THESIS FOR THE DEGREE OF LICENTIATE OF PHILOSOPHY

Where from and by whom?
Tracing academic and practitioner visions of energy systems change related to lower income countries

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Cover illustration: This image is intended to be illustrative. It is also perhaps provocative. It communicates this Licentiate Thesis's focus on how envisioning energy systems change is a political rather than neutral act. The image was produced with the AI programme "StarryAI" which produces images based on textual prompts. The textual prompts used for this image were "Envisioning the future, energy systems change, lower income countries, photo realistic". With these prompts, specific technologies take centre stage: somewhat warped yet unmistakeably solar PV and wind turbines. These technologies are enmeshed with the buildings in the image. No people are visible. The blue skies, verdant vegetation and sun conjure an optimistic atmosphere. Like what is studied in this Licentiate Thesis, this is a specific vision which foregrounds certain things from a certain perspective. In this case, the perspective from which this is envisioned is ambiguous and arguably problematic. It is the product of an algorithm which is opaque to the majority of users of this technology. While the provenance and implications of the image are troubling, the image conveys some of the central concerns which motivate this work.

Abstract

Dominant agendas of global sustainable development broadly emphasise the urgency of a transition towards an environmentally, socially and economically preferable future. Critical scholars have raised concerns that this transition either produces new environmental, social and economic problems or reproduces those problems of the present system. They call instead for more radical transformations, encapsulating both material change and epistemic pluralism in research related to this. Energy systems are a key domain in which these different conceptualisations of change are discussed. One critical area in which perspectives diverge regards the spatial aspects of how energy systems change is designed and implemented within and between countries. Where do, will or could the drivers of sociotechnical change stem from? Which places are expected to be more beneficiaries than generators of change, and what are the implications of this for ambitions of "sustainability"?

The answers to these questions, I argue, depend on how, and from where, these processes of change are envisioned. This licentiate thesis advances this inquiry by exploring how, from where, by whom and for whom energy systems change is envisioned related to lower income countries, with Rwanda as the principal country of focus. This broad landscape is explored through a synthesis of three articles which approach these questions using different theoretical approaches. These articles analyse processes of knowledge production at a global level. They also explore how energy systems change is envisioned by academics from diverse research traditions. They additionally examine actors seeking to facilitate or implement energy systems change at a national and subnational level. Together, my analysis shows that actors who are from, or based in, higher income countries are often envisioned as the principal architects of energy systems change. Common kinds of actors invoked include scientists, donors or private sector companies with an international footprint. Additionally, similar ideas are often articulated by actors who describe themselves as being from lower income countries. A prerequisite for the latter is however that they either are: (1) practitioners working for organisations headquartered in higher income countries, or (2) academics working with theory developed in higher income countries.

Alternatives to these visions exist. Such alternatives place a greater emphasis on the role of users as coproducers of change originating from whichever place is envisioned to benefit from change. This licentiate thesis therefore illustrates the need for both academics and practitioners – particularly those based in or from higher income countries and working in relation to lower income countries – to reflect carefully on how they envision the energy systems change which they participate in. This is to avoid locking in assumptions regarding who or what drives change, particularly when change is urgently demanded. I argue that such assumptions risk locking lower income countries such as Rwanda into global circuits of capital on an imbalanced footing. This may reproduce relationships of economic dependence and capital accumulation in higher income countries. The thesis concludes by reflecting where else this thesis may speak to, noting my own analytical focus on the geographic situatedness of knowledge making. I argue that this thesis may be relevant to other locations besides Rwanda (and perhaps even locations in higher income countries) which host encounters between globalised agendas of change emphasising urgency and scale and other possibilities which are more rooted in localised framings of problems and solutions.

Keywords: sociotechnical change, innovation, lower income countries, agency, directionality, spatiality, temporality, framing, sociotechnical imaginaries, knowledge politics

Foreword

Writing this licentiate thesis has been like trying to write a report for a football match while the game is still being played. My mind is full of ideas which are coming and going, stabilising and destabilising. Thus, this thesis is my half time analysis, to crudely extend the metaphor. It is the state of play. While I'm unsure precisely what conclusion this PhD project is heading towards– which is both thrilling and unnerving – this feels like a suitable time to reflect on where this project has come from.

Five years ago, I was still working as a Consultant in the UK on energy and climate change projects which sought to achieve sustainable development, working in both higher and lower income countries. I still have huge respect and admiration for many of the colleagues I worked with; and believe I was involved in some genuinely valuable projects. However, I also had a growing sense of unease and questions which I felt I needed to answer. Why was I – a British graduate of History and Politics in my mid-twenties working in countries I knew relatively little about – treated by both my employers and various public and private sector clients and stakeholders as a knowledgeable and influential authority on matters of energy, technology, climate change and "development"? What role was I playing, relative to the people and communities who were supposed to benefit and who were often far away from where I was usually based? Why did I meet these people so rarely when I was engaged in the process of designing solutions? And finally – both as a consultant and in my subsequent job as a climate policy analyst – why did people's eyes light up every time words such as "innovation" was mentioned? And why did they seem to have such a specific and narrow idea of what counts as "innovation" in relation to sustainability?

These questions are not novel or innately insightful. However, it would be remiss not to acknowledge them since they represent my own personal journey back into the world of academia, and directly frame what follows. I had been exposed to related questions and theories in my undergraduate and masters, pertaining to the legacy and ongoing effects of colonialism, as well the history of science, technology and innovation. These lay semi-dormant during the first 7 years of my professional career but came to the fore in periods of uncomfortable reflexivity: whether thinking to myself on a long bike ride or 6am chats at an afterparty. The first reaction they induced was a pivot away from working in relation to lower income countries and instead doing policy research specifically related to UK transitions towards net zero. This didn't answer the questions in my mind though. If anything, it made them louder. I saw parallels in how I was advising on decarbonisation on a broad scale from a detached positionality and through a specific frame. My decision to do a PhD is a product of these questions becoming so loud in my mind that I had no choice but to attempt to answer them.

My hope, rather than expectation, is that somehow these insights – or perhaps the conversations which have informed them - could be of value to actors in helping to ensure that a multitude of visions of energy systems change are recognised as possibilities. And furthermore, that visions which emphasise meaningful inclusivity of historically overlooked and excluded peoples are enacted.

Thank you to everyone who has supported me through this journey thus far. I reserve special mention to all of my ridiculous and amazing friends; to my wonderful family; to my lovely supervisors and examiner; to the people of Sweden for welcoming me to their country which has reminded me how beautiful the world is (despite my terrible Swedish language abilities); to the people of Rwanda – with gratitude to all of those I interviewed - for also welcoming me and reminding me that one can feel hopeful about humanity; and to the legendary Dalia, of course.

Contents

List of appended articles:

Article 1: Ali, M., Couto, L.C., Unsworth, S. Debnath, R. 2021. Bridging the divide in energy policy research: Empirical evidence from global collaborative networks. Energy Policy, Volume 173, 2023

Article 2: Unsworth, S., Ahlborg, H., Hellberg, S. Agency, directionality, location and the geographic situatedness of knowledge making: The politics of framing in innovation research on energy.

Earlier versions of this article have been presented at the SPRU PhD forum 2021 and the ERSS Conference 2022.

Article 3: Unsworth, S., Ahlborg, H., Hellberg, S. "Everything needs time" or "we don't have time": Contrasting sociotechnical imaginaries of energy systems change related to electricity and cooking services.

"If the location of innovation is Rwanda, it responds 100% to the problem. If it is grown outside of Rwanda; maybe it can solve some problems but not all of them. Whoever plans an innovation, plans it according to their own country".

- Respondent interviewed in Rwanda, March 2022

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1 Introduction

1.1 Background

Energy systems are currently subject to urgent calls for sociotechnical change, accompanied by visions of what this change could or should constitute. For example, UN Secretary General Antonio Guterres conjures an explicitly utopian vision by describing the global transformation of the energy system towards renewable energy as being "the peace plan of the 21st century" (UN News, 2022). While these demands for – and visions of – change at first glance may appear similar, they stem from different people and places from around the world and are highly heterogeneous. They are conceptualised from radically different worldviews and perspectives. How the present is perceived, what kind of future is envisioned, and who, what and where is evoked in the pathways towards these futures, differ across visions of change. They have vastly different implications for actors such as energy users. These calls and visions of change are geographically situated in different ways, stemming from different politico-institutional levels and extending across different scales of intended influence.

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Such calls and visions emanate most visibly from the so-called "global" scale (Newell & Bumpus, 2012), characterised by international agendas of sustainable development. This agenda is enshrined in the Sustainable Development Goals (UNGA, 2015) and the Paris Agreement (UNFCCC, 2015), both of which place the energy system at the forefront of narratives of transitions towards sustainability. These international agendas of change may have a strong conditioning effect on the national, subnational, transnational and corporate visions of energy systems change, although more localised agendas also co-exist alongside them.

Those who make demands for and design processes of change are often not those whom the processes of change are intended to affect. As alluded to above, when change is discussed at the academic, policy or corporate level these discussions tend to prescribe certain roles to certain categories of actors. For example, Kenis et al., (2016) note that energy users continue to primarily be imagined as end-consumers, as opposed to *agents* of change in the context of energy. Such a passive role may even be explicitly promoted by actors external to the location of change, with the intention of extracting value out of the location (Karanasios & Parker, 2018). Political discourse tends to place a strong emphasis on the importance of who is seen to be actively participating in a process, reflected by the common language of "stakeholders". However, this language also creates a contested space regarding what level of participation is considered appropriate for an actor holding some form of "stake" in any given process.

From a historical perspective, processes and outcomes resulting from changes in the energy system are demonstrably complex from the perspective of energy users, despite common assumptions that they benefit. Scholars have observed that the participation of citizens in the design of change has often happened in such a way which has closed down other possible pathways of change. This includes closing pathways which may be more closely aligned with citizens' actual needs and worldviews (Stirling, 2008). Empirical evidence has demonstrated how the arrival of renewable energy systems in specific locations has reproduced unequal relations of power; both between users and external intervention designers, and within communities of intended beneficiaries (Ahlborg, 2018). Political ecology work has sought to question the implicit narrative that the only thing which renewable energy (and the associated "clean", "green" or "sustainable" development agendas) will bring is benefits (Newell & Bumpus, 2012; Brock

et al., 2021; Knuth et al., 2022; McCarthy & Thatcher, 2019). These analyses point to the risk that processes of sociotechnical change do not deliver the kinds of futures which are desired *for* energy users by agendas of sustainable development; or *by* the energy users themselves.

These concerns regarding the local effects on individual users connect to more systemic concerns about what energy systems change might involve, and where it may head towards. Scholars have alleged that processes of sociotechnical change may enact coloniality by driving new forms of extractivism or paternalism: particularly when the spatial configuration of envisioned change envisions benefits for peoples in lower income countries, but locates drivers (Kumar, 2022), technologies (Mavhunga, 2017), profits (Coleman, 2019) or other aspects of the process in higher income countries.[1] To put it more simply; the risk is that sociotechnical change towards future energy systems reproduces the inequalities of previous systems on a macro scale. Nonetheless, there are also opportunities for energy systems change to redress these imbalances.

Sub-Saharan Africa is one part of the world where these risks and opportunities are playing out in real time. The region is composed of many lower income countries with huge unmet and growing demand for energy, but also composed of highly heterogeneous circumstances. Achieving universal energy access has been described as *the* central priority of the region by international observers (International Energy Agency, 2022). Many possible pathways exist for different countries, embodying different sociotechnical configurations which countries might aim for (e.g., more decentralised or centralised infrastructure, more emphasis on fossil fuels or renewables, greater focus on poverty alleviation or economic growth, to name but a few key variables). Ockwell & Byrne (2017) differentiate between "shallow" or "deeper" transformations of energy systems in the region. Shallow transformations might lead to provision of power without addressing underlying gender, class and rural-urban injustices. A deeper transformation of energy access, by contrast, requires the active participation of *all* kinds of actors, including users.

Ockwell & Byrne subsequently make two key points which motivate this Licentiate Thesis. First, they highlight the following phenomena in how change is currently conceptualised in the region:

"The idea of private sector entrepreneurs driving innovation and technological change in developing countries seems to have captured the imagination of international policy-makers and donors"
- (Ockwell & Byrne, 2017 p.9)

Secondly, they highlight the necessity of moving away from this rather singular narrative and open up to alternatives:

[1] Various terminologies have been used to categorise countries in the world into groups reflecting political, economic and social differences, such as the "Global North" and "Global South". I find these terms to be somewhat amorphous and to require encoded judgements regarding what constitutes "North" and "South". While I do work with these concepts at specific points in the thesis, on a general basis I prefer to work with a simple and concrete distinction between nation states as either lower or higher income. I define lower income countries to be "Low and Middle Income Countries" (LMICs) and higher income countries to be "High Income Countries" (HICs) as defined by the World Bank. While the notion of a binary geographic distinction between more and less "developed" places has been critiqued (Horner, 2020) I do find it necessary to somehow distinguish between places.

"Multiple framings, narratives and pathways are possible. Different groups of actors will interpret the world in different ways, interpretations arising from their own experiences, situations, understandings, values and interests. Favouring certain framings over others, they will seek to promote narratives that would help to create their preferred development pathways. Some narratives will be more dominant than others, perhaps because they are promoted by powerful actors, and are likely to become manifested in interventions. Other narratives remain marginalised, perhaps because they are promoted by groups who are themselves marginalised or powerless."
- (Ockwell & Byrne, 2017 p.12)

This Licentiate Thesis is guided by these reflections. It investigates how energy systems change is envisioned in lower income countries, with particular focus on Rwanda[2] as one country in Sub-Saharan Africa whose government is pursuing rapid and far-reaching energy systems change. I tentatively draw conclusions which may bear some relevance to other contexts which also experience external actors who are connected to global agendas participating in envisioning of change. I seek to set visions related to Rwanda as a nation state against a broader, porous and transnational landscape of actors envisioning and participating in energy systems change related to lower income countries. Through this, I seek to make a contribute towards the literature on transitions and transformations towards sustainability.

This licentiate thesis has a central focus on how change is envisioned. While I work with a number of theories and concepts which operationalise this focus, in navigating between these terms I use the terms "visions" and "envisioning" when speaking broadly, following the basic definition of a vision as "an idea or mental image of something" and envisioning as "to imagine or expect something to happen, appear, etc. in a particular way" (Cambridge Dictionary, 2023). I then consider the academic concepts I use, such as sociotechnical imaginaries and framings, to be specific kinds of either individual or shared visions. Imagining and framing are similarly specific ways of envisioning change. In article 2 I focus more on envisioning as a process, and in article 3 I focus more on the possible contents of shared visions. Similarly, "spatiality" is another central focus of this Thesis. I use this term to refer broadly to spatial aspects of how change is conceptualised. Within this broad category of spatiality, the Thesis also works with more precise terms. "Location" refers to locations associated with envisioned activities (e.g. innovation happening in Kigali). "Geographic situatedness of knowledge making" refers instead to the onto-epistemological situatedness of where actors and scholarship speak from and to.

1.2 Research concern and gap

Broad research concern

This research departs from a concern about how socio-material stocks and flows of technology, finance and knowledge are understood to play a role in energy systems change related to lower income countries. These stocks and flows are imbalanced. For example, material assets are concentrated primarily in higher income countries, while flows into countries in Sub-Saharan Africa remain small (Braiton & Odhiambo, 2022). Scholars have demonstrated that academic knowledge production is set against a context of historic dominance by indexed journals and higher income countries (Amarante et al.,2021; Chelwa, 2021). Furthermore, the top 10 countries in the world considered "most innovative"

[2] See section 4.1 for a motivation of why this thesis has a particular focus on Rwanda.

from a technological perspective by globally recognised indicators are all higher income countries (WIPO, 2022).

In a socio-material understanding, material stocks and flows cannot be disentangled from how stocks and flows are envisioned by actors, despite a distinction often being made related to what is considered measurable. Visions of system dynamics include perceptions related to aspects such as:

- Which places are dependent on others for financial support and why (Dos Santos, 1970)
- Where in the world "experts" are located, and who thus requires education (Nightingale, 2005)
- Who and where in the world "makes" technology, and who and where receives it (Mavhunga, 2017)

All of this is set against the broader context of colonialist extraction and repatriation of value from lower to higher income countries. Thus, a central concern cutting through this research regards the assumed positive effects of technology-enabled energy systems change; and where financial capital stocks may accumulate; and what relationships of dependency may be (re)established between actors and places as a result of sociotechnical transformations (Baker, 2022).

But how to operationalise this broad concern? To do this, I focus on unpacking the kinds of visions described above, on the assumption that they have potential to affect material energy systems change. Academics have put forward various tools to help unpack these visions, such as "framing" (Wolsink, 2020) and "sociotechnical imaginaries" (Jasanoff & Kim, 2015) which this licentiate thesis works with. Literature on framing has focused more on frames perceptible in academic, policy and media documents, whereas imaginaries also consider performative actions and discussion. However, there are notable gaps in these literatures on how visions are analysed.

Research gaps

The specific research gaps which this licentiate thesis seeks to fill are twofold. The first relates to from whom – and based where - produces visions and who or where these are intended for. The second relates to the conditions by which some visions come to dominate others.

Firstly, academic discussion of the concepts of "framing" and "imaginaries" in the literature on sustainability transitions and transformations has been largely limited to imaginaries which speak from and to higher income country contexts. The spatial focus of literature is more on the locational contents of these visions (e.g. which places are foregrounded) rather than their geographic situatedness in terms of by whom and from where they are produced. The existing literature on framing related to energy focuses more on thematic aspects of framing (e.g "smart grids") rather than unpacking the provenance of these frames including where they are framed from. The conclusions of this literature either implies that the frames described could apply anywhere (Wolsink, 2020) or that they apply to the same place which they are framed from (e.g. visions from and to higher income countries). The literature on imaginaries has paid more attention to lower income country contexts (see for example Delina, 2018) but similarly tends to study imaginaries from and to the same nation state. Simmet (2018) is a notable exception in examining how international agendas condition imaginaries of change held by local actors in Senegal, and provides an example which I seek to build upon.

The gap I therefore contribute towards filling relates to better understanding who is envisioning change related to a specific location and how is this vision geographically situated. This is intended to complement existing scholarly efforts to unpack the contents of visions in the literature on imaginaries and framing. I believe this has instrumental potential in making the politics between visions explicit and shaping which visions are materially performed. Through this, I seek to build academic understanding regarding how precisely processes of change are envisioned: particularly how alternative and perhaps marginal visions relate to the material change which happens. I thus seek to join the small but growing body of literature which investigates the technologies, actors and places that come into – and more importantly out of – view when change is the focus of analysis (Ockwell & Byrne, 2017; Priebe et al., 2021; Kumar, 2022).

Secondly, research on framings and imaginaries has focused primarily on describing the differences between visions, analysing which may be more or less dominant and why (see for example Ballo, 2015; Levenda et al.,2019). There has been comparatively less focus on examining the conditions under which certain visions emerge – and the role of academic knowledge in particular – beyond explaining that certain visions are associated with certain groups (Longhurst & Chilvers, 2019). In this thesis, I focus on how flows of academic knowledge production combined with the enduring presence of donor financiers and other "international" actors in lower income countries may condition the energy systems change which is envisioned. I then seek to connect this analysis of academic knowledge flows with analysis of the empirical characteristics of these visions: what locations, actors, temporalities and directions are put forward. I do not causally claim that specific visions always crystallise under certain conditions. However, I believe contextualising visions of change with evidence of socio-material flows of knowledge, technology, finance may help to provide insights regarding why some visions are more dominant than others.

2 Research design

2.1 Research objective

I seek to address hese gaps by characterising visions of energy systems change focused *on* (but not necessarily *coming from*) lower income countries. I aim to geographically situate *where* framings and imaginaries of energy systems change in lower income countries stem from. Within this, I aim to indicate the specific ways in which envisioning processes may make assumptions about how change can happen, including when change is envisioned from an external perspective. In doing so I hope to avoid onto-epistemological lock-ins regarding how energy systems change is conceptualised, and instead contribute towards answering calls to make space for more pluralistic possible change pathways. I seek to do this in a manner which takes an open perspective regarding the possible roles which could be played by domestic energy users in lower income countries, while noting the limits on this imposed by my positionality as an academic based in a higher income country.

The final aspect of my aim is to make a link between visions of energy systems change in lower income countries, and discussions of the geographic situatedness of knowledgemaking. This helps us to explicitly highlight the ongoing role played by locationally external actors in producing academic knowledge; knowledge that both frames problems and solutions alongside other inputs to wider sociotechnical imaginaries of energy systems change.

2.2 Research questions

In order to achieve this broad objective, I organise my research around the following questions:

1. Who produces and funds academic knowledge related to energy systems in lower income countries and what are the implications of this from a knowledge politics perspective?

2. What are the characteristics of energy systems change envisioned by scholarship which uses the concept of innovation?

3. What are the characteristics of energy systems change envisioned by actors who seek to implement this change in lower income countries?

4. Who is envisioned to act as architects of energy systems change affecting energy users in lower income countries? Who envisions them as architects and what are the implications of this?

It is notable that these questions are predominantly questions which relate to the characteristics of visions, and by whom and from where they are envisioned. This reflects the strong focus at this stage in my PhD project on the kinds of actor that participate in visioning, and where they are located. I have less focus on *how* these visions are materially enacted for example, or *why* some visions seem more dominant than others; these are questions which may inform the remainder of my PhD.

2.3 Scope

The scope of this licentiate thesis is bounded in several ways, to keep this work manageable and to reflect the incomplete and ongoing nature of this project. Firstly, the work is set against a context of recognising many socio-material stocks and flows of technology, knowledge and finance, amongst many other factors which influence how energy systems change is conceptualised and enacted. However, in this licentiate, I foreground certain flows and place others in the analytical background. Thus, I seek to be reflexive over my own scholarly act of framing, making explicit my values and motivations for this specific research framing in the same way that I analyse others, drawing on the ideas of boundary critique (Ulrich & Reynolds, 2020). My analytical interest is specifically in a) the flows and characteristics of academic knowledge which condition visions (covered in RQ1) and b) how precisely change is envisioned within academic articles as well as in Rwanda's energy sector (covered in RQ2 and 3).

Similarly, I could look to other communities of actors for both knowledge and visions of energy systems change. However, I focus specifically on academic knowledge published in indexed journals by scholars, and on actors who present themselves as *implementers* or *facilitators* of energy systems change. Thus, this licentiate has a clear focus on actors who are to varying degrees elite, relative to the majority of energy users in lower income countries. I seek to understand how different actors envision the role of users, but at this stage in the PhD project I do not directly seek to analyse vision stemming from the users themselves.

The thesis operates at different spatial scales. The scope considers geographically situated knowledge about – and visions of – energy systems change which could be understood to somehow be relevant to energy users in Rwanda. Some of the analysis has a much less granular focus, such as article 1's study of academic knowledge production related to all lower income countries. Similarly, article 2 does not speak directly to Rwanda, but rather looks across countries with specific attention paid to sub-Saharan Africa. However, I interpret much academic work, studying the USA and Europe for example, as making claims to generalisability and thus could well be utilised to shape energy systems change in Rwanda. In the spirit of symmetry, I thus make the claim that Rwanda is at least equally as valid a location to theorise change and innovation from as higher income countries. Furthermore, I argue that more theorizing related to lower income countries could be valuable considering the historical imbalance of evidence which favours higher income countries. While article 3 does have an explicit locational focus on Rwanda, actors seeking to implement change in Rwanda may be – and often are – situated outside Rwanda. Thus the scope is shifting, dynamic and not always adhering to nation state boundaries.

While some elements of my research related to Rwanda may generate comparable and generalizable insights, care should be taken in considering which elements of this research travel well and which details are more contextually specific. For example, the details of the imaginaries themselves are strongly contextualised in Rwanda's social, cultural, political and geographic context. What may have wider relevance is the dynamics through which the imaginaries close down some pathways and open up others. These dynamics are particularly important to recognise when the pathways connect to international agendas of sustainable development, since these agendas heavily condition visions in many other countries.

The thesis is bounded temporally to relate primarily to visions of energy systems change which are either forward or backward-looking but that relate to the comparatively near term, i.e. up to roughly

15 years into the past or future. This means that the analysis has a strong orientation towards contemporary concerns regarding sustainability. In article 1, studies which are included in the bibliometric scope may extend much further into the future or past. However, we do not engage with the empirics of any individual study in this article. Instead, the focus is more on their contemporaneity as scholarly objects (most papers were published in the last 15 years). In article 2 we study a mix of forward and backward-looking scholarship, but none have an explicit empirical focus on the deeper past or future (e.g. 20 or more years from the present). In article 3 we frame the analysis in relation to the 2024 targets, making the primary focus of the paper forward-looking. However, relatively near-term historical events do come into view as constitutive of desired futures, and some respondents do elaborate visions which extend towards unspecified points in the future.

RQs 2 and 3 both refer to the characteristics of energy systems change. Change can be characterised and analysed in plural ways. Innovation is a critical term which is commonly used to describe novelty and it is central to the sustainability transitions literature. However as discussed in article 2, I find that when innovation is used by academics and practitioners, it often carries encoded assumptions such as who practices innovation, where it happens and why. I therefore prefer to use the term “change” for my own analysis and choose to study innovation as a concept in article 2 to unpack these different connotations. When I do refer to innovation in this thesis, I adopt a broad understanding which is effectively synonymous with change. Other key concepts used to characterise change by which I tease out differences between visions and academic knowledge of energy systems change are spatiality (comprised of geographic situatedness of knowledge making and locations of innovation), agency, temporality, and directionality of innovation. These concepts are a good fit given my intention to speak to the literature on transitions and transformations to sustainability.

Finally, the technological scope of the thesis is broad and I do not specify the relevance of certain technologies above others. However, my orientation towards energy users in Rwanda means that I am interested in technologies which somehow affect users directly. These are typically closer to demand and final consumption than primary energy production. This distinction is sometimes porous though, recognising that some of technologies used by energy users in lower income countries (such as Solar Home Systems) both produce energy and provide the means to consume it as well.

3 Theory

3.1 The theoretical foundations I speak from

This licentiate thesis is situated at the interface between a number of theoretical domains. The starting point from a theoretical perspective has been a focus on the politics of knowledge, stemming from two somewhat related academic traditions.

The first is that of Science and Technology Studies (STS). This longstanding academic tradition holds that scientific knowledge and technological applications are always situated (Haraway, 1988; Rose, 1997) and "agents of political production" (Jasanoff, 2011 p.12) despite the common presentation of knowledge as universal, neutral and objective (Grosfuguel, 2011). A central insight from the literature is that the theoretical positions and methodological approaches adopted by scientists and researchers are constituted by – and reproduce – practices and beliefs about how the world works and the role of different groups in it (Jones, 2015; Marttinen, 2015; Merchant, 1990).

The second academic tradition which this thesis is guided by is the work of post- and decolonial scholars who have shown how worldviews stemming from actors in typically higher income countries have come to dominate and drive complex effects across many aspects of society (Mbembe, 1992; Fanon, 2002). Scholars have demonstrated the worldmaking effects of the implicit Eurocentrism in much knowledge making (Said, 1978), particularly in the domain of science and technology (Mavhunga, 2017). Asymmetrical power relations are understood to structure processes of knowledge production, such that recognised knowledge producers often have an "outsider" positionality, with a marginalising effect on "insider" knowledges such as that of indigenous peoples (Elabor-Idemudia, 2011). These post- and decolonial perspectives connect to critiques of neoliberalism and its construction of hierarchies of knowledges, delegitimising the localised and situated knowledges of highly informed resource users (Nightingale, 2005).

Noting this constructed and contested nature of knowledge, I focus on the ontological dimensions of knowledges and their productive qualities in shaping the world we live in (Baert & Rubio, 2011). This is reflected by my usage of the language of socio-material entanglements, which breaks down distinctions between human perception, social relations and the "material" or "technical" (Hultin, 2019). I follow a relational and performative socio-material approach. For example, this enables me to conceptualise technologies related to energy systems change not simply as material artefacts, but rather as embodying aspects of the designer's world view and visions for intended use and impact. Technologies can additionally embody the conditions under which they were designed, such as the perspectives of those who financed it. This socio-material perspective strongly connects to the STS concept of coproduction, in which material and social work is constantly coproduced and cannot be disentangled from each other (Jasanoff, 2004).

As a broad lens, a knowledge politics frame is not a call to dismantle or discredit knowledges around which there may be substantial consensus. Rather, it encourages careful reflection around the logics which underpin research and its world-making effects (Bellacasa, 2011). This can shape how problems and solutions are conceptualised and is subject to the same power relations as the rest of the world.

A final note in terms of theoretically orienting the research is to acknowledge the role of political ecology as a source of inspiration. Political ecology research focused on energy is growing as a research domain. This research is highly instructive in placing an explicit focus on critical theory and showcasing unequal power relations which have a conditioning effect on visions and enactments of sociotechnical change (see for example Newell & Bumpus, 2012; Brock et al., 2021). This serves as a reminder to us that visions, frames and imaginaries play an active role in the unequal distribution of costs and benefits of change (Rodríguez-Labajos, & Martínez-Alier, 2015). The literature also highlights possible naivety in the sustainability transitions literature (a related but distinct field from political ecology) in undervaluing the significance of spatiality and the role of elite actors (Lawhon & Murphy, 2011).

3.2 Innovation and transitions or transformations towards "sustainability" as the literature I speak towards

While these are the theoretical perspectives this licentiate thesis speaks from – and thus hopes to contribute towards – the literature speaks towards the Sustainability "Transitions" and "transformations" literatures mentioned above. I use these terms on an overarching basis, recognising that the term 'transitions' is contested. For some scholars it connotes excessive stability of regimes, institutions and networks, with "transformations towards sustainability" preferred (Beck et al., 2021). What these literatures have in common is a focus on some kind of structural or systemic change, as opposed to change of any kind (Geels, 2002).

Similarly, I also connect to academic discussions of innovation and sociotechnical change which relate to processes through which transformations take place. However, as with transitions and transformations, innovation is often imbued with – and heavily connotes – desirable characteristics of change (Godin, 2015; Andersson & Törnberg, 2018). For many, speaking of innovation as driving change conjures visions of certain actors and processes and casts others in the background, hence my preference to work with the broader term "change" in this thesis.

The qualities and politics of "sustainability" are another domain this licentiate thesis seeks to contribute towards. The term sustainability is commonly associated with normative agendas of "sustainable development" grounded in the logic of various international statements and agreements such as the 1972 Stockholm Declaration and the 1987 Brundtland Report (Sovacool & Hess, 2017) and more recently the Sustainable Development Goals. Following my focus on visioning, I understand sustainability to relate to a vision of a somehow desirable future, which is contested and strongly connected to how different actors perceive the world. However I believe that the idea of sustainability, like innovation, is itself contested (Rose & Cachelin, 2018), and the directionalities associated with framings and imaginaries of change often include embedded perspectives on what counts as sustainability.

3.3 Unpacking visions of energy systems change through frames and sociotechnical imaginaries

This licentiate thesis places a focus on how energy systems change is envisioned. I use the terminology of "visions" to refer broadly to how different actors (e.g. the private sector) and "actants"[3] (e.g.

[3] Given my position of recognising socio-materiality, we believe seemingly apolitical artefacts can be thought of as actants that 'do' things and are enrolled in politics (Law & Singleton, 2013; Akrich & Latour, 1992) through being encoded in different ways and with different things.

academic articles) envision this change process. There are several approaches which relate somehow to visions of change: e.g. discourses, pathways, scenarios, leitbilder and futuribles. These examples are all derived primarily from scholars working in higher income countries. These concepts may consequently frame the analysis in a certain way, pointing to my own positionality as a European scholar. Somewhat relatedly – although more focused on explanations of historic rather than future change – the Subaltern School of thought has sought to reveal the colonial construction of hierarchical categorisations of actors which locate agency amongst those in higher rather than lower income countries (Moosavi, 2020). A long history of scholarship has worked against higher income country-derived narratives as the most authoritative explanatory visions, advocating instead for recognition of the agency of marginalised people. A central argument is that marginalised peoples across the world should be given the opportunity to provide their own visions of history, visions that may very well differ from higher income country-centred perspectives (Guha, 2013). Moosavi concludes that "For Guha, Mohanty, Spivak and others in the Subaltern School, intellectual decolonisation must involve redressing the failure to properly include voices from beyond the Global North, especially the voices of non-elite people" (Moosavi, 2020 p.338). These insights are valuable in bringing an explicit politics of exclusion to discussions of how (and by whom) change is envisioned.

I work with two main concepts in order to unpack visions of energy systems change: framing and sociotechnical imaginaries. Framing has a long conceptual history, associated originally with how ideologies and domains such as the media organise reality in a certain way (Barthe et al., 2022). Framing understood in the basic sense is not so much an academic theory so much as an intuitive concept. Like taking a photograph, one can frame an issue by freezing a situation, viewing it from a certain perspective and including some things in the picture and not others (Devereux, 2007). This basic notion of framing has subsequently been connected to theoretical discussions by considering how theorizing as well as non-academic methods of sensemaking frame the world in a certain way. Framing becomes a way of navigating (and often reducing) extreme complexity to a specific conceptualisation (Chong & Druckman, 2007). Acknowledging framing leads to an appreciation that issues can be viewed from a huge range of possible perspectives. Of particular relevance is how framings enable actors to make shortcuts and reach evaluations of issues, or views on pathways forward, despite having limited, incomplete or non-existent knowledge related to them (Chong & Druckman, 2007). Framing has been linked to the STS concept of problematisation; the process of how (and by whom) a problem is defined in a given situation, including definition of causes and possible pathways forward (Barthe et al., 2022).

In the energy domain, scholars have begun to demonstrate how various "frames" related to renewable energy exist which frame desirable change processes and embed assumptions and encoded knowledges about technologies. These frames are often used by scholars in seemingly apolitical technology-focused academic articles. For example, articles which describe smart grids as "smart" necessarily frame alternatives as not smart (Wolsink, 2020). Another example is the inclusion of the commonly used term "flexibility" for the demand side (often used by system developers), effectively demanding that electricity users accept less flexibility from their perspective (Fjellså et al., 2021).

A second concept I work with in this licentiate thesis is sociotechnical imaginaries. This concept stems from the Science and Technology Studies literature and seeks to unravel the various components which constitute forward-looking visions of the future transitions (Jasanoff & Simmet, 2021). From the specific perspective of this licentiate thesis, STI embody the concept of socio-material entanglement described

above by drawing "attention to the entanglement of the materiality of complex sociotechnical projects with the normative aspects of collective imaginations of states of society" (Beck et al., 2021 p.145). Sociotechnical imaginaries are one such tool to analyse envisioned flows of technology, knowledge and finance. The focus on imaginaries means no binary line is drawn between whether flows are real or perceived; imaginaries have performative potential to be enacted in flows of technological artefacts. Beck et al. also emphasise the importance of stabilisation of imaginaries through public performance. Thus, my research seeks to explore how imaginaries of energy systems change come about, and why some imaginaries are performed to a greater extent than others. This indicates the possibility of positive feedback loops between certain imaginaries and materiality.

In this licentiate thesis, I draw on both of these concepts for different forms of analysis. I use framing to unpack how academic articles conceptualise energy systems change, perceiving each article as an actant (Akrich & Latour, 1992; Law & Singleton, 2013). This allows me to illustrate how articles frame things in a certain way and thus envision change, reflective of the authors' world views at that point in time. I then work with sociotechnical imaginaries to navigate the combined worldviews and visions stemming from actors seeking to actively *implement* energy systems change and consider the relation of these imaginaries with what is materially enacted. Together, these conceptual tools enable me to maintain an explicit focus on "the politics at play in the collective imagining of sustainability transformations" (Beck et al., 2021).

3.4 Categories of analysis for differentiating between visions of energy systems change

I unpack and analyse visions of change and processes of envisioning using the concepts of agency, spatiality, temporality and directionality. Contrasting visions of energy systems change engage with these concepts in different ways, making them useful analytical tools.

Agency has become a central category of analysis in discussions of transitions and transformations towards sustainability (Pesch, 2015; Fische & Newig, 2016; Huttunen, 2021). Agency has traditionally been contrasted with structure; and is used to describe actors with the capacity to affect change. The transitions literature has been critiqued for it focus on structural aspects (most notably in the commonly used transitions theory the Multi-Level Perspective, see for example Lepoutre & Oguntoye, 2018). It has been argued to overlook actor agency in change processes, and when agency is emphasised it tends to foreground actors envisioned to be acting in a perceived "niche" and has tended to overlook actors such as domestic users (Pesch, 2015); although one should note that users of various kinds (e.g. from domestic energy users to industrial users) *can* be conceptualised as niche actors. Related to this, critical scholars have argued that energy scholars have also tended to overlook subaltern actors and domains of informality as agential, reflecting epistemological Eurocentric bias (Kumar, 2022). Thus, scholars attribute different degrees of agency to different kinds of actor. Some actors are envisioned as unable to enact change in a certain context, whereas others are able to. As Beck et al. (2021 p.147) explain, it becomes "possible to consider the negotiation of agency within broader horizons of possibility offered by sociotechnical change; that is, to see how people's agency is imagined as opened up or constrained by global and local imaginaries". This Licentiate Thesis is particularly interested in how contrasting visions attribute varying degrees of agency to different actors.

Spatiality – understood here as how conceptualizations of change engage with locations and are shaped by their geographic situated – has become a major theme in transitions (Coenen & Truffer, 2012;

Coenen et al., 2012; Truffer et al., 2015). I follow the guidance of Bridge (2018) to understand location as not merely the "absolute location" of an event but rather to consider both the locations associated with logics of change as well as the scales at which change is envisioned. This includes interactions between "global" governance regimes and the "local"; noting for example that opportunistic actors can represent "local" interests at global levels and vice versa (Newell & Bumpus, 2012). Furthermore, relating back to my focus on knowledge politics, I also consider the onto-epistemological geographic situatedness of perspective from which actors speak from and to (Sugiharto, 2022). The perspective from which one speaks is situated in multiple ways (Collins, 2000) but in this article we foreground situatedness primarily in geographic terms. "Speaking from" can thus comprise both the location of research practice as well as the provenance of the academic logics, frameworks and methods used (Sugiharto, 2020). With regard to which places research speaks towards, scholars have also problematised the tendency in academia to make generalizable knowledge claims (Grosfoguel, 2007) and have demonstrated how powerful interests limit the extent of knowledge claims which can be made by those somehow "outsiders" to dominant knowledge production (Collins, 2000).

Directionality, understood here as the possible directions associated with change, has a long conceptual history in discussions of technological pathways (Lovins, 1976; Stirling, 2008) and is now a central category of analysis in transitions and transformations towards sustainability (Trischler et al., 2022; Kanger & Schot, 2019; Köhler et al., 2019). Scholars have alleged that discussions of directionality constitute a contested discursive space which imposes constraints and boundaries on possible future systems in terms of their possible shapes and configurations (Andersson et al., 2021). This connects strongly to my focus on STI; that conceptualisations of change typically include some forms of expected or desired outcomes, or concerns about less desirable possibilities. While this is primarily a forward-looking concern, framings and STI can also condition where change processes are envisioned to originate from, including interpretation of past events.

Temporality is the final category of difference by which I navigate visions of energy systems change. I understand this to refer to the implied pace – often described in terms of "urgency" (Kumar, 2022) – of energy systems change in different visions (Bellacasa, 2011). It additionally includes locating the relative importance of time and envisioned pasts, presents and futures in frames and visions of change, including perceptions of the permanence and transience (Simone, 2020) of actors and processes.

4 Methodology

4.1 Project context

I receive funding for my PhD through the internal Chalmers initiative GENIE (Chalmers, 2023). I have received no substantive external direction in terms of where and upon what I focus my research besides conversations with my supervisors. Much of my research in this Licentiate Thesis looks across geographies. This project has however always been intended to relate particularly to Rwanda as a country.

There are two main reasons for this. The first is that as a PhD student at Chalmers I am connected to a wider research programme which bridges Chalmers with the University of Rwanda (UR). This is composed of several PhD students, postdoctoral researchers and faculty members in both countries collaborating on energy research. My main supervisor plays a central role in these ongoing collaborations. It is through these collaborations that I have come to be involved at the Innovation Hub at UR's African Centre of Excellence in Energy for Sustainable Development as an advisor. As part of this, I helped to organise the University of Rwanda's inaugural Innovation Week in early 2022 in Kigali, meaning my role in relation to the Innovation Hub is a key aspect of my public profile in Kigali. The second reason is that, in my previous work as a consultant I visited Rwanda on multiple occasions, so I have some degree of familiarity with the country and reasonably solid networks in the public and private energy sector.

Nonetheless, this is not a project "about" Rwanda as a country in the sense of an empirical scope, and the research does not seek to instruct Rwandan people *about* Rwanda. One could imagine a project equivalent to mine asking research questions of a similar nature related to a different country. It is more that my own positionality and networks make Rwanda an interesting place to connect to my research design. Nonetheless, Rwanda has a unique national context and a government with ambitions for rapid energy systems change which connect strongly to global agendas of sustainable development. I also acknowledge that Rwanda's political context and public debate is strongly dominated by the ruling party in Government (Beswick, 2010; Ngcayisa, 2021; McDoom, 2022), contributing towards a strong top-down vision of energy systems change.

4.2 Methods

I employ a variety of methods in this licentiate. These are summarised briefly below, along with the rationale for choosing these methods.

For article 1, the primary research methods are quantitative regression analysis (Figures 4, 5 and 6 of article 1), network analysis (Figure 7 of article 1), literature review (Section 2 of article 1), and qualitative reflexive analysis of possible research processes and configurations, based on the analysis and the authors' own experiences (Table 3 and Figure 10 of article 1). The bibliometric data we work with includes over 6000 published academic articles which relate somehow to energy in lower income countries. My involvement was primarily in the literature review and qualitative reflexive analysis described above including developing Table 3 and Figure 10 of article 1, as well as analysing the quantitative results and framing the academic discussions which the analysis speaks towards. The core quantitative method was chosen prior to my involvement in the article, since two of my co-authors

conducted an early version of this quantitative analysis independently. Thus, it has been a valuable learning experience to connect this kind of econometric research to my own interest in critical theory. A key aspect of my role in the writing team was to discuss the implications of our methodological decision to work with quantitative econometric methods and how this erases some of the nuances in the data (e.g. related to author positionality).

For article 2, the primary research method is integrative literature review. We purposively sample a range of literatures known to engage with the concept of innovation, including scholarship from economics, sustainability transitions and decolonial thinking. To do this, we identified 88 articles which engage with the concept of innovation in the domain of energy. Our strategy for article selection uses keyword searches, ranking searches by publication date and citations and reading of abstracts to check that an understanding of innovation plays a substantive role in the article. This sought to bring together a combination of "seminal" articles along with newer or niche perspectives, relating to a variety of theoretical approaches towards innovation as well as being a geographically broad sample. We then structure the literature sample around categories of analysis by which the articles differ: agency, spatiality and directionality, as well as investigating how the articles are situated onto-epistemologically. This research method was selected at the outset of my PhD, primarily as a way of enabling me to learn about a broad range of approaches to innovation. However, alongside this pedagogical exercise, I also wanted the review to make a conceptual contribution by envisaging academic articles not only as knowledge sources but also as data and actants which reproduce certain framings of innovation.

For article 3, the primary research method is semi-structured interviews. 62 separate interviews were conducted, the majority of which took place in Rwanda in February – April 2022. These interviews included national government, district government, educational institutions, finance institutions, intergovernmental organisations, funds and programmes, private companies and non-profit organisations. These actors were selected via purposive sampling since they presented themselves as either facilitating or implementing energy systems change in Rwanda. While many of these imaginaries are Rwanda nationals, many of the organisations interviewed have an international footprint or employ foreign workers, meaning the spatial footprint of these imaginaries stretches beyond the national borders of Rwanda. We as the author team selected these methods to enable me to spend time in, and gather data related to, Rwanda. This acts as a complement to the entirely desk-based nature of the first two articles while avoiding me going directly to engaging with energy users, which may have been problematic given my lack of embeddedness in Rwanda and experience and lack of academic networks for collaboration.

The orientation of respondents towards Kigali, reflecting a strong rural-urban dichotomy which I identify in article 3, also conditioned my own experience of data gathering. The majority of my interviews took place in cafes, restaurants and hotel bars which would have been economically inaccessible to the majority of energy users in Rwanda. This has advantages, in that it helped me to occupy an analytical vantage point as alongside the actors I study who envision energy systems change. However, it also points to the fact that my research should not be considered an exhaustive account of everything that is happening in relation to energy systems change in Rwanda. Article 3 is the tip of an

iceberg[4]. This furthers the importance of me avoiding drawing prescriptive or general conclusions about how things are materially within Rwanda, let alone how things should or should not be (Rutazibwa, 2014).

4.3 My positionality and knowledge making

From the beginning of my PhD, discussions of positionality have been central to my research design. These began primarily as a matter of concern on a personal level, related to my interest in decolonial theory. This speaks to an underlying likelihood that my research unintentionally reproduces aspects of coloniality in academic research practice (Marchais et al., 2020) by establishing me as a knowledgeable authority *on* lower income countries, meaning I extract value and benefit more than those I write about. Over time, I have however moved away from a binary understanding that me doing research equates simplistically to coloniality. Some elements of my work have an undeniably colonial character, related to my identity. I am nonetheless endeavouring to practice care and reflexivity in how I practice research. How I engage with actors, for example; which theoretical perspectives I work with; what kinds of evidence I produce; and which audiences it is appropriate for me to speak to.

My interest in discussions of positionality is both a point of self-reflection for my own processes of knowledge production but also a topic of intellectual relevance to my research, pertaining to the politics between knowledges on energy systems change. A central idea here has been Soedirgo & Glas's (2020) discussion of how positionality is dynamic and shifts, requiring active and ongoing reflexivity. My shifting positionality is distilled in different ways in each of the articles I have written in this Licentiate Thesis, each capturing a specific point in time. This bears similarities to how I characterise the articles of others as actants in article 3.

My identity is that of a white, European male researcher who cannot speak Kinyarwanda apart from basic greetings. This marks me out on a fundamental level as an "outsider" from the lived reality of most energy users in lower income countries such as Rwanda. However, I do have some "insider" characteristics when one considers that my object of study is not energy users themselves, but rather the community of actors who envision the role of users in energy systems change. My seven previous years of working on energy, climate and other themes, in Rwanda amongst other countries, have given me a professional identity as part of this transient and transnational "expert" community. One could argue that claiming a kind of insider status in relation to Rwanda, as a European, has colonial overtones. While I would not entirely disagree with this – I seek to acknowledge how I gain privilege by coloniality and am complicit in its enduring structures (Moosavi, 2020) – it nonetheless reflects the material composition of the international climate, energy and development workforce which I study.

Drawing these aspects together gives me a complex and shifting positionality which oscillates between insider and outsider (Dywer & Buckle, 2009). This oscillation depends on at least a) the communities which I am orienting myself in relation to (which includes both those I study and those I engage with academically) and b) which aspects of my identity I present at any point in time. In article 1, we draw a binary divide between countries in our research design. This renders us clear "insiders" to the dominant higher income country-based energy academic community which we critique from within, and

[4] This relates to the idea of "dark innovation" elucidated by Martin (2016) – that we only see a very small portion of what happens as academics, based on what one casts an analytical lens upon.

outsiders to the lower income country-based scholarly communities which we seek to advocate for in our analysis. I also occupy a shared positionality with my co-authors, all of whom are members of the international diaspora, based at institutions in higher income countries and coming from Brazil, India and Sudan. In article 2, we are "insiders" to the critical academic community seeking to problematise innovation, with an implicit suspicion of more positivistic understandings of innovation (which in this context becomes an "outsider" positionality). In article 3 our positionality is more ambiguous and shifting, more rooted in my own identity as the lead author doing fieldwork in Rwanda. I am much more outsider than insider to most actors I engage with in Rwanda, but as mentioned above I do nonetheless possess insider characteristics through my connections to organisations with an international footprint working in Rwanda.

While I primarily reflect over positionality geographically, given my aforementioned concerns about reproducing colonialist methods of knowledge production, I am also a temporal "insider". I am not studying the distant past or future which I have no direct connection to. This has clear benefits since I have opportunities to interact with and to some extent immerse myself in the phenomena I study. It does nonetheless come with drawbacks. I am likely to be subjected to my own bounded rationality and myopia in terms of what I focus on, lacking for example a longer-term perspective on the processes of change which are under way. My analysis, while discussing change as dynamic, is itself a snapshot in time, taken from *within* this time. I thus do not assume the positionality either of the all-knowing outsider from a "cockpit" perspective (Stirling, 2019) or as a pure insider amongst those I study. Across spatial and temporal dimensions, this research aspires – rather than claims – to be undertaken from what Stirling (2019) describes as an analytical "worms eye view". I am entangled with what I study and view it from a certain positionality. This positionality is in turn shifting over time and varies in how proximal it is to what I study.

This constant shifting of positionality, combined with my concerns regarding coloniality, can lead to a kind of epistemological motion sickness. I have thus sought to render this process explicit and reflect on it on an ongoing basis. In line with the guidance of Soedirgo & Glas (2020), I have been recording my experiences in a diary tracking the traces I feel have been left by my PhD since October 2020. I have sought to utilise this as an accountability mechanism by making an entry every 1 - 3 months on what has happened, what challenges I have encountered, and what needs to change. To date I feel it has however acted more as a space for retrospective reflection rather than driving changes in my own behaviours. As Soedirgo & Glas note, it is much easier to acknowledge the complexities of positionality than to ensure that one's research design dynamically shifts in tandem with one's positionality.

4.4 Implications of my positionality for my research

Rutazibwa (2014) explores what knowledge production on Rwanda does when undertaken from a Western positionality. Rutazibwa implies that much knowledge production from a spatial "outsider" positionality unwittingly adopts a well-intended but paternalistic and problematic stance. This stance seeks to intervene in order to assist Rwanda in progressing towards a Western ideal of the "good life" e.g. peace, democracy and liberalised free trade, and prompts critique of the country by these scholars when such characteristics are not recognised. Rutazibwa, a member of the Rwandan diaspora, navigates these challenges by rendering her own positionality explicit, explaining that "This research doesn't inscribe itself in the canon of research seeking to inform Rwanda" (Rutazibwa, 2014 p.291).

This provides a useful example from which to orient my own research in relation to Rwanda. As a European researcher my ambition is not to inform Rwanda as a nation state. Rather it is to prompt reflexivity amongst actors in various locations whose activities at national or local levels can be connected to – or are mandated by – transnational or international agendas of energy systems change, such as that of sustainable development.

5 Results and contributions

In this section I briefly summarise each of the articles appended to this thesis. An outline of each article is included in Table 1 below. Following this I summarise the aim, theoretical framing, results and academic contribution of each of the articles in turn, including how they relate to one another.

Table 1: Outline of articles appended to licentiate thesis

Article	Article type	Method	Spatial perspective
1. Bridging the divide in energy policy research: Empirical evidence from global collaborative networks	Empirical	Quantitative, econometric and bibliometric	Global; individual countries considered a unit of analysis in relation to institution of corresponding author for articles and data on research funding. Interest is primarily in the geographic situatedness of knowledgemaking.
2. Agency, directionality, location and the geographic situatedness of knowledge making: The politics of framing in innovation research on energy	Conceptual literature review	Qualitative, literature review and textual coding	Global; reviews articles with varied geographic framing, but a subset of sample is focused on sub-Saharan Africa. Both locations of innovation and geographic situatedness of knowledge making are categories of analysis.
3. "Everything needs time" or "we don't have time": Contrasting sociotechnical imaginaries of energy systems change related to electricity and cooking services	Empirical	Qualitative, semi structured interviews	Related – but not limited – to Rwanda. Interviewees are those seeking to implement or facilitate energy systems change in Rwanda, although many are not Rwandan nationals and many organisations have footprints much wider than Rwanda. Interest is primarily in which locations are associated with innovation in these visions, although there is also some consideration on how knowledge considered relevant to change is geographically situated.

5.1 Bridging the divide in energy policy research: Empirical evidence from global collaborative networks

This article provides quantitative evidence of geographical imbalances in energy research practices. We produce evidence regarding where scholars are based who do highly cited energy research on lower income countries. We also investigate which countries receive funding to do research and which countries fund this research, as well as network analysis of research partnerships. This is achieved by conducting primarily quantitative analysis of a combination of country GDP data and bibliometric data on citations and funding of energy research articles which refer to lower income countries. The article

also complements this quantitative evidence by considering how these dynamics of research production may feed into wider imbalances in how problems and solutions are conceptualised (and from where), including research configurations between the Global North and South.

The article contributes by connecting energy as a research domain to longstanding discussions of epistemological provenance and scholarly reflexivity. This contribution is a reaction to the enduring orientation of energy research towards more natural science perspectives which focus the analytical lens on the object rather than practice of scholarship.

The theoretical framing is one of epistemological query. The article is situated amongst research which seeks to unveil and critically analyse the characteristics of knowledge production related to energy as a domain. Thus the article operationalises theoretical contributions from decolonial scholars and critical geographers – who have highlighted the continuing dominance of Global North scholars and epistemological perspectives – in the energy research domain.

The empirical results indicate that most scientific articles recommending energy policy for lower income countries have a primary author based in a higher income country, funded by a higher income country institution, indicated by Figure 2 below. In the figure, Box 1 indicates the concentration of articles conducted by scholars based in higher income countries which are also funded by higher income countries. Box 2 indicates the much smaller number of articles funded by lower income countries which still are channelled primarily towards comparatively higher income countries. The number of citations articles receive correlates strongly with the GDP of the country of primary author, indicated by Figure 1 below. Finally, funders support authors based in countries of the same income band or higher, as opposed to funding authors based in lower income countries, for example. These results each have implications for the journey from conceptualisation to dissemination for academic articles, which is described in Figure 3 below, adapted from Figure 10 in the original article. This Figure also acts as a summary of our academic contribution.

My main role in relation to this quantitative analysis has been to make sense of these results, frame them in relation to broader discussions in the literature, as well as reflecting on their implications. As part of this, I worked on the nuances between research configurations which may be obscured by focusing purely on broad macroeconomic trends. Most critically, we call for these kinds of quantitative analyses of knowledge production to also pay attention to the extent to which funding, senior scholars, junior scholars, conceptual approaches and fieldwork approaches are more or less proximal to the country being studied. In Table 3 of article 1, we outline the different kinds of risks related to how research is framed and conducted, in a plea for greater scholarly reflexivity by those involved in energy research related to lower income countries.

This article sets the scene for the licentiate thesis by describing on a geographically and conceptually broad level how influential energy scholarship related to lower income countries is primarily undertaken in and funded by higher income countries, building evidence regarding flows of academic knowledge and research finance (RQ1). This evidence raises questions regarding from where problems and solutions are framed in academic research related to lower income countries: particularly when those involved in researching them are often so geographically distant.

Furthermore, the article sets an important tone of scholarly reflexivity at the outset for this Licentiate Thesis. It demonstrates how our own act of higher income country-based scholarly production reproduces the imbalances we study. This subsequently emphasises the importance of a cautious and critical approach to research, particularly in terms of the extent to which I seek to generalise my findings to elsewhere, and to use my own scholarship to place greater emphasis on the work of scholars who may be disadvantaged by these imbalances where this is possible and necessary. This includes for example looking for framings and visions of energy systems change conceptualised from and in lower income countries, as in articles 2 and 3. Note that due to the interests of co-authors, the focus is on energy policy as opposed to specifying energy systems change, but I posit that the results related to flows of academic practices and funding still provide an analytical foundation from which to investigate energy systems change on a broad level.

Figure 1: Correlation between the log of total citations and log of GDP of country of primary author (R2 = 0.55). The two-tier characterisation of countries into lower income countries and higher income countries we use is expanded to show the relationship between total citations and GDP across the World Bank's four income groupings.

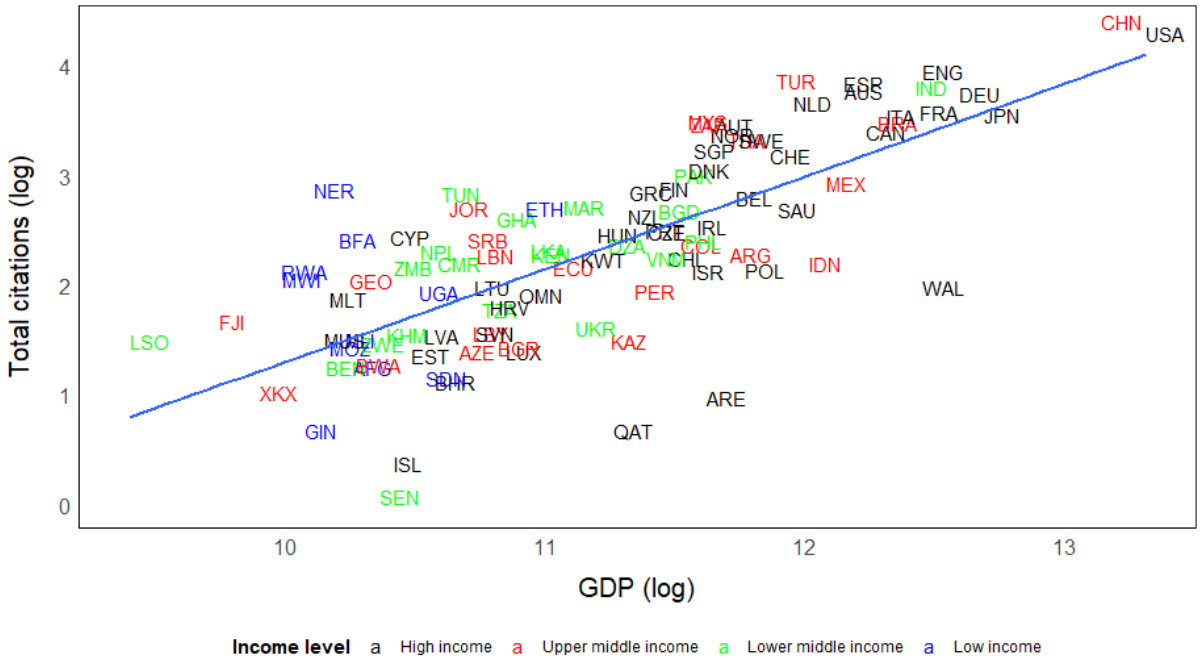


Figure 2: GDP per capita of country of author vs country of funding (sample of 905 papers for which funding information is available). The size of the bubbles represents the number of studies; the x-axis represents the GDP per capita of the country of funding; the y-axis represents the GDP per capita of the country of primary author.

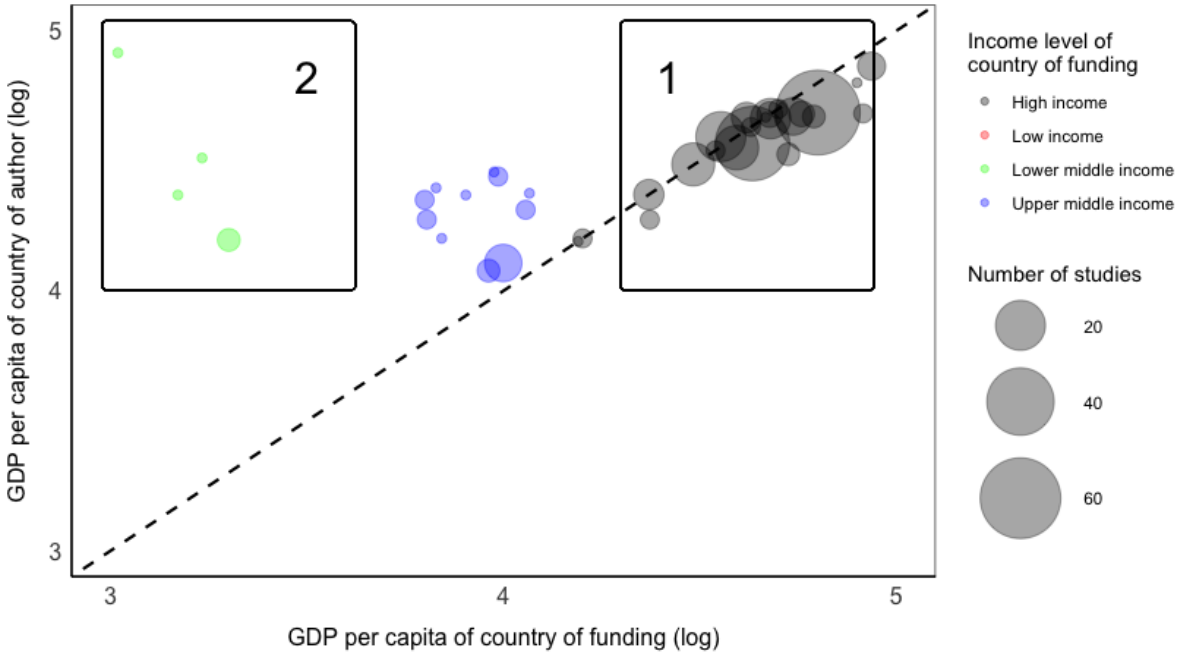
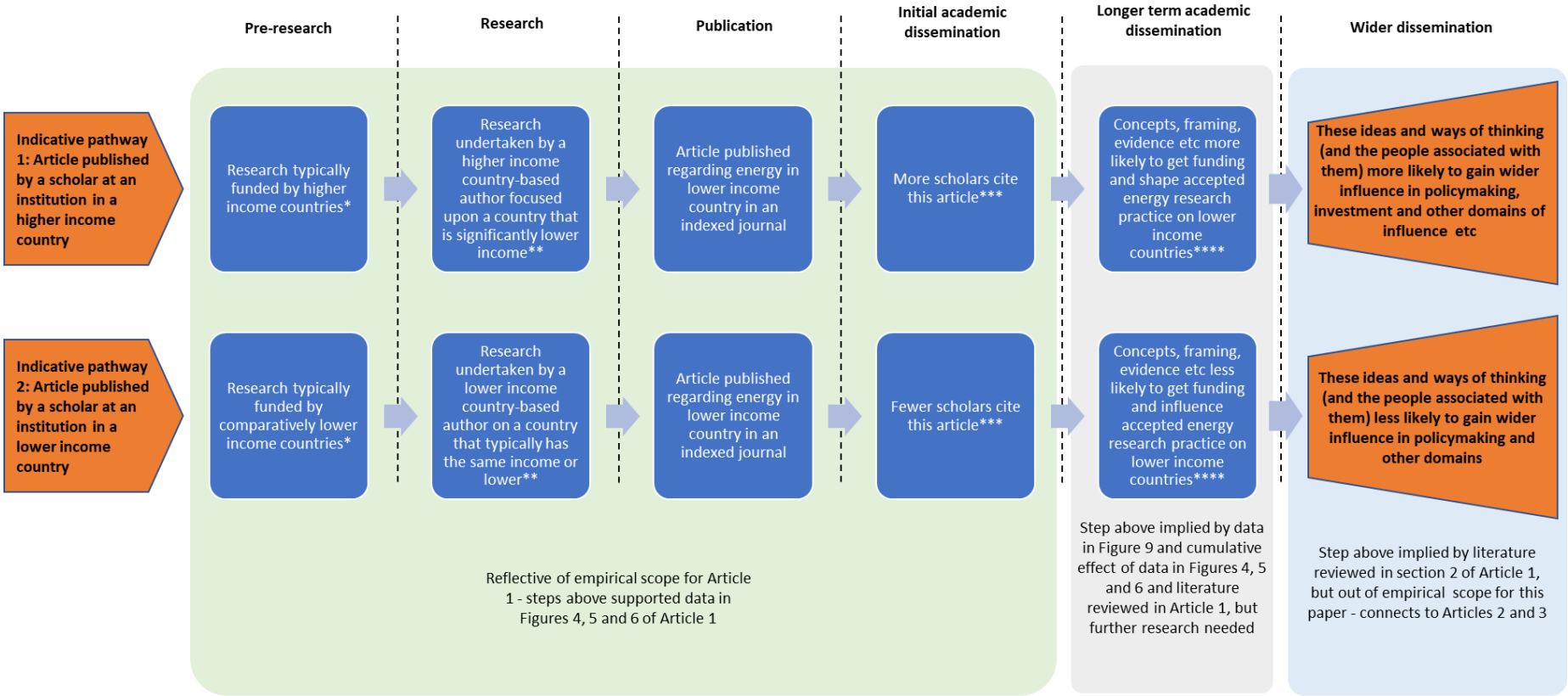


Figure 3: Summary of the quantitative evidence presented in article 1 through two indicative pathways comparing hypothetical academic articles which related to energy in lower income countries



*Supported by data presented in Figure 6 of Article 1 ** Supported by data presented in Figure 5 of Article 1 *** Supported by data presented in Figure 4 of Article 1 **** Supported by data presented in Figure 9 of Article 1

5.2 Agency, directionality, location and the geographic situatedness of knowledge making: The politics of framing in innovation research on energy

This article explores how scholarship working with the concept of innovation envisions energy systems change. The article works with a literature sample of 88 articles to analyse and differentiate between how change processes are framed, i.e. what is brought into the foreground by analyses and thus by extension, what is left in the background.

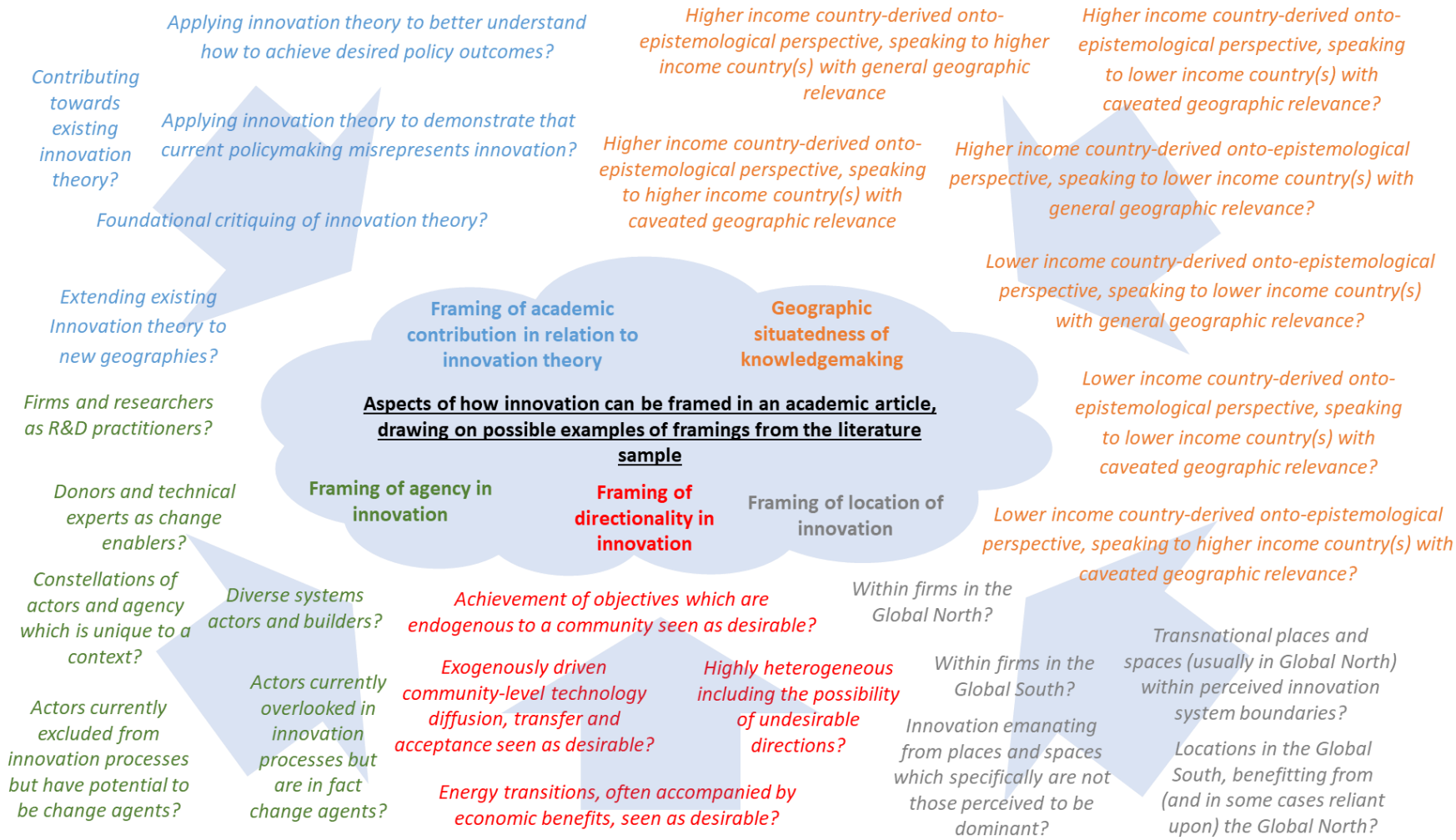
This article rendering the knowledge politics in innovation research explicit. We argue this is often hidden from view and thus innovation scholarship often lacks reflexivity. Furthermore, the categories of analysis by which we show innovation to be framed – agency, directionality, location and the geographic situatedness of knowledge making – provide insights in relation to our concern about how actors and places are portrayed as passive or absent in innovation. We form a scholarly bridge between literatures of innovation studies and sustainability transitions and knowledge politics and framing.

The theoretical framing is oriented around the politics between academic knowledges. We draw upon the Science and Technology Studies literature in particular which has sought to demonstrate that concepts such as innovation are highly contested and political in how they are understood. Innovation as a concept has the potential to be adorned with a wide range of possible connotations and meanings beyond its core definition related to novelty and change. We as authors analyse the productive space created by the conceptually amorphous connotations of innovation. We seek to navigate between framings and to unpack their implications for how visions of innovation might be enacted.

The empirical results demonstrate how the literature sample varies in terms of how it engages with different characteristics of innovation. It is evident that there are several different academic framings of innovation which place emphasis on different actors and locations. Most notably, there is a perceptible difference between: (1) articles which foreground firms as actors, associated with desirable directionality and positive outcomes, and (2) a more critical literature which critiques the assumptions of this mainstream, instead focusing on marginalised actors and possible outcomes (also including those which may be undesirable). The firm-oriented literature is primarily theorised from higher income countries and assumes general relevance. Other perspectives on innovation, most notably frugal or jugaad innovation, stem from lower income countries. Amongst these perspectives, caveating of the geographic relevance of conclusions is more common. One article in the sample also theorizes innovation from an explicitly Eastern perspective in response to the perceived dominance of Western theorizing. Figure 4 provides a visual representation of how different characteristics are framed which we identify within the sample. The bubble represents how they form constellations of different aspects of framing in any given article. This is illustrative of framing as a process rather than an exhaustive account of frames. There are both more aspects of framing than those we identify, and more ways of framing.

This article continues the focus on flows of academic knowledge from the first article (RQ1) but sacrifices the breadth of article 1 (up to 6000 articles) for depth (a close reading of 88 articles), in order to investigate how energy systems change is framed (RQ2). Reflecting the more granular level of analysis, this article introduces the analytical categories of agency, directionality and location to tease out differences between how energy systems change is framed in relation to innovation. Some of these categories which pertain to the characteristics of change are then are also used in article 3.

Figure 4: Visual summary of the multidimensional ways in which innovation is framed, based on the different aspects identified in the literature sample. This indicates how any specific article draws on a constellation of different aspects of framing.



5.3 "Everything needs time" or "we don't have time": Contrasting sociotechnical imaginaries of energy systems change related to electricity and cooking services

This article investigates the characteristics of imaginaries emerging from those seeking to facilitate or implement energy systems change related to Rwanda. The focus is particularly on processes of change related somehow to electricity and cooking services at a household level. This focus reflects the central role of these energy domains in government plans, plans which correlate closely with international agendas of sustainable development.

This article makes a conceptual contribution to the literature on sociotechnical imaginaries through an explicit framing around how Rwanda as a national context is envisioned to connect to transnational flows of technology, finance and knowledge. We examine from where in the world, driven by whom, and at what speed and time that change is envisioned to take place when it relates to a specific country. Secondly, the article makes an empirical contribution as the first study of sociotechnical imaginaries related to Rwanda that I am aware of which focuses specifically on the energy domain.

We use this theoretical frame to unpack how actors seeking to facilitate or implement energy systems change imagine different aspects of this process, such as the role of energy users. We consider a range of evidence to be constitutive of imaginaries of change. For example, actors describing past events can still contribute towards sociotechnical imaginaries. We also recognize that accounts of preferred change may be strongly idealized. These imaginaries may be more or less dominant, and they may mobilise resources to differing extents. We also recognise that other sociotechnical imaginaries are likely to exist besides those we characterise.

The empirical results are structured around two stylised sociotechnical imaginaries. The first imaginary is oriented around strategically adopting the right technologies and practices at speed – from outside Rwanda – to meet the cost-driven demands of user-consumers. This is aided by acceptance from user-legitimators. The second imaginary instead advocates for carefully growing solutions domestically, stemming from and developed in partnership with user-producers. This plots a bespoke and energy-secure economic development pathway for Rwanda. Specific actors, organizations and even individuals can hold contradictory views that partially belong in both imaginaries: they do not categorise neatly. These imaginaries differ in various ways which are summarised in Table 2.

This article links directly to article 2, by asking a similar question which regards how energy systems change is envisioned in terms of characteristics such as agency and directionality (RQ2). However, it asks this question of actors working in relation to Rwanda rather than of academic articles. This enables us to contrast how these different domains envision change. By connecting to a specific geographic location, this article also enables the thesis to start analysing more precise, situated visions as opposed to operating at the broader scale of the first two articles.

This article also seeks to build off the first two articles by investigating the empirical characteristics of imagined change in terms of agency, location, temporality and directionality. This enables us to ask whose, and what forms of, knowledge are understood to contribute towards desirable forms of change. This considers the kinds of academic knowledges studied in the first two articles, but also knowledges of energy users for example. We thus analyse an additional sphere of "practitioners" where energy systems change is envisioned which is adjacent to the academic sphere of the first two articles. Beyond

this, we also tentatively point towards linkages between these spheres, particularly with regard to actors speaking from or based in higher income countries.

Table 2: Main characteristics of the two stylised sociotechnical imaginaries described in article 3

Characteristics of imaginary	Imaginary 1: More urgent, private sector-led and internationally imported technological development pathway for Rwanda	Imaginary 2: More gradual and domestically developed technological development pathway for Rwanda coproduced by users, the private sector and local research institutions
Approach to agency and the role of users	- Private sector is the principal agents of change, connected to international finance - Private sector has intimate knowledge of user needs and effective business models - Users are primarily consumers whose main demand is low cost - Rural energy users require education to understand the benefits of proposed solutions - Users can gain agency via economic empowerment as an outcome of technology acceptance - Adoption can be boosted by user legitimators, e.g. neighbours	- Users are active agents of change alongside the private sector: co-production is central - Actors at local research and education institutions are also key agents of change - Users instigate change processes and sometimes design or produce hardware themselves - Users' needs are complex, related to their daily lives and preferences - Technologies which have been designed outside Rwanda often marginalise the precise needs of end users
Approach to locations of innovation	- Countries outside are generative of useful hardware innovations and may be better suited than those coming from within - Useful activities taking place within Rwanda relate to identification of existing solutions which are a good fit for the context - This may include some customisation of business models such as Pay-As-You-Go (PAYG) - Kigali is a centre of activity connecting actors to international finance and technology and also provides a base for remote monitoring of activities in rural areas	- Rwanda is generative of useful hardware innovations, even if it may be overlooked by patent-based innovation analyses - Testing and tinkering with hardware is also useful, with customisation effectively creating Rwandese innovations which are fit for context - Localised manufacture of solutions using local resources can drive localised benefits - Rural locations can be centres of innovation, perhaps even more so than urban areas such as Kigali

Approach to temporality	- Speed and urgency of change are critical - Rapid pace of change is a good fit for the urgency demanded by external funding sources targeting sustainable development - Rwanda as a country needs to keep up with pace of technological change abroad - Organisations need to pivot away from slower bespoke projects towards those which are rapidly scalable and standardised - Rapid expansion to other countries is a priority - A shift is occurring as implementing actors move out of villages and towards Kigali for better connectivity	- Appreciating a gradual and perhaps incremental pace of change is critical, related to the realities and challenges associated with working on energy in Rwanda - External funding can disincentivise innovation by focusing on delivery and fund-chasing by organisations - Disconnected to urgency demanded by external funding sources targeting sustainable development - Longstanding local companies need to play a central role in change – deep knowledge
Approach to directionality	- Change processes should target quantifiably large impacts on energy production and consumption patterns - Environmental sustainability is central, particularly forest protection - Economic catch-up and leapfrogging carbon intensive growth is critical - Energy systems change both enables and is enabled by a digitalised future (linked to improved access to non-energy products and services) - A privatised and liberalised market is a key ingredient to desirable change	- Change processes may not always deliver quantifiably large impacts on energy production and consumption - Environmental sustainability should be understood on a localised level i.e. using local resources responsibly to local benefit - Domestic energy security is a key priority, including a much stronger balance of imports related to technology - The above connects to a domestic innovation-led development pathway

6 Discussion

Below I include a short discussion of the body of work I have produced for this licentiate thesis, structured around my four research questions.

6.1 Research question 1

Who produces and funds academic knowledge related to energy systems in lower income countries and what are the implications of this from a knowledge politics perspective?

This research question is primarily addressed by article 1. As described above, we find a clear dominance of higher income countries across production, funding and citations. As the article concludes, this indicates a risk that energy systems change is conceptualised from a higher income country epistemological perspective. If processes of change in lower income countries ultimately owe their framing and theorizing to unreflexively authored papers originating in higher income countries (as implied by Figure 3) this points to a broader risk that lower income countries embark upon material pathways of change which lack a grounding in the specificities of place. This could lead, for example, to the adoption of technologies or practices which work sub-optimally in a specific context (Yuliani, 2017). Change being conceptualised by scholars from higher income countries may furthermore lead to a tendency to recommend connecting lower income countries to sources of finance, technology and technical support which are more proximal to the scholars than the locations to benefit. This may be a way in which lower income countries are connected to sites of globalised capital accumulation which concentrate wealth from multiple locations in typically higher income countries or amongst elites in lower income countries (Harvey, 2004).

However there are two important caveats to these possibilities. The first is that the article does not tell us which research (whether precise recommendations or broader conceptualisations) is enacted in other domains outside academia: for instance in policy framings, material infrastructures or practices. It simply tells us, in concrete terms, who dominates academic knowledge production, and confirms the existence of a cycle of imbalances within academia. Our insights from article 2 shed additional light on this. The article indicates that when one seeks plurality of academic perspectives on a concept (in this case innovation) rather than highly cited literature only, the results can be heterogeneous. It may be that seemingly marginal framings of concepts like innovation are those to be materially enacted *if* they represent a good fit for actors in lower income countries seeking to facilitate or implement energy systems change. This would seemingly lower the possibility of the risks described above.

This relates to the second caveat; that the scope of article 1 is limited only to indexed journals. What is thus rendered in the background by the article's framing is the many forms of grey literature, non-indexed work and unpublished contributions which may still contribute towards how energy systems change is conceptualised in lower income countries. Of particular relevance here is our evidence gathered from article 3 on the envisioned role of energy systems change in Rwanda. The first imaginary, which locates drivers of change as primarily exogeneous to Rwandan energy users, is a close fit with the empirical findings of article 1. This imaginary indicates that dominant knowledge of energy systems change in lower income countries is produced from far away, and thus prefers similarly exotic technological solutions and capital flows. Regardless of whether one sees this as problematic, the two are compatible as constitutive of a dominant vision. However the second imaginary, rooted in change

processes emanating from communities within Rwanda, emphasises the role of local knowledge producers as critical. The specific knowledge producers cited in this second imaginary have a minimal academic research output which would likely barely register in the quantitative analysis of the first article. However their local knowhow and strong connections with local energy sector actors leads to them being envisioned as key change agents and knowledge producers. This indicates that multiple envisioned systems of innovation and change can co-exist within lower income countries, some of which place formal academic knowledge in the background.

This reminds us that scholars should not simply use academic indicators such as citations and academic output to proxy for academic activity (or influence over it). This is despite the enduring tendency of scholarship to do this (for example Li et al.,2020). While higher income countries dominate what can be thought of as "mainstream" academic knowledge production, my findings from articles 2 and 3 demonstrate that alternative knowledges exist which may connect to alternative imaginaries of energy systems change, such as those which place greater influence on localised knowledges driving energy systems change. Thus as scholars, we can acknowledge the dominance of higher income countries producing and funding ofmost internationally recognised forms of energy research. We should however not allow our knowledge of this to become instrumental in closing down recognition of where else knowledges may come from. To put this differently; analyses like article 1 are necessary. However it does not necessarily entail envisioning centres of knowledge production in lower income countries simply as victims of ongoing coloniality. Instead, scholars can work to envision these countries as generative of alternatives. Such an agenda may consequently require alternative research methods which look beyond commonly recognised metrics such as academic publications, citations or patent statistics which consistently rank lower income countries as second tier on a global level (see for example Cornell University et al., 2020).

6.2 Research question 2

What are the characteristics of energy systems change envisioned by scholarship which uses the concept of innovation?

This question is primarily addressed by article 2. The central insight from the analysis is that characteristics of energy systems change are highly heterogeneous. This is perhaps a reflection of innovation being used as a vehicle for different framings, which foreground certain characteristics as particularly interesting or desirable. One can see that for some scholarship, innovation is a process which can broadly reproduce versions of the status quo. In such cases it typically includes isolated change within a specific area, albeit change which may be highly disruptive within that area. For example this may be a flip in who and where has competitive advantage in market terms, or a reduction in emissions due to technological substitution. For others, energy systems change is imbued with an emancipatory quality associated with social transformation; that processes of change can and should place marginalised and excluded actors in the foreground. Within the literature sample there are varying degrees of radicality in terms of how much visions of energy systems change depart from what could be considered the mainstream innovation literature. It is noteworthy that this idea of an innovation mainstream – associated with economic growth, the private sector and a bias towards techno-optimism – is itself generative of alternative visions by acting as a kind of antagonist which other scholarship defines itself in opposition to (Arora et al., 2019; Pettersson & Lindberg, 2013).

6.3 Research question 3

What are the characteristics of energy systems change envisioned by actors who seek to implement this change in lower income countries?

This question is primarily addressed by article 3. As with the second research question, the conclusion is that visions of energy systems are heterogeneous, even in a place such as Rwanda which has a very strongly articulated top-down vision of energy systems change. However here we speak of a distinct group of practitioners rather than academics. We characterise two imaginaries from respondents working in relation to Rwanda. Both of these connect to elements of the Rwandan government's visions for the country's future, but they place greater emphasis on different parts. It is notable that the first imaginary is found amongst organisations with an international footprint; it may be that this is one of the reasons that this logic of change locates the means and processes of change as exogeneous to Rwanda. This bears similarities with the research framings identified in article 2, with a key differentiator between directionality of change being whether it stems from drivers exogeneous or endogenous to the actors for whom change is envisioned.

While this research question is primarily addressed by article 3, the discussion of framing as a way of envisioning change in article 2 also has relevance to the question of whom the actors are that frame themselves – or are framed by others – as implementing change. While I investigated the imaginaries of change perceptible *within* what these actors said, a broader vision around who are perceived as critical agents of change is also perceptible in who I interviewed as a group. Recognising the research method of "snowballing", it is notable that none of those interviewed told me as the Lead Author and interviewer to go and interview energy users as change agents. A small minority advised me to spend time observing interactions with energy users, which I did.

This point on framing is undoubtedly in part shaped by my own outsider positionality and networks. One would expect respondents to tell or show me what they wanted me to hear or see. It nonetheless still does indicate that while at least two shared visions of change exist in Rwanda and that there is a spectrum between them, both are envisioned by respondents from a broad perspective which is closest to the vision of applying innovation to achieve policy outcomes described in article 2. The latter vision of change targets economic development or sustainable growth and is implemented primarily by the Private Sector as change agents. While the second imaginary places notably less emphasis on usage of externally developed technology and therefore accumulation of capital elsewhere, both imaginaries do include a basis in market-oriented logics and economic growth as desirable. The desire to problematise technologically driven economic growth as a desirable outcome of change and innovation (found in some of the academic framings of article 2) is absent in this specific domain of implementers.

6.4 Research question 4

Who is envisioned to act as architects of energy systems change affecting energy users in lower income countries? Who envisions these architects and what are the implications of this?

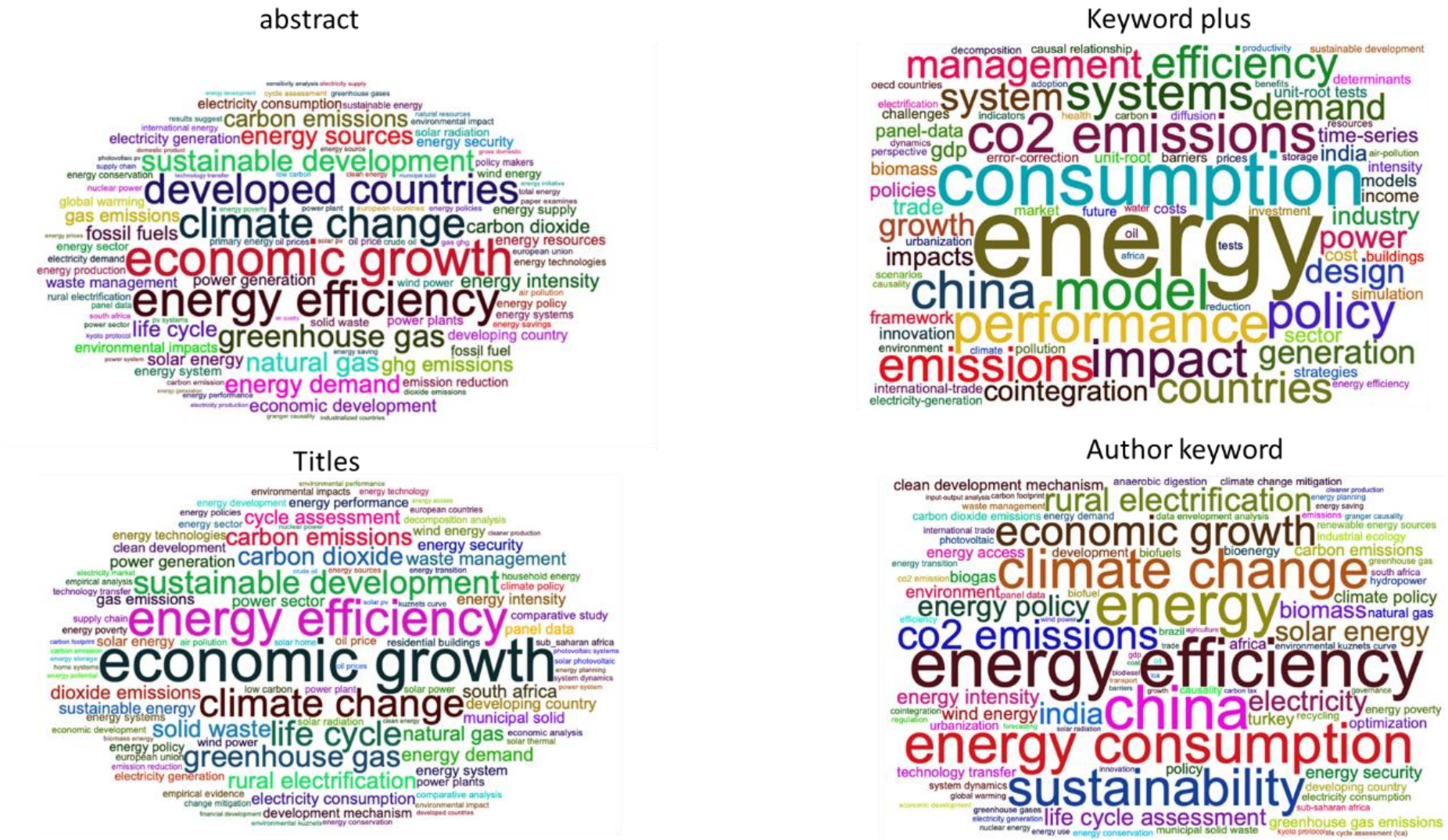
A headline finding across the three articles is that actors from both lower and higher income countries participate in the envisioning of energy systems change in lower income countries, whether this is through academic knowledge production or implementation. While likely obvious to many, it is necessary to state this explicitly. A common rhetoric (which I heard multiple times in interviews for

article 3 with high profile international institutions) is that the principle role of funding and technical support initiatives stemming from higher income countries is to enable and help implement lower income countrys' own visions of change. The evidence in this Licentiate Thesis demonstrates patently that this is not the case. These kinds of actors come with their own visions, logics and assumptions of how change happens. These visions risk becoming dominant, supported by the unequal landscape of flows such as those evidenced in article 1. Thus part of the answer to this research question is that these actors – scholars, practitioners, finance providers and technical experts based at institutions in or from higher income countries – are themselves co-architects of envisioning processes. They exert agency through visioning activities which are heard, read about or enacted. This same observation can be reflected back at this act of scholarship. My own work will intervene, in however small a way, in how energy systems change in Rwanda and perhaps other lower income countries is envisioned.

This has implications for who are envisioned to act as architects of change *within* these visions. A finding from articles 2 and 3 is that external actors are primarily envisioned as central architects of change *by* actors somehow external to lower income countries (whether in terms of the company they work for, or the institution they are based at). To put it another way: actors from lower income countries rarely are those who envision external actors as facilitating and delivering change. The main instance of this happening is when these actors work closely with organisations, finance or theories stemming from higher income countries. Multiple Rwandan respondents pointed to the importance of their rurally located research institutions training students who develop and share innovations in collaboration with communities. Several respondents emphasised furthermore the generative potential of the local communities themselves for change. Others explained how finance from external donors in fact stifles locally-embedded processes of change.

Here we may zoom back out to the broad landscape view of academic areas of focus provided by Figure 5 (originally Figure 9 in article 3). This shows a strongly techno-economic conceptualisation of energy: the words which stand out across the word clouds are words like economic growth, energy efficiency, environmental concerns such as emissions reductions and climate change. These kinds of outcomes (understood here to relate to directionality) can be connected to the innovation framings perceptible in article 2 and the sociotechnical imaginaries in article 3. The actors which come to the foreground as architects of energy systems change who might deliver these kinds of outcomes are the international private sector, who can rapidly mobilise to locations and meet requirements for funding disbursement. References to specific kinds of actors are barely perceptible in the word clouds. This is perhaps a reflection of the strongly technocentric nature of much energy research or perhaps an unspoken assumption that it is the private sector that does this work. One can perceive terms such as energy "consumption" and "demand" cropping up repeatedly; implying that it is in this consumptive capacity that energy users are envisioned in dominant research designs.

Figure 5: Word cloud constructed for abstract, keyword plus, article title and author supplied keywords for articles between 2001 and 2020 (n = 6,636) from the main bibliometric data set analysed in article 1.



7 Conclusion

Across the three articles, certain patterns are perceptible. The private sector (along with alternative implementers such as NGOs), the knowledge producers (such as academics and engineers), and the system builders (such as funders, policymakers and regulators) all crop up repeatedly as architects of change, reflecting mainstream narratives and conceptualisations of innovation systems. There is a dominant archetype which envisions the primary architect of change to be an actor external to energy users (and often to the countries these users are within). This archetype is held together by a combination of actors at different spatial scales and with differing degrees of agency. This includes for example practitioners and academics seeking to influence change at a transnational or international scale, as well as national-scale government actors and practitioners in the specific case of Rwanda in article 3. These actors mutually reinforce this archetype in academic, policy and practitioner arenas, such as the consistent belief that the private sector delivers change and innovation, with flows of academic knowledge relating to lower income countries to some extent supporting this archetype.

This has implications for the ability of communities to shape their own develop pathways. With regard to flows of technology and finance, it risks users, via energy systems change, merely being connected to global circuits of capital accumulation and dependence upon technologies which external actors have monopolies upon (Harvey, 2004). Perhaps troublingly, this mainstream which decentres users is most notable when there is a close association with normative agendas of environmental sustainability (in article 2) and urgency specifically (in article 3). This implies a binary trade-off between the urgency of sustainability and slower logics which focus on recognising and fostering agency amongst marginalised actors.

However, more optimistically, alternatives to these visions exist around the margins of both flows of academic knowledge related to lower income countries and amongst implementers of change. These visions, while only occasionally placing energy users at the centre as architects of change, do work against dominant visions. They locate key milestones in processes of change – such as conceptualisation, design, testing and production of new ways of doing things – closer to energy users and the places which they seek to benefit. This has substantively different implications from the perspective of possible future stocks and flows of future technology and capital. These alternative visions are derived from a patchwork of similarly varied actors. This includes academics (often those interested in critical theory to varying extents) and actors working for locally headquartered organisations in Rwanda. This also includes some national government actors and international practitioners who express concern about the importance of context and building local capacity. Describing these different coalitions of actors helps to demonstrate that both contrasting visions can be found amongst actors operating at different scales of influence in articles 2 and 3.

A valid question could be raised at this point, as to why we should seek to place users in lower income countries closer to the centre of design processes. As multiple respondents in article 3 expressed, perhaps users have busy lives and mainly want a low cost, reliable solution. My response would be that there can be – and currently is – room for this logic. However, scholarship analysing processes of

innovation and change situated at the "Grassroots" level[5] – one of the approaches to innovation analysed in article 2 – indicates that such activities can generate sociotechnical configurations that might otherwise be constrained. It can do this by explicitly unpacking and exposing the politics within more dominant systems. This can both boost accountability in processes of change as well as broadening possible directions of change (Smith; 2014; Smith & Stirling, 2017). In my research, one can compare actors who import and retail climate finance-subsidised and foreign-designed solutions into Rwanda with those who dismantle solutions from abroad, study them and then design their own: or design from scratch. These bespoke designs are suited to local climatic conditions and use locally available materials, in doing so building the capabilities of local people. I would argue that while communities should not be *obliged* to participate in innovation processes, neither should they be effectively excluded from participating via assumptions that all they want is low-cost, ready-made solutions: and framing this as a trade-off between participation and service provision. The current dominant visions of change related to lower income countries close down more than open up these possibilities for participation.

On a conceptual level, this thesis underlines the value of theoretical approaches such as framing and sociotechnical imaginaries which enable scholars to unpack the characteristics of and politics between visions of change. This focus on how problems and solutions in energy systems change are framed – combined with recognition of relationships of dominance in knowledge production – reaffirms the importance of humility and reflexivity for scholars such as myself. I urge scholarly caution for example in assuming the contextually specific details of Rwanda's imaginaries translate elsewhere. Nonetheless, I do think that comparisons can be drawn carefully elsewhere around the world, including in higher income countries. Such comparisons can be drawn with other encounters between globalised agendas of change emphasising urgency and scale and other possibilities more rooted in localised framings of problems and solutions.

[5] Grassroots innovation has been defined as a "diverse set of activities in which networks of neighbors, community groups, and activists work with people to generate bottom-up solutions for sustainable developments; novel solutions that respond to the local situation and the interests and values of the communities involved; and where those communities have control over the process and outcomes" (Smith & Stirling, 2017). The precise categories of "grassroots" actor who participate in a situation are contextually specific and are likely to vary particularly between higher and lower income countries. I would argue in Rwanda, small businesses and locally embedded research and educational institutions might be considered coproducers of a form of "grassroots" innovation alongside communities, through their emphasis on them playing an active role in both change processes and outcomes. Nonetheless, the exact nature of this coproduction process requires further study; I study how these actors depict change rather than observing the performance of it.

8 Plans for further work

A promising avenue of research is to explore the role of locally situated knowledge production in visions of energy systems change referred to in the second imaginary in article 3. This could place emphasis on local research and education institutions as both training future change agents but also generating change themselves in close connection with energy users. It could be valuable to understand in more detail the role of this knowledge production as a counterpoint to the focus on academic knowledge in article 1.

Another avenue of research is to focus more specifically on following specific flows of technology, finance and knowledge, from points of "production" to points of "consumption" which pertain to energy systems change in lower income countries. The analysis to date focuses more on how these flows are perceived by actors and actants from a specific perspective – whether implementing actors or academic scholars and articles. It may be thus beneficial to flip this analytical focus, and instead follow a particular technological or financial flow – e.g. a particular funding programme or organisation working on a specific technology – as it travels in order to establish how different actors interact in these socio-material flows and shapes the character of energy systems change.

This licentiate thesis does try to make some cautious claims regarding why some imaginaries and frames of energy system change are materially enacted to a greater extent than others, and further work could seek to explicitly analyse the power relations which may help to explain this. However such analysis risks propagating a narrative which only acknowledges the material dominance of imaginaries which foreground the agency of actors in or from higher income countries. Therefore, further research might alternatively seek out contexts in which strongly localised narratives, perhaps emphasising marginalised or excluded peoples, are being materially enacted. Further research could ask; under what conditions does this come about? Similarly, such research could explore, on a broader level, the link between who is doing the envisioning (i.e. locally embedded actors), and what visions and material enactments come into being. This may demonstrate how these actors may envision change differently; and also raise different hopes or concerns about the implications of change, for example. This can thus connect work on sociotechnical change on a broad basis to how alternative rather than dominant outcomes can be envisioned and enacted.

A further avenue of research could be to explore in more detail the relationship between urgency and questions over who and where delivers energy systems change – specifically, examining in more detail *why* a slower pace of change is considered fundamental to more locally situated narratives of change. This could also explore the complexities of temporality at different scales, differentiating between the character and urgency of concerns expressed locally with national or international concerns. This research could stem from a normative standpoint of supporting the urgency of environmental and social concerns, while being suspicious of the necessity of neoliberal market logics as the only way of delivering this which necessitate dependency.

A final note to add, in relation to my plans for further work, regards the theoretical framings and literatures which I work with. Given the ongoing nature of this work, I only relatively recently became familiar with the theoretical framing of sociotechnical imaginaries, in looking for a theoretical fit for the empirical data I gathered for article 3. I thus plan to spend more time reading this literature in more

detail, including critiques of the concept. I furthermore intend to read more critically into the distinctions between and provenance of different academic approaches related to envisioning pathways forward. These approaches include, but are not limited to, framing and imaginaries. This may provide the basis for a possible conceptual contribution. Furthermore, as my PhD project progresses, the importance of understanding spatiality in my research from a critical perspective is becoming increasingly evident. Literatures such as Energy Geographies and Political Ecology, which I have only read to a limited extent thus far, may provide important avenues for me to strengthen my theoretical foundations. Future work could potentially be situated within these domains.

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