the future 3: Breaking Through!

Capability-accumulation	*Strategic regime support*
Rapid	*Disjoint*
Cumulative, ecosystemic, widening	*Contesting ideologies, limited interest*

In the *"Breaking Through!"* image of the future, environmentally-impactful business schools of the Global South have helped start-ups to create innovative concepts. In the lead markets, local capabilities are multiplying rapidly. These start-ups venture into the energy transition without governmental support.

Certain hubs help entrepreneurs in innovating methods, products and services for decentralised renewable energy. A range of intermediaries and new financial instruments assist them to experiment in the off-grid solar sector and other market segments alike. Many firms have scaled up, and entirely novel actors create new niche markets.

Many Global South regimes are pulled by a model of centralised development. Most governments ignore the economic opportunities of the energy transition. The mindset of decentralised renewable energy pioneers is different and some of their locally-adapted innovations diffuse to neighbouring markets.

6.4 Image of the future 4: Surfing the Wave!

Table 8. Image of the future 4: Surfing the Wave!

Capability-accumulation	*Strategic regime support*
Rapid	*Aligned*
Innovative and productive capabilities	*Emancipatory for leapfrogging*

The *"Surfing the Wave!"* image of the future projects a paradigm-level change, where decentralised renewable energy meets efforts of value chain upgrading in the Global South. A systematic strengthening of capabilities has enabled local firms to accumulate diverse types of knowledge, skills and networks.

Alongside international power shifts, a stronger Global South voice has created new partnerships. Vocational and higher education programmes, innovative policies and new financial modalities assist local companies to manoeuvre the new paradigm. Virtual finance and local currency lending make entrepreneurial actors less dependent on the dollar and yuan.

A novel industrial identity results from a perfect storm. The majority of Global South regimes focus in the renewable energy industry. In new industrial hubs, surplus renewable electricity is converted into electro-fuels to address domestic demand or to supply neighbouring and international markets.

7 Discussion

This dissertation aimed to look at start-ups, as market pioneers and potential key actors, to conceptualise the entrepreneurial dynamics of the energy transition at the forefronts of the Global South. Next, I discuss the contributions of this study into its three scientific fields (futures studies, innovation and development studies and transition studies), identify issues pertinent to governance and decision-making, and point to further research directions.

7.1 Contributions to futures studies

Scientifically, in the field of futures studies, especially Inayatullah (2008; 2022) is interested in who gets to create the future, and how. This research demonstrates how pioneer analysis as a method can assist in the identification of key actors in the Global South and the interpretation of their future-creation efforts. In fields, sectors or countries where futures studies is not yet widely popular, if pioneers are treated as weak signals, attending to them could assist in the study of possible futures. In such cases, attention should be paid to identifying and interpreting what in them specifically points to the potential of the future. I also suggest that the agency of the future possessed by start-ups, as highly-innovative firms with disruptive and imaginative abilities, deserves attention. Through a foresight lens, many types of glimpses of futures, and their alternatives, are revealed by them. In my study, I attended to them as agents of change in the economic sphere, which allowed me to interrogate the political-economic dimension of the energy transition. When it comes to futures literacy, the adoption of a critical lens helped me to problematise overtly simplified explanations and related discourses.

As another contribution to this field, I allude to an idea of deliberative foresight that would stimulate co-creative learning efforts about futures. Although it was not fully fledged in this study, deliberative foresight could mean explorative, inclusive and participatory endeavours aimed at cumulative and systematic futures learning. Collaborative efforts could be conducted between the Global North and the Global South actors to pilot this approach also in research, as an attempt to decolonise. In such cases, pioneer analysis through its potential for further applications could be applied as one part of the method toolkit.

7.2 Contributions to innovation and development studies

Innovation and development studies, as a scientific field, shares an interest in transitions (e.g. Onsongo and Schot, 2017) and development pathways, and has further potential to be explicitly oriented to futures. In my research, drawing on existing theorisations, I introduced a novel categorisation that assesses entrepreneurial firms based on their innovativeness into the East African context. In this case, I examined the uptake of environmentally-friendly technologies due to their potential importance in the future. The framework in Article III, which differentiates firm-level capabilities across four levels, is adaptable also to other sectors.

In principle, it could be applied to examine how entrepreneurial actors are deploying environmentally-friendly technologies in other Global South contexts. In addition, my empirical findings document 'how' futures with more environmentally-friendly technologies are created. Besides spotlighting knowledge, skills and actor-networks, such frameworks could be combined with ecosystem-mapping to help specific sectors to be systematically attended to. Similar suggestions have been raised in Lema et al. (2021).

7.3 Unleashing the hidden potential of transitions in the Global South

As concerns societal change, the anticipatory perspective of foresight and futures studies aims to allow evolutionary and long-term patterns to be identified, and also to be shaped. Therefore, I raise the possibility of combining foresight techniques, tools and methods with other analytical approaches.

As concerns frameworks about sustainability transitions, it could be beneficial to obtain information of key actors, such as the agency of start-ups. Studies on this topic could contribute to related studies on the seeds of transitions. Analyses of micro-level actors who possess agency and point to futures should recognise a range of supportive actors in micro-, meso- and macro-levels, so that pioneers and their endeavours are not treated in isolation. In theory, an enhanced understanding of interactive and collaborative patterns within the said ecosystems could contribute to the emergent literature on transitions in the Global South.

Overall, for enrichening global debates, this study supports an idea of experimenting with new and innovative frameworks as well as efforts aimed at building both transition and foresight capabilities in the Global South. One of contributions of the images of the future in this study is in allowing more detailed questions to be asked of innovation, knowledge, finance, and technology in the Global South marketplace, as well as the power dynamics within global innovation

networks. As a related story of technological change, China accumulated capabilities very strategically in the 2000s. The anticipatory element of such frameworks could also assist long-term planning efforts in different sectors as well as visioning for a more equitable global innovation economy. Efforts aimed at sustainability transitions by deploying environmentally-friendly technologies could attend to associated gains, such as where, how and what kinds of value will be created. Through criticality and creativity, we can explore what can, could or should be transformed. If foresight can generate understanding of the complexities, uncertainties as well as undetected opportunities, joint collaboration with local scholars in the Global South will be integral in any transnational exercises.

7.4 Anticipatory governance in the Global South

Concerning the enhanced integration of foresight into decision-making, as anticipatory governance, detailed thought should be dedicated to what kinds of strategic regime support will be needed. Increasingly often, such policy prescriptions point to a more holistic and horizontal or a mission-oriented approach, preferably as transformative policy mixes, involving the state. Alongside off-grid trajectories, as the production costs of solar and wind have decreased, alternative socio-technical pathways are opening up in different countries for their energy systems, including those up until now attracted by coal in the power sector and other fossil fuels. Efforts are necessary for novel pathways to be unveiled, for preferable ones to be identified, and eventually, to be realised. Within this context, such exercises should place a value on local effort (Bugge et al., 2024).

Learning from this study, the efforts of start-ups, as key actors, are suggestive of a ‘transformed’ future within which the role of actor-networks is potentially quite important. And yet, explicit thought would be needed on strategic efforts that assist in the accumulation of production capabilities in a wide-eyed manner. Overall, the collection of empirical evidence of capability accumulation within innovative firms, and its associated complexities, could assist policy-makers to address the political economy of the energy transition.

Without studies that acknowledge and deal with identified potentials, there is a danger that governance and policy-making ignore emergent change. In such a scenario, struggles of sustainability transitions in the Global South may endure. Conventionally, some international development policy programmes and actors assumed a role where they inspire and cultivate seeds of change. It is unclear how national and international actors should assist Global South actors and entrepreneurial firms e.g. to accumulate capabilities in the energy transition. It would appear to be necessary to imagine how, for example, civil society actors, educators, and start-up firms can assume complementary and collaborative roles also under

protectionist headwinds. The recognition of power imbalances in global innovation networks and entrepreneurial ecosystems could be a useful first step. If policymakers aim to develop dynamic and resilient approaches aimed at market support within transitions, then they should also open to the so-called "VUCA world" of volatility, uncertainty, complexity and ambiguity, in practical recognition of shifting geopolitical landscapes and also regular crises.

7.5 Further research directions

The recognition of the early signs of change, as seen through pioneers, is a promising research strategy, which allows questions to be formulated early on – already at the onset of developments in their initial stage.

Further studies may be needed on how markets behave within the energy transition. Equally, other types of sustainability transitions (e.g. in other sectors) of the Global South merit their own attention. If the interactions of entrepreneurial firms with other key actors were visualised, they could breathe life into local, national and regional innovation ecosystems with particular environmentally-friendly technologies. This study recommends further inquiries that track how capabilities within innovative Global South companies are accumulated; for example, by drawing on ethnographic methods or through longitudinal studies. As another frontier, more efforts may be necessary to better understand local start-up cultures, and how Global South firms can innovate frugally within them. Clearly, much more research will be necessary to anticipate and explore the many other implications of transitions, as socio-technical processes of change that are already underway, and how they could affect the heterogeneous societies of the Global South.

As a final note, this study concentrated on the political-economic facet of decentralised and distributed technologies within Global South contexts. Further studies that investigate this emergent socio-technical imaginary are welcomed, as a potentially exciting and innovative field of research that invites different scholarly perspectives.

8 Conclusions

This study has aimed to answer how looking at pioneers, as catalysing actors, can assist in conceptualising the emerging dynamics of the energy transition, and help study its economic potential in the Global South. Concerning its four sub-research questions, the study has answered three, and is suggestive of the fourth, namely on the relevance of deliberative foresight.

At the outset of this study in futures research, the intention was to learn from the pioneers of the energy transition, and specifically, to identify and interpret the pull of decentralised renewable energy uptake. Another motivation for the research stemmed from the limitations of technocentric studies and associated narratives. As the study went on, and focused on the Global South, the limitations of a primarily Global North propagated theory of change to transitions became increasingly apparent. As one conclusion from this study, despite remarkable market gains with off-grid solar photovoltaics in East Africa, with a start-up boom, it would appear to be too premature to speak of leapfrogging, not to speak of a widening or self-reinforcing socio-technical pathway without some caveats.

As suggested by the sub-studies of this research, despite techno-economic change, the socio-technical imaginary of decentralised renewable energy is not yet shared by all parties in the Global South. Somewhat concerningly, where certain technology-leaders are increasing their impetus to act upon the transition, it appears to be far less clear who are assumed to be in charge of elevating the activities of local entrepreneurial firms and related, wider ecosystems in the Global South, and the cultivation of a decentralised mindset. Such conclusions seem justified, when viewed through the off-grid solar photovoltaics start-ups boom in Kenya and Tanzania, as the main empirical case study. Expectations related to the long-term planning efforts for the energy transition in Chile would appear to support this statement.

As illustrated in the four images of the future of this study, market-led transitions with more environmentally-friendly technologies do not evolve in isolation, but are informed by globally-innovative networks. From a political-economic perspective, if the narratives of the transition overlook capability-accumulation and strategic regime support, as critical uncertainties to the transition, they may be challenged by local actors and could be claimed to lack local viability. Therefore, this study argues

that the realisation of a just transition would see it as necessary to challenge some of the orthodox innovation patterns of the global innovation economy. To add, these images of the future should be understood as a source of inspiration, as they are not fixed.

Amidst a heightening protectionist turn, the calls to economic development, which traditionally have been very vocal in the African soil, could gain new impetus. Within such landscapes, the study demonstrates how start-up entrepreneurs act as catalysts. Additionally, they make for meaningful analytical units, as nodes in global innovation networks and ecosystems, whose role within Global South transitions should not be overlooked. Existing research recognises the importance of entrepreneurs and firms in economic change. In this regard, the energy transition is no exception. For enhanced policy and programmatic relevance, Global South research and policy institutes are assumed to have an important role in investigating some of the identified themes more closely. For the seeds of decentralised renewable energy to become more deeply-rooted across Global South economies and geographies, all involved parties are called upon to scan for futures more widely and deeply. As the futures of the energy transition are being shaped, such studies could be dedicated to aspirational futures with requisite detail.

To conclude, an aim at opening the futures of the energy transition in the Global South is a call to explore and deepen promising pathways for leapfrogging with shared visioning – and to act upon a truly desirable future.

Abbreviations

DRE — Decentralised renewable energy describes a cluster of non-centralised ways to use and produce energy, primarily, electricity with renewable energy technologies. Technologically, firms at this sector benefit from the convergence of distributed, peer-to-peer approaches with ICTs (see below) and mobile finance.

4IR — The Fourth Industrial Revolution characterises more affordable, powerful and smaller sensors, machine learning, and artificial intelligence. Exemplified and symbolised by an idea of a ubiquitous mobile internet in the entire world, the advances in communication and digital connectivity make this revolution different from the previous industrial revolutions.

ICT — Over the later part of the 20th Century, the information and communication revolution changed our world irreversibly. This revolution, as a basis for the digital transformation, was a transition that stimulated economic development, and also gave birth to the semi-conductor industry at a host of East Asian countries and firms, also coined as East Asian Tigers.

OGS — Off-grid solar power denotes systems, products and services that use solar photovoltaics outside the central electricity grid. Mini-grid systems are also off-grid solutions. They can operate autonomously as stand-alone systems, be connected, or integrated as hybrid systems, in various sizes for various uses. The off-grid solar sector is a niche or a sub-sector to the DRE sector.

SDGs — The 17 Sustainable Development Goals, adopted by the United Nations Member States until 2030, are at the heart of the global development agenda. Achieving these targets points to the necessity of systemic change, as a transformation. As relevant for this study, SDG 1 aims at

ending poverty, SDG 7 at clean energy, SDG 9 at innovation, SDG 13 at climate action. In addition, SDG 10 concerns fighting inequalities and SDG 17 aims at global partnerships.

Key concepts

Energy transition

In the energy transition, decentralised renewable energy technologies that are more sustainable are phased in, and conventional fossil fuel-based generation is phased out. The uptake of solar photovoltaics, as a single technology, promotes electrification and is evolving with the digital transformation, and represents its early seeds. Overall, transitions are gradual, deep, complex, and non-linear processes of socio-technical change.

Foresight

Foresight is the disciplined analysis of alternative futures, as a systematic and participatory process to gather intelligence about the future. Foresight aims to create awareness and alert about issues, in support of many types of actors, including policymakers, in making better-informed decisions by considering future eventualities, scenarios and outcomes. Foresight techniques aim to assist us to navigate the uncertainty of the future and explore alternatives in a structured way. It can assist in medium- to long-term visioning and joint actions, amounting to mental time travel.

Global South

Geographically, the so-called Global South usually denotes Africa, Asia, Latin America and the Caribbean, and Oceania (excluding Australasia). The Global South includes a large and complex geography that has diverse energy landscapes, regulatory environments, and developmental challenges. Conceptually, the Global South can also be understood through the global networks and structures of power that are invented, maintained and re-created, and may influence political, economic as well as technological choices.

Innovation capability	The ability of an actor to innovate by using knowledge, skills and actor-networks forms its innovation capability. In this study, with empirical data on firms, thanks to them, a firm can identify new ideas and convert them into new or improved methods, processes, products, or services. They can be deployed with a specific technology and they are also of economic value.
Latecomer firm	A 'latecomer' firm is an entrepreneurial firm in search of new market opportunities. A latecomer firm aims to catch up with firms already at the global innovation or technological frontier. The origin of the term stems from literature on global development studies. Some firms from the Global South may face disadvantages due to their location outside of globally-leading innovation and technology hubs and related resources.
Lead market	Lead market denotes an environment, e.g. a country or a region, where pioneering economic actors help an innovation to be first widely accepted and adopted. As a term used in innovation theory, developments at lead markets may assist in a process of regional or global diffusion, and also provide a signal to laggard markets.
Leapfrogging	Leapfrogging denotes a firm that develops a radical innovation, which challenges incumbent firms. A leapfrogging nation, as a wider assumption, is assumed to bypass traditional stages of development, when it jumps to the latest technologies (by skipping stages); or it explores an alternative path of technological development, which involves emerging technologies, with new benefits and new opportunities (by creating a new path). In some analyses, only the market or technological aspects of leapfrogging are addressed.

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OF TURKU

ISBN 978-952-02-0728-1 (PRINT)
ISBN 978-952-02-0729-8 (PDF)
ISSN 2343-3159 (Print)
ISSN 2343-3167 (Online)

Painosalama, Turku, Finland 2026