ACCELERATING DECENTRALIZED ENERGY TRANSITIONS: A SOCIO-TECHNICAL PERSPECTIVE

A Thesis Submitted to the College of Graduate and Postdoctoral Studies in Partial Fulfillment of the Requirements for Doctor of Philosophy in the School of Environment and Sustainability

University of Saskatchewan

Saskatoon

By

MARTIN. J BOUCHER

© Copyright Martin Boucher, (June 8, 2021). All rights reserved.

Unless otherwise noted, copyright of the material in this thesis belongs to the author.

Permission to Use

In presenting this thesis/dissertation in partial fulfillment of the requirements for a Postgraduate degree from the University of Saskatchewan, I agree that the Libraries of this University may make it freely available for inspection. I further agree that permission for copying of this thesis/dissertation in any manner, in whole or in part, for scholarly purposes may be granted by the professor or professors who supervised my thesis/dissertation work or, in their absence, by the Executive Director/Director of the Department or the Dean of the College in which my thesis work was done. It is understood that any copying or publication or use of this thesis/dissertation or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of Saskatchewan in any scholarly use which may be made of any material in my thesis/dissertation.

Disclaimer

Reference in this thesis/dissertation to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement, recommendation, or favoring by the University of Saskatchewan. The views and opinions of the author expressed herein do not state or reflect those of the University of Saskatchewan, and shall not be used for advertising or product endorsement purposes.

Requests for permission to copy or to make other uses of materials in this thesis/dissertation in whole or part should be addressed to:

Executive Director, Graduate School of Environment and Sustainability

Room 323, Kirk Hall, 117 Science Place
University of Saskatchewan

Saskatoon, Saskatchewan S7N 5B8 Canada

OR

Dean
College of Graduate and Postdoctoral Studies
Room 116 Thorvaldson Building, 110 Science Place
University of Saskatchewan
Saskatoon, Saskatchewan S7N 5C9 Canada

Abstract

Whereas past transitions were often long multi-decadal affairs, the current energy transition requires a much shorter time horizon. Reducing carbon emissions to avoid the worst impacts of climate change is essential. Socially and technologically driven pressures are creating opportunities to observe accelerated social-technical change in action. By observing ongoing accelerated transitions, the goal of this dissertation is to further the understanding of the mechanisms of these transitions. This dissertation asks two questions: (1) In the context of accelerated social and technical change, is society or technology the driver? And (2) how can an understanding of this dynamic be used to further accelerate social and technical change? To explore these research questions, this dissertation focuses on a case study of a particular accelerated transition that is currently unfolding—decentralized energy. To operationalize answering the addressing questions, comparative research alongside an in-depth case study analysis was conducted.

The dissertation is divided into five manuscript chapters. The first manuscript, *Chapter Two*, begins with an overall discussion on decentralized energy: its opportunities, challenges, and justice considerations. The next manuscript, *Chapter Three*, compares the governance dimensions of decentralized energy transitions in three medium-sized northern cities. Using the same three case studies, *Chapter Four* compares the case studies using energy futures analysis. The remaining two manuscripts, *Chapter Five* and *Chapter Six* focus on a single case study of solar energy in Saskatchewan. In *Chapter Five*, the paper explores the idea of effective public engagement that considers how energy justice issues can be used to drive DE transitions. *Chapter Six* builds from the previous chapter and argues for practical suggestions to accelerate DE transitions based on observations from the public engagement activities and a discussion on decision-making.

This dissertation concludes with three insights that synthesize the aggregated findings. (1) There are unintended consequences to accelerated energy transitions. Energy justice can be used as a framework to unearth tensions and potentially attempt to predict where unintended consequences may appear. (2) A transformed role of the state is needed to facilitate acceleration, one that employs a more interactive form of governance and public policy. (3) Further research that uses a comparative approach with a focus on governance dimensions can lead to more useful insights to understand accelerated transitions.

Abbreviations

AC	Alternating Current
ACEP	Alaska Center for Energy and Power
CCS	Carbon Capture and Storage
CHP	Combined Heat and Power
Chugach	Chugach Electric Association
CIHA	Cook Inlet Housing Authority
DE	Decentralized Energy
EV	Electric Vehicle
FIT	Feed-in-tariff
GHG	Greenhouse Gas
IEA	International Energy Agency
IPCC	International Panel on Climate Change
IPP	Independent Power Purchase Agreement
LCOE	Levelized Cost of Electricity
LLT	Luleå Lokaltrafik AB
ML&P	Municipal Light and Power
MLP	Multi-level Perspective
PV	Photovoltaic
QCA	Qualitative Comparative Analysis
REAP	Renewable Energy Alaska Project
SaskPower	Saskatchewan Power Corporation
SES	Saskatchewan Environmental Society
SL&P	Saskatoon Light and Power
SNM	Strategic Niche Management
SSAB	Svenskt Stål AB
STRN	Sustainability Transitions Research Network
STT	Sustainability Transition Theories
TIS	Technological Innovation Systems
TM	Transitions Management
UN	United Nations

Acknowledgements

This dissertation would not have been possible without the generosity of people who supported me. I want to start by thanking my family. My wife, Olenka, was by my side from the ups-and-downs of this journey. When frustrated, she encouraged and reminded me why this work mattered. She celebrated my successes, like when I got my first publication. She patiently listened to presentations and discussed ideas—becoming perhaps somewhat of an expert on the topic of energy transitions. When I needed to work long hours, she took care of our sons. To my four-year-old son, Jude, all he has known is a father exerting most of his mental energy on this project. I promise to make it up to you! To my parents, both of whom passed away while in the process of attaining this milestone. Among their many lessons, they taught me the importance of being uncompromising in the pursuit of work that matters and has a positive impact on the world. I hope that this accomplishment meets their expectations.

I could not have asked for a better supervisor, Dr. Jeremy Rayner. His wisdom and encouragement have guided me along this journey. I will always appreciate our many brainstorm sessions—a true master at unlocking the jumble of thoughts in my brain. I want to thank my dissertation committee: Dr. Tong Chung, Dr. Bram Noble, Dr. Peter Phillips, and Dr. Toddi Steelman. All of them have been generous with their time and have provided me with insights and thoughtful feedback. Irene Schwalm, the academic advisor at SENS, was there at the beginning when I had questions at the start of the program through the end. I would like to thank two of my collaborators: Dr. Brett Dolter and Joni Karjalainen. They are featured in some of the work found in this dissertation, and I have benefited from their insights.

The School of Environment and Sustainability (SENS) has a decidedly interdisciplinary approach to their graduate programming. It was this innovation from SENS that originally drew me to this school to pursue my PhD. My background ranges from the physical sciences (physics, mathematics, and human evolution) for my undergrad; to the political sciences and humanities for my masters; and to the engineering project management and energy efficiency space as the majority of my professional workplace experience. SENS gave me a home to pursue a dissertation that pulls from all of these experiences. More importantly, the interdisciplinary approach allowed me the intellectual arena to address interesting and relevant research questions—and that is what matters most to me. This interdisciplinary model that SENS encourages has afforded me many academic opportunities, such as successful conference presentations, publications, scholarships, and research grants. At the time of writing, I have been fortunate to have all manuscripts in this dissertation either published or considered for publication.

This dissertation would not have been possible without the support of once strangers. I want to thank the interviewees in Luleå, Anchorage, and Saskatoon. Luleå Technical University in Luleå, Sweden and the University of Alaska in Alaska, USA provided me with office space and support during my month-long data collection at each location. The hundreds of participants in the stakeholder engagement sessions across Saskatchewan shared their time, energy, and ideas. They were generous with their time and support of this work. Their expertise and perspective have been directly included in this dissertation and influenced my thinking.

I have been fortunate to receive financial support from the provincial and federal government, private sector, and university throughout this dissertation. During my tenure as a PhD student, I received the Queen Elizabeth II Scholarship ($20,000), SSHRC Joseph-Armand Bombardier Doctoral Scholarship ($75,000), the University of Saskatchewan SSHRC Retention Scholarship ($18,000), Graduate Teaching Fellowship ($17,000), the SENS Nexen Energy Graduate Scholarship ($90,000), and the Peter MacKinnon Graduate Fellowship ($10,000).

Dedication

To my parents, Madeleine and Marcel, who supported me at the start of this journey but were not able to see it to the end. I miss you and love you.

The desire that guides me in all I do is the desire to harness the forces of nature to the service of mankind

Nikola Tesla, 1934

Preface

As I write to capture the overall message of this dissertation, I think of my father, who grew up in the 1930s in rural Quebec, and my sons, who will grow up in a vastly different energy landscape. My father came from a large, poor family of 15 brothers and sisters. They had little in the way of energy services. For lighting, they made candles and used kerosene lamps. For heating and cooking, they used a wood stove. The family purchased little and operated their small farm nearly self-sufficiently. In today's context, we would say that they lived sustainably. When I was growing up, my father would opine about energy use in our house. He instilled in my siblings and me the importance of turning off the lights, closing doors and windows when not in use, and filling up the wood fireplace to offset heating costs in the winter. He did this not because of concerns about climate change or sustainability but because it was wasteful not to. For him, energy services, such as lights and heating, were scarce.

My sons, aged two months and four years, will likely have a much different relationship with energy. I suspect they will be motivated by climate change and the pursuit for sustainability. Living sustainably will not necessarily mean being poor—it will likely be a choice, either as a broader public decision or an individual choice. Perhaps their day-to-day interactions with energy will be more automated and integrated across energy services; maybe they will generate their own electricity; or maybe, the promise of nuclear fusion will finally bear fruit, and energy will be nearly infinitely plentiful, however unlikely. I do not know what the energy future is for my sons, but I know it will be much different from my father's. The energy system is not static and will continue to change.

This dissertation is not about the past or the future—it is about now. But to say that this dissertation is not informed by the past and driven towards a possible and hopeful future would be inaccurate. This dissertation focuses on components of the energy system that are often not thought of as part of the energy system but serve as powerful drivers of change. The relationship my father’s family had with energy was as much about the state of the energy technology as it was about the policy, governance, and politics that impacted it. At the time, electricity service provisioning was not a new technology. In neighbouring Ontario, for instance, electricity services were well established. Political frustrations amongst Quebecers about the cost of electricity, outsider ownership of its utilities, and the slow rollout of rural electrification created a backlash with an accompanying political response in the province. In 1944, Quebec moved towards a public ownership model for its electrical system, part of which would include provisions for rural electrification. At this time, the rural parts of Quebec had limited or no electrical service. Leveraging its natural endowments, Quebec proceeded with a rapid expansion of hydroelectricity. Today, Quebec has one of the lowest electricity rates in the country and a profitable export market. Everyone in the small town where my father grew up now has reliable, affordable energy services—and they would expect nothing less. Times have changed. For my sons, there will be new challenges and opportunities filled with exciting technological innovations with their unique set of policies, politics, and governance. But I ask myself, would I have set my sons on the right course?

Upon pursuing this dissertation, I imagined a version of myself as an expert in all things to do with energy. With this in-depth knowledge, I would be able to paint a picture of a pathway forward. I have since learned that the energy system is much too complex for any one person to understand. Just as my father could not have imagined the changes in the energy system, I too am limited. I do not know what I can tell my sons about their energy future. But what I do know is that the energy system must change and change quickly. Unlike that of my father, the energy system of my sons' future must change and adapt rapidly. Pressures from climate change, the cost of electricity, public involvement in the energy system, and rapid technological innovation are putting immense pressure on the energy system to reinvent itself. How will human ingenuity and innovation shape the world of my sons' future? This dissertation is about *accelerating* energy transitions. For the last five years, I have read intensively, conducted public engagement workshops, interviewed stakeholders and experts, organized conferences, panels, and speaker series, and have had many conversations on how the energy system is changing. The five papers I present in this dissertation are a reflection of these experiences.

Index

Chapter 1: Introduction

Chapter 1: Introduction

That we are in the midst of an energy transition is clear. The rise of renewable energy and the focus on energy efficiency—alongside low carbon technologies like nuclear energy, coal using carbon capture and storage, and natural gas—point to a shift in the energy system. The transition towards a clean energy system fueled by renewable energy, such as wind, solar, biomass, geothermal, and hydroelectricity, can be expected to continue. In 2018 renewable energy generation grew by 14.5%, which represented only a slight decline from its historical average (BP, 2019). Solar energy, in particular, will likely reach a prominent role in the future global energy mix (Breyer et al., 2018). Breakthrough innovation and cost reductions in storage and micro-grid development are showing promise and could overcome a key challenge of intermittency of renewables and support the likely proliferation of electric vehicles (EV) (Gallo, Simões-Moreira, Costa, Santos, & Moutinho dos Santos, 2016; Kittner, Lill, & Kammen, 2017; Nykvist & Nilsson, 2015; Safaei & Keith, 2015).

Energy transitions are not new. Industrial, and predominately western, societies have already faced multiple energy transitions in the last 200 years. The first industrial revolution in the 18th and 19th centuries saw the transition from an extractive and agricultural economy to a suite of transportation and manufacturing technologies using steam power. In the 19th and 20th centuries, major energy transitions continued in the second industrial revolution, with the arrival of gas-powered transportation and widespread electrification. These transitions are long-term processes often involving significant reconfigurations of the energy system, typically taking 50 years to move from diffusion to dominance (Fouquet, 2010). For instance, the transition from gas to electricity for lighting took from 1880 to 1935—65 years (Fouquet, 2010). It was not until costs decreased and service quality improved that electrical lighting became widespread, which follows the general pattern of past energy transitions of increased convenience, reliability, and affordability, and, finally, use. If history is the lesson, the ongoing energy transition will likely take many decades and need to provide superior services than the incumbent energy system.

Whereas past transitions were often long multi-decadal affairs, the current energy transition requires a much shorter time horizon. Reducing carbon emissions to avoid the worst impacts of climate change is essential—and the world has taken notice. Recent work within the energy transitions literature has emphasized the importance of an *accelerated* transition, which would involve transforming the social and technical dimensions of the energy system (C. Roberts & Geels, 2018; Schot

& Kanger, 2018). To advance this agenda, the International Panel on Climate Change (IPCC) has emphasized the need for unprecedented changes in all sectors of society (IPCC, 2018b). The International Energy Agency (IEA) has similarly insisted on the need for *accelerated* changes to the energy system (IEA, 2019). Countries, regions, and cities have been developing plans to pursue the goal of *accelerating* renewable energy and energy efficiency (ex. New Zealand Government, 2019). Even the recently released 17 sustainable development goals from the United Nations, highlight the need for a mix of social and technological "fixes." These pressures, among others, suggest a need for an *acceleration* towards low emissions' technology involving significant social and technical reconfigurations.

Although an accelerated transition is required, the trajectory of the current transition is unfolding in a similar fashion to those of past transitions (Smil, 2016b). If this status quo is maintained, it is highly likely that the internationally agreed upon target of maintaining global temperature increase to 1.5^{o}C will be surpassed (IPCC, 2018b). Fortunately, cases of accelerated energy transitions exist. This dissertation will focus on a particular case of accelerated social and technical transition—decentralized energy (DE). Unlike the broader global energy transition, DE technologies *are accelerating*. The motivations and drivers for this acceleration are many: social entrepreneurship, community development, self-reliance, reduced costs, and lower environmental impact (IEA, 2019b).

Why focus on accelerating DE and not on large-scale renewables or nuclear power? DE can, and often, functions alongside centralized energy generation options. These large-scale sources are essential to the energy mix and are a significant source of global low-emissions electricity generation. As of 2018, nuclear energy represented 10% of the global electricity supply and is likely to continue to grow as a low emissions option (IEA, 2019). Nuclear energy as a large-scale transition pathway, however, is not experiencing an accelerated transition as is DE. Demonstrating an accelerated trajectory, for instance, is small-scale and distributed solar energy, which now accounts for half of the total solar growth (IEA, 2019b). The focus of this dissertation will be on why and how DE is unfolding.

The literature on transitions emphasizes the need for public policy and other social interventions to hasten the pace of transition (Markard, 2018; Turnheim et al., 2019). The approach in this dissertation builds on this tradition. Supported by the insights in the literature on future and past examples of rapid transitions, this dissertation documents the unfolding of an *ongoing* accelerated transition in which (1) the pace of transition is increasing relative to the overall transition (<10 years from concept to implementation), and (2) there exists a deliberate attempt to achieve acceleration. The manuscripts that form the basis of this program of research answer the following two questions:

> **Question One: In the context of accelerated social and technical change, is society or technology the driver?**
>
> **Question Two: How can an understanding of this dynamic be used to further accelerate social and technical change?**

1.1. Dissertation Approach

The focus of this dissertation is highly interdisciplinary because the energy system can be best understood from an interdisciplinary perspective. For many years, the idea that one could study energy from multiple disciplines would have been uncommon. Although rare, there were scholars, such as Hughes and Laird, at the vanguard of interdisciplinary research on energy transitions as early as the 1980s (Hughes, 1983; Laird, 2001). Engineering and economics were the dominant disciplines that drove much of the initial research and analysis in this field (D'Agostino et al., 2011; Sovacool, 2014b, 2014a). Research in the social sciences and humanities rarely addressed energy issues. Research methodologies and attitudes towards research on energy have changed. Since I started this Ph.D., energy as an interdisciplinary field of research has emerged as a burgeoning space of inquiry, including academic journals, research institutes, conferences, and books. Even outside the academy, policymakers and businesses are keen to address energy issues using a broader intellectual toolkit. In hindsight, the fact that the field of energy research was not always interdisciplinary may seem strange now.

Dissertations are, by their nature, narrowly focused. For good reason, the pursuit of adding to human knowledge is necessarily specific, but interdisciplinary research must achieve a delicate balance between specificity and inclusivity, incorporating disciplines and unique approaches to improve the research process. Interdisciplinary researchers are confronted with the challenge of creating boundaries around what *is* and *is not* included in their research, despite the temptation to learn everything. I felt the pull of this temptation and have certainly learned a lot. I believe, however, that this dissertation draws from the strengths of interdisciplinary research—cross-discipline knowledge synthesis, collaboration with multiple disciplinary scholars, and creative problem solving—while avoiding its pitfalls—over inclusion of disciplines and breath at the expense of depth. To operationalize interdisciplinarity, I constructed the dissertation as a program of research with five manuscript chapters, each addressing components of larger research questions on accelerating social and technical transitions.

The manuscript chapters comprising this dissertation each address components of DE transitions based on research from public engagement activities, governance, energy justice, and transitions' futures. The concluding chapter synthesizes aggregated contributions of the manuscripts and provides a response to the two research questions. This introductory chapter provides relevant background information about energy, sustainability transitions, and DE. Beginning with a brief history of DE, DE is discussed as a concept, an overview of socio-technical transitions is presented, and sustainability transition theories are reviewed. After this background information, the dissertation structure and chapters are summarized. This contextual understanding sets the foundation for the remainder of the dissertation.

1.2. Decentralized Energy

1.2.1. A History

Renewable and DE has been the norm—not the exception—throughout history. In fact, for most of human history, decentralized renewable energy was the only available source of energy (Sørensen, 1991). Biofuel, in the form of dung or wood, has provided a source of heat for most of human evolutionary history. Evidence shows that humans were using fire 350,000 years ago —predating our evolutionary lineage from *Homo Erectus* to *Homo Sapiens*. Deeply ingrained in the human evolutionary story, energy is linked to our ability to use energy to survive and thrive in nearly every terrestrial environment. The ancient Greeks and Romans famously used parabolic mirrors to harness the Sun. With a shortage of fuelwood, they found that harvesting the sun afforded them a local and decentralized source of energy. It is only in the 20th century that non-renewable and highly centralized energy has become the predominant source of energy. Large-scale energy generation units that predominate our energy system have been added to our repertoire of energy options in the last 100 years—a quick and recent change in human evolutionary terms.

Patterns of DE have emerged alongside the push towards ever-larger centralized generation. The electricity system was initially decentralized. Small intercity street lighting systems were developed as early as the 1880s (Hughes, 1983). Edison's electric illuminating system that went into operation in New York City in 1882 began an innovation revolution in cities around the world. Developments in alternating current (AC) incrementally shifted the energy paradigm from decentralized to centralized facilities. This configuration involves electricity moving from high voltage to low voltage and developing highly centralized and nationalized systems of electricity distribution. AC and centralized electricity production have since become the norm in most districts and have increased the global standard of living. The 1970s to the 1990s saw the beginning of liberalization and unbundling of generation, transmission, and distribution of electric utilities.

Modern innovations in Information Communication Technologies (ICTs), microgrids, and various renewable energy innovations are creating an opportunity for another transition in the energy paradigm. There are many notable benefits of a decentralized configuration. DE has been shown to better deal with the challenges of intermittency, scalability, cost-effectiveness, and environmental concerns (Ambec & Crampes, 2012; Lo Prete et al., 2012; Orehounig, Evins, & Dorer, 2015; Quiggin, Cornell, Tierney, & Buswell, 2012; Sonnenschein, Lünsdorf, Bremer, & Tröschel, 2014; Thakur & Chakraborty, 2015; Weidlich et al., 2012; Yang, Entchev, Ghorab, Lee, & Kang, 2014; Zahedi, 2011). DE can be used to manage peak loads and standby capacity (Pepermans, Driesen, Haeseldonckx, Belmans, & D'haeseleer, 2005). There is also evidence that decentralization can create greater grid resiliency, technological flexibility, and opportunities for small business and community investment (Alanne & Saari, 2006a; Atzeni et al., 2013; Bouffard & Kirschen, 2008; Coaffee, 2008; Droege, 2002; Faber et al., 2014; Fonseca & Schlueter, 2013; Thakur & Chakraborty, 2015; Walker, Hunter, Devine-wright, Evans, & Fay, 2007). DE has been shown to reduce emissions (Akorede, Hizam, & Pouresmaeil, 2010; Hughes, Chaudhry, & Ghani, 2011). As well, decentralization has the potential to provide an array of societal benefits to the local economy, to reduce poverty (Alanne & Saari, 2006b; R. W. Saunders, Gross, & Wade, 2012; Walker, 2008), to provide novel ownership structures, and to offer unique opportunities for local empowerment (Bomberg & McEwen, 2012; Orehounig et al., 2015; Seyfang, Park, & Smith, 2013). DE has been shown in the literature to increase energy diversity, innovation, learning, and flexibility, all of which contribute to adaptive capacity and power sector resiliency (Meerow & Baud, 2012). The lower initial and incremental capitals costs for DE projects allow for novel implementation strategies as well as opportunities for more equitable distribution in low income jurisdictions (Hiremath, Kumar, Balachandra, & Ravindranath, 2011; Mohammed, Mustafa, Bashir, Ogundola, & Umar, 2014; Rojas-Zerpa & Yusta, 2014; Turkson & Wohlgemuth, 2000). DE has been shown to distribute institutional power dynamics that are typical of many monopolistic utility firms (Meyer, 2003).

1.2.2. DE as a Concept

Since I began this dissertation, research on DE has been prolific. In the last three years alone, research on DE has included work as varied as privacy and security issues of micro-grid developments (Zhumabekuly Aitzhan, Svetinovic, & Zhumabekuly Aitzhan Nurzhan; Svetinovic, 2016), management and simulations (Karavas, Arvanitis, & Papadakis, 2017; Karavas, Kyriakarakos, Arvanitis, & Papadakis, 2015; Kofinas, Dounis, & Vouros, 2018; van der Klauw, Gerards, & Hurink, 2017), the incorporation of battery technology (Murray, Orehounig, Grosspietsch, & Carmeliet, 2018), and developments in blockchain and how it can integrate with DE (Imbault, Swiatek, De Beaufort, & Plana, 2017). There is also a growing and recent literature on non-technical developments in DE, such as economics (Casey, 2018; Liu, Zuo, Liu, Liu, & Kennedy, 2018; Thomsen, 2018; Vimpari & Junnila, 2017), community investment and finance (Curtin, Mcinerney, Gallachóir, & Salm, 2019), political dimensions (Aunphattanasilp, 2018; Burke & Stephens, 2018; van Veelen & van der Horst, 2018), ethical and justice issues (Boucher, 2016; Dolter & Boucher, 2018; Pinker, 2018), socio-technical transitions and public policy (Adil & Ko, 2016; Skjølsvold, Throndsen, Ryghaug, Fjellså, & Koksvik, 2018), and governance considerations (Delina, 2018; Lammers & Diestelmeier, 2017).

Despite the proliferation of publications, there remains little, if any, consensus in the literature on the defining parameters and terminology of DE (Alanne & Saari, 2006b; Wolfe, 2008a). Wolfe (2008) defines DE as "the production and distribution of energy within the boundaries of, or located nearby and directly connected to, a building, community or development" (p. 4509). Although this broad definition of DE covers the spectrum found in the literature, in general, there is no consensus on the definition (Alanne & Saari, 2006c; Bazmi, Zahedi, & Hashim, 2011; Keirstead, 2008a; Rojas-Zerpa & Yusta, 2014; Soshinskaya, Crijns-Graus, Guerrero, & Vasquez, 2014; Turkson & Wohlgemuth, 2000; Wolfe, 2008b). Much of the emphasis in the literature is on specific technologies. Distributed generation, micro-generation, and local power are among many the terms used to describe the scaling down and decentralizing of the electricity system. DE technologies include co-generation, biomass power, small-scale wind power, photovoltaic power, biogas, and wind power (Bazmi et al., 2011; Keirstead, 2008b), as well as demand-side management technologies such as energy efficiency and conservation (Stadler & Bukvić-Schäfer, 2003). In other words, DE is not focused on one particular technology but can instead be understood as a strategy that includes various generation, distribution, and conservation technologies that work in tandem.

Summary of defining parameters of DE:

- *Proximity* — Generation is in close physical proximity to end use (i.e. within community, town, or city).
- *Relative Size* — Amount of generation is small at any given single point.
- *Strategy* — A combination of technologies, which could include synergies between generation, distribution, and conservation options are used.

For this dissertation, DE is understood as energy generation or energy efficiency at the municipal level at different scales of energy production from individual users, to the neighbourhood, to an entire city (Aiken, 2012). The dissertation recognizes that there are conceptual differences between centralized and decentralized configurations (see Table 1.1).

Table 1.1

Conceptual differences between centralized energy and decentralized energy

Centralized Energy	**Decentralized Energy**
Few large-scale energy production facilities	Many mixed-scaled energy production facilities
Command-and-control paradigm	Network paradigm
Vertical integration	Horizontal integration

Source: (Boucher, 2016)

That centralization can be disrupted or destabilized by DE can be represented on a spectrum (see Figure 1.1): conservation, local generation, and distributed generation. Conservation is decentralized in that it disrupts the reliance on the centralized grid. As an example, a zero-carbon home, such as a passive house, may be disruptive to the centralized grid by decreasing reliance on the overall infrastructure service. Local generation includes solar, wind, and geothermal power that is produced at a municipal scale. Localized generation is decentralized because it disrupts the prevailing electricity regime by producing energy inputs to the centralized grid or by being self-reliant. At the end of the spectrum is distributed generation, which includes various generation, distribution, and conservation technologies that work in tandem. Demand-side management technologies and provisions such as energy efficiency and conservation are also central to DE. Along the entire spectrum, they can further destabilize the centralized regime.

Figure 1.1

Spectrum of decentralization

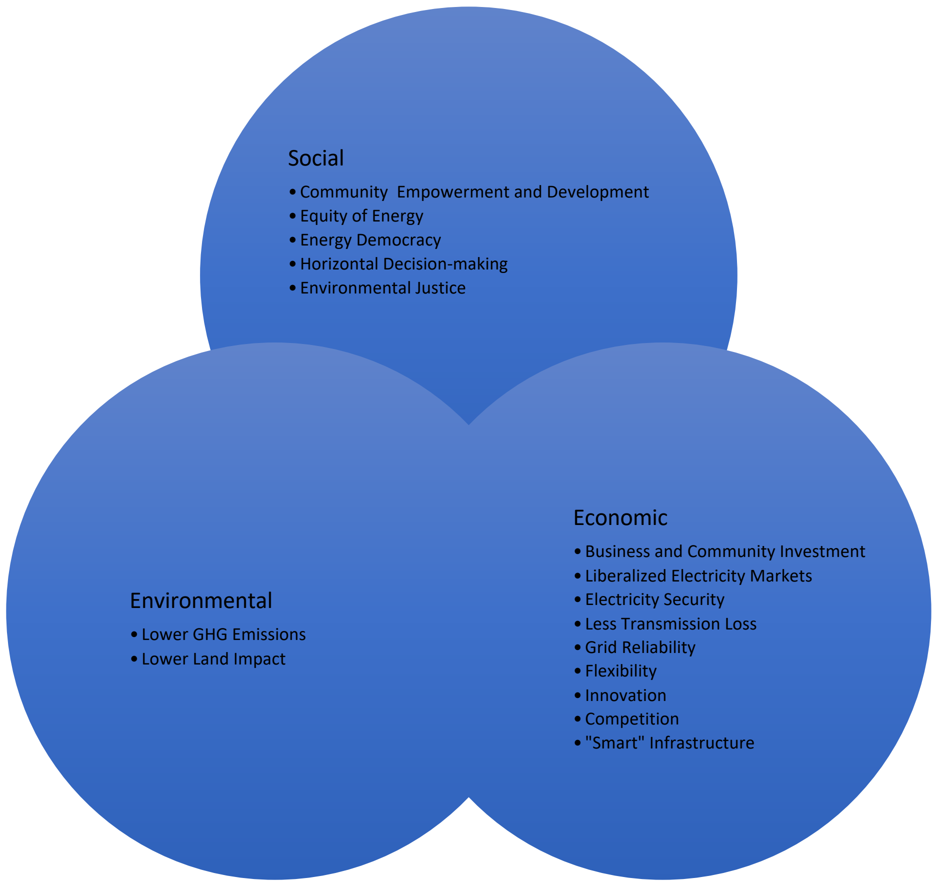
1.3. Sustainability and Decentralized Energy

The literature recognizes that there are sustainability benefits for DE. Fields of study need to move away from their “narrow academic disciplinary subdivision” and focus more broadly on “sustainability and environmental impact mitigation of the energy sector” (Manfren, Caputo, & Costa, 2011, p. 1033). DE involves not only the physical infrastructure but also political, economic, and social considerations (Alanne & Saari, 2006c; Wolfe, 2008b). A shift from centralized to more decentralized electricity production, therefore, poses significant complexity challenges (Karger & Hennings, 2009). The literature on DE is informed by disciplines including public policy, engineering, business, finance, economics, community studies, development studies, political science, environmental science, computer science, planning, technology studies, and behavioural science.

In the literature, there is a diversity of definitions and frameworks on the concept of sustainability. Many scholars use the term sustainability narrowly to simply mean an overall reduction in carbon equivalent emissions (Chen et al., 2008; Clark & Isherwood, 2004; Keirstead, 2008a; Meyer, 2003; Williams, 2010). Others incorporate a broader definition of sustainability in their analysis: "The concept of sustainable development is evolved for a liveable future where human needs are met while keeping the balance with nature" (Bazmi et al., 2011, p. 575). Others focus on the sustainable development of a region, arguing that “improving energy efficiency and de-linking economic development from energy consumption (particularly of fossil fuels)” is essential (Ramachandra, p. 286, 2009). Some scholars argue that DE can offer more supply security and reliability than a centralized grid network (Karger & Hennings, 2009; Meyer, 2003). This is especially true for small island states (Stuart, 2006). There is a vast array of perspectives on how DE potentially aligns with sustainability. Figure 1.2 summarizes the various aspects of DE connecting them with each pillar of sustainability.

Figure 1.2

Nexus of sustainability and decentralized energy



1.4. A Review Energy Transitions and Socio-technical Systems

Many scholars have addressed the temporality and speed of transitions required to decarbonize the energy system (Fouquet, 2016; Grubler, Wilson, & Nemet, 2016; Smil, 2016a; Sovacool, 2016; Sovacool & Geels, 2016). Knowledge of past energy transitions and pathways may help bring an understanding to posterity (Chabrol, 2016; Fouquet & Pearson, 2012; Grubler, 2012; Hirsh & Jones, 2014). Smil is critical of the claim that the energy transition has the potential to expand rapidly within the global energy system (Smil, 2016b), noting that the global transition to renewables over the past 25 years has been slower than past energy transitions. Smil (2016b) concludes the following:

> Their [renewable energies'] share has roughly doubled in 25 years, growing at an average annual rate of about 3%, not an unusually rapid expansion during early stages of energy transitions: coal was gaining at a rate of more than 5%/year between 1850 and 1870, oil gains averaged more than 8%/year during 1880–1900, and natural gas gained its global market share at 6%/year between 1920 and 1940 (p. 195).

The IEA agrees with the slow pace of renewables in its recent global energy analysis, noting, "cost reductions for renewables, on their own, will not be enough…" and arguing that "structural changes in the design and operation of the power system are needed" (IEA, 2016, p. 4). Sovacool (2016) argues that despite the slow pace, the modern context is unique amongst previous energy transitions. He highlights four characteristics of why this transition is unique: a scarcity of resources, rapid decline in the price of renewable energy; new scales of energy implementation; and new values associated with energy.

According to Sovacool (2016), there are four main conceptual approaches found in the literature on energy transitions (see Table 1.2): *(1) political ecology, (2) sociology and social practice theory, (3) ecological modernization theory,* and *(4) socio-technical transitions.*

Table 1.2

Four key conceptual approaches to understand energy transitions

	Socio-technical transitions	**Ecological modernization theory**	**Sociology and social practice theory**	**Political ecology**
Disciplines	Science and technology studies, evolutionary economics, structuration theory	Environmental science, environmental sociology, policy studies	Sociology, anthropology, and cultural theory	Human geography, ecology, political geography
Focus	The development or introduction of new technologies leading to new socio-technical configurations	Environmental regulation, reform, and governance	Changing practices, habits, socialization, normalization	Contestation, enclosure and exclusion, accumulation by dispossession, global production networks, neoliberalism
Key Authors	Frank Geels, Johan Schot, Arie Rip, Frans Berkhout, René Kemp, Wim A. Smit, Thomas Hughes	Ulrich Beck, Maarten Hajer, APJ Mol, FH Buttel, Richard York, Martin Jaenicke	Elizabeth Shove, Gordon Walker, Loren Lutzenhiser, Harold Wilhite	David Harvey, Michael Watts, Paul Robbins, James McCarthy, Gavin Bridge

Source: (abridged version from (Sovacool, 2016))

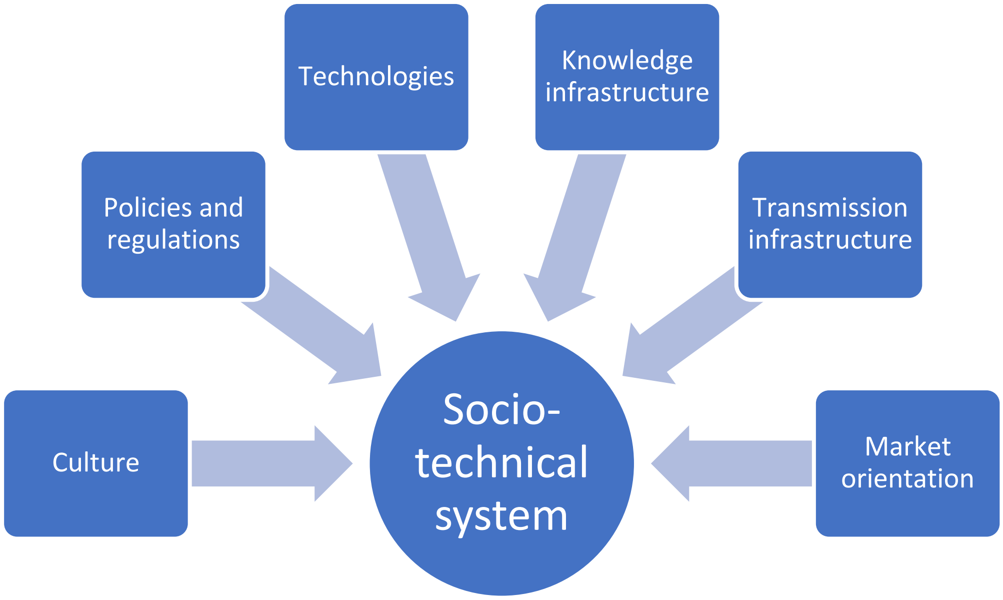
The focus of this dissertation is socio-technical transitions to DE, with a particular interest in sustainability transitions theories (STTs). It is important to highlight that there is overlap between Sovacool's categories, particularly with socio-technical transitions. Ecological modernization theory, sociology and social practice theory, and political ecology all have a disciplinary focus. However, socio-technical transitions are not linked to disciplines in the same way. Rather, they are frameworks that can be inclusive of many disciplines. STTs attempt to bring together a range of disciplines to understand and impact the socio-technical transition to goals related to social and environmental sustainability. Meadowcroft points out that "literatures on institutional economics, the sociology of technology, and innovation studies all point to ways in which society can become trapped in sub-optimal outcomes" (Meadowcroft, 2009, p. 329). STTs are not intended to stay within disciplinary boundaries but instead to be inclusive to develop a robust framework for the interpretation and understanding of transitions. Markard et al. (2012) argue that "*Sustainability transitions* are long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption" (p. 956). The authors further note that although STTs originated in the disciplines of innovation studies and evolutionary economics, "socio-technical transitions differ from technological transitions in that they include changes in user practices and institutional (e.g., regulatory and cultural) structures, in addition to the technological dimension" (Markard et al., p. 956). In sum, STTs are built on the understanding of transitions as dynamic multi-decadal processes. The focus is not on fixed outcomes but instead on the transition process itself.

There has been much interest in STT recently. *The Journal of Environmental Innovation and Societal Transitions* has provided a platform for literature in this field. A further platform is provided by the Sustainability Transitions Research Network (STRN), a network of scholars located internationally that holds bi-annual conferences. There has also been an exponential increase in academic publications in this field over the past 20 years (Markard et al., 2012; Turnheim et al., 2019).

STTs are built around the concept of a socio-technical system (see Figure 1.3). A socio-technical system involves market preferences, culture, regulations, physical and knowledge infrastructure of a particular technology or industry (Martens, 2015).

Figure 1.3

Socio-technical System



Source: (adapted from (Kern & Smith 2008))

STTs focus on the interplay of three different levels: *(1) socio-technical niche, (2) socio-technical regime,* and *(3) socio-technical landscape.* These three levels are oriented as an interdependent hierarchy. Meadowcroft (2009) notes that the three levels are,

> a basket of future oriented visioning devices (goal, visions, pathways and intermediate objectives); a practical focus for activities (arenas and experiments); and a broad 'philosophy of governance' that emphasizes decision-making in conditions of uncertainty, and the gradual adjustment of existing development pathways in light of long term goals (p. 325).

In the sections below, I discuss the defining parameters of each of the three levels.

(1) Socio-technical Niche

Initially, niches were understood to be novel technologies with sustainable attributes. This term has since been expanded to include novel social configurations as well as technologies. For instance, outside social actors, such as environmental activists, can be important contributors to niche development (Smith, Voß, & Grin, 2010). A niche involves new actors and innovations that are protected via a range of policies, such as subsidies or regulations (Smith et al., 2010). A niche may or may not make its way through the current regime. Niches are technological and include social innovations that have not yet achieved social legitimacy in the mainstream. According to Raven and Geels (2010), "The basic idea is that the emerging community carves out a protected space for the new technology" (p. 89).

Moreover, niches "form the micro-level where radical novelties emerge" and "these novelties are initially unstable sociotechnical configurations with low performance" (Geels & Schot 2007, p. 400). Niches attempt to disrupt and infiltrate the regime by various processes that may include political pressure, technological outperformance of the existing regime, and social transformation, to name a few. There is no single or clear path for the niche to become part of the regime; however, multiple pathways have been suggested. These are discussed later in the chapter.

(2) Socio-technical Regime

The socio-technical regime consists of the existing and dominant system. As Smith et al. (2010) point out, "Socio-technical regimes are structures constituted from a co-evolutionary accumulation and alignment of knowledge, investments, objects, infrastructures, values and norms that span the production-consumption divide" (p. 441). A regime is the incumbent institutions, technologies, and regulations that are currently in place. There is not a precise definition of socio-technical regime (Geels, 2002). Incumbents within the regime are often resistant to the niche, which may disrupt their role within the regime. In this way, path dependency, or lock-in, can be created within the regime. However, the regime is not always stable, and windows of opportunity at times exist where the niche can upend the regime. In a study on the Dutch energy transition, Bosman, Loorbach, Frantzeskaki, and Pistorius al. note that "regime destabilization is a process resulting from strings of cascading pressures" (p. 2014). This tension is discussed in the sections below.

(3) Socio-technical Landscape

The socio-technical landscape occurs at the macro level, involving broad economic policies, environmental constraints, political ideology, and culture (Smith et al., 2010). The landscape is the meta-level, which includes factors such as social movements, political affiliations, culture, and macro-economic conditions (Smith et al., 2010). According to Geels and Schot (2007), "The sociotechnical landscape forms an exogenous environment beyond the direct influence of niche and regime actors (macro-economics, deep cultural patterns, macro-political developments). Changes at the landscape level usually take place slowly (decades)"(p. 400). Landscape changes can place significant pressure on the regime that demands a shift within the regime. In this instance, there may be a window of opportunity for the niche to take hold within the regime. Once again, this is discussed further in the section below.

1.5. Sustainability Transition Theories

The most prominent of the STTs are transition management theory (TM) (Jan, Kemp, & van Asselt, 2001; Kern & Smith, 2008; Loorbach, 2010), technological innovation systems (TIS) (Bergek, Jacobsson, Carlsson, Lindmark, & Rickne, 2008; Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007; Jacobsson & Johnson, 2000), strategic niche management (SNM) (Kemp, Schot, & Hoogma, 1998; R. P. J. M. Raven & Geels, 2010; Smith, 2007), and multi-level perspective (MLP) on socio-technical transitions (Geels, 2002; Frank W. Geels & Schot, 2007; Smith et al., 2010). These STTs are used to understand and describe socio-technical regime shifts toward sustainability goals. Sustainability within the sustainability transitions framework is primarily understood as a reduction in environmental impacts. This can take the form of GHG emissions reduction or the ecological and land use impacts of energy technologies and infrastructures.

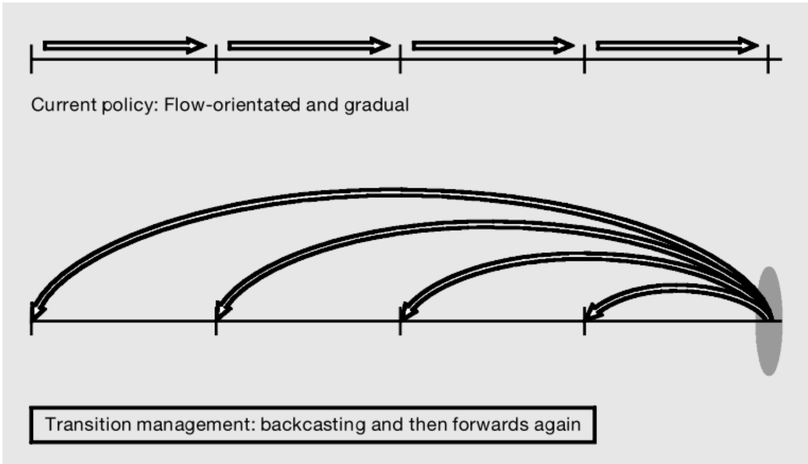
1.5.1. Transition Management (TM)

TM attempts to help scholars understand, and as the name implies, actively manage sustainability transitions. TM is interdisciplinary and rooted in evolutionary economics and systems theory (Meadowcroft, 2009). In addition to the management aspect, TM can also be understood as an intellectual framework that uses a historical dialectical approach to understand future policy transition positioning (Jan, Kemp, & van Asselt, 2001; Kern & Smith, 2008; Loorbach, 2010). In other words, the transitions of the past are instrumental in informing the transitions of the future.

The emphasis of TM is on long-term societal and sustainability goals while providing short-term operational actions. Its focus is on long-term visions (at minimum 25 years), "which function as a framework for formulating short-term objectives and evaluating existing policy"(Jan et al., 2001, p. 23). Conventional policymaking typically functions in the short term. TM was developed out of a need to provide a governance framework to solve modern day complex problems and long-term challenges (Loorbach, 2010). The idea is to respond to the challenge of complexity in a dynamic process of negative feedback. In order to do so, "the structural uncertainties surrounding future development necessitate more explorative, experimental, and reflexive approaches" (Loorbach, 2010, p. 164). In this way, TM is a management practice that uses back-casting in a continual process of reorientations and refinements (see Figure 1.4).

Figure 1.4

Back-casting of short-term and long-term objectives



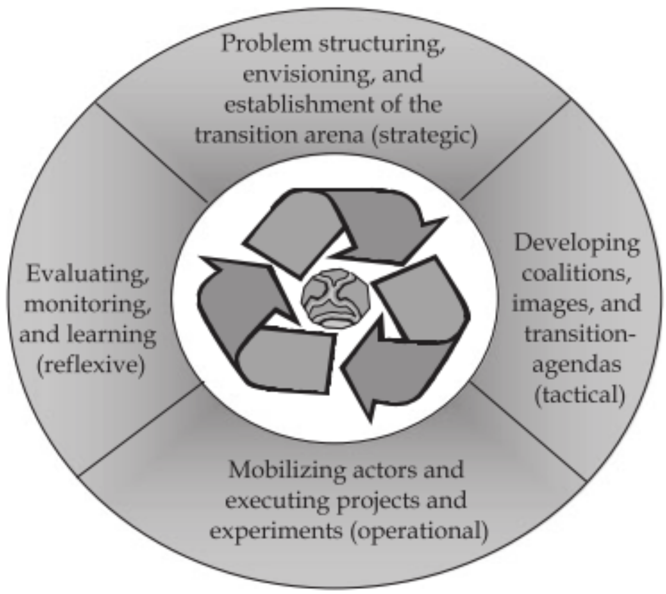
Source: (Jan et al., 2001)

In TM, societal transitions are understood as a nonlinear process. TM uses a dynamic and co-evolutionary approach as a governance framework. TM seeks to bring together actors to create aligned visioning and goals. In this way, "all social actors look to government to take the lead" (Jan et al., 2001, p. 30). Using the instruments of government, it attempts to steer and serve as a guiding force towards a particular sustainable goal. In practical terms, TM involves establishing strategic innovation networks and collaborative opportunities, or so-called "transition arenas" of public and private actors to both create a shared vision and objectives. Actors, in this case, may be quite diverse from various parts of civil society. The role of the government in TM is to facilitate this co-learning process, which can help garner both public support and regime alignment with short-term and long-term goals.

Loorbach (2010) developed a TM model with four activities created as cyclical feedback: *(1) Strategic, (2) Tactical, (3) Operational,* and *(4) Reflexive* (see Figure 1.5). (1) The strategic activities focus on *culture* and involve the visioning process between actors to develop and refine long-term goals. These activities also include an assessment of the political landscape. (2) Tactical activities focus on *structures* and involve setting in motion short-term policies. These may include enacting subsidies for novel technologies, funding for R&D, or changing regulation. (3) Operational activities focus on *practices* and involve establishing experiments to encourage the proliferation of innovation. The intent is to encourage the development of "societal, technological, institutional, and behavioral practices that introduce or operationalize new structures, culture, routines, or actors" (Loorbach, 2010, p. 170). (4) Reflexive activities involve assessment, analysis, and evaluation of the governance process.

Figure 1.5

Transition Management Cycle



Source: (Loorbach, 2010)

TM has faced criticism for being too limited because it functions primarily within the regime (Jan et al., 2001). In a later work, Jan et al. (2014) point out that TM “tries to utilize two-world options: options that are viable both in the existing system and in a system that satisfies the transition objectives” (p. 25). In 2001, Holland implemented TM as a policy with the Fourth Dutch National Environmental Policy Plan, but a case study analysis found that radical niches had difficultly impacting the regime (Kern & Smith, 2008). For instance, the Dutch government, in conjunction with actor groups, developed a set of criteria for niche innovations; however, the criteria "unduly neglect[ed] social and institutional innovations and accentuate[d] marketable technological fixes" (Kern & Smith, 2008, p. 4099). Social and technological innovations that may be highly disruptive and not fully market-ready do not fit well within the TM approach. Smith (2007), also argues that "Transition management recovers a role for niches, but the precise relations between niche and regime still requires further analytical attention" (p. 431).

1.5.2. Strategic Niche Management (SNM)

As the name suggests, Strategic Niche Management (SNM) is a process that focuses on the strategic management of niche innovations. The intent is to create opportunities for niche innovations to make regime shifts for incorporation into the regime (Kemp et al., 1998). Niche innovations under the SNM framework are defined as new technological innovations that have preferable sustainable attributes but are not currently part of the socio-technical regime. In other words, they are not in the mainstream or may not be fully market ready. A modern example is electric vehicles (EVs). Although the electrification of motor vehicles is associated with lower GHG emissions,[1] there are notable barriers to the widespread implementation of these vehicles, including prohibitive costs, lack of charging infrastructure, and performance, cultural, and regulatory challenges. SNM can help manage these barriers, while acting as a catalyst to transition to a regime with EVs. In practical terms, SNM of EVs may take the form of providing special financial incentives to reduce cost barriers, generating research and development spaces to improve performance, and creating regulations to allow this technology to proliferate. Overall, those using SNM seek to strategically align policies to create a regime shift from the status quo to environmentally sustainable practices emphasizing niche development.

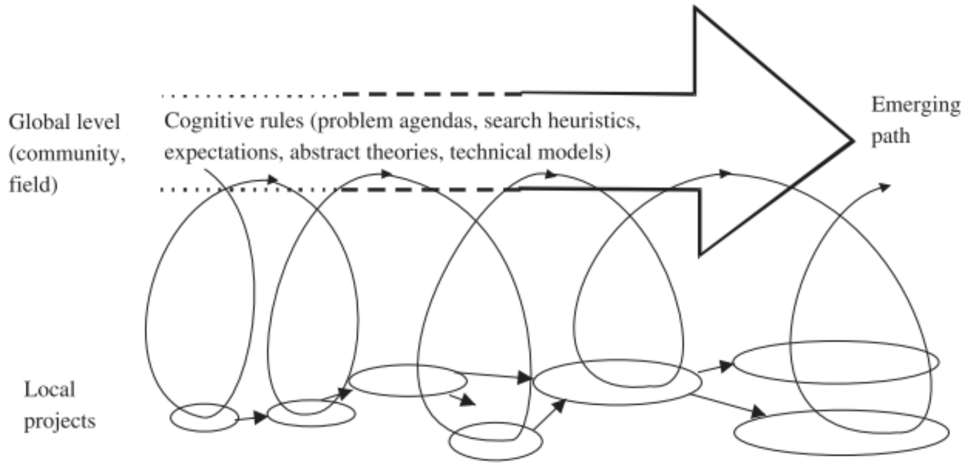
SNM is a process of co-evolving interaction with the niche and incumbent regime such that a new stable regime is created. In this way, SNM builds on the concepts of social constructivism and evolutionary economics (R. P. J. M. Raven & Geels, 2010), based on experience that "suggests radical changes begin within networks of pioneering organizations, technologies and users that form a *niche* practice on the margins of a regime" (Smith 2007, p.429). To facilitate this process, SNM "is more likely to act as a stepping stone, which facilitates—rather than forges—change in a new direction" (Kemp et al. 1998, p.191). Through a heuristic process of technological selection by the regime, the niche development is co-evolutionary (see Figure 1.6).

Figure 1.6

Strategic Niche Management

---

[1]EVs in jurisdictions with high levels of fossil fuel-based electric generation may have higher GHG emissions than gas or diesel-fueled vehicles.



Source: (Raven & Geels, 2010)

Figure 1.6 shows the adaptive development of niche innovations towards an emerging path. There is a paradoxical challenge with SNM and radical niche formation. Key to SNM's success is alignment and compatibility with the niche and the incumbent regime. Radical niches that involve significant institutional challenges to the incumbent regime "will not diffuse much at all since they demand too many (structural) changes" (Smith 2007, p. 430). In this situation, a stable niche and a highly unstable regime may create an opportunity for the niche innovation to make a regime shift (Smith, 2007).

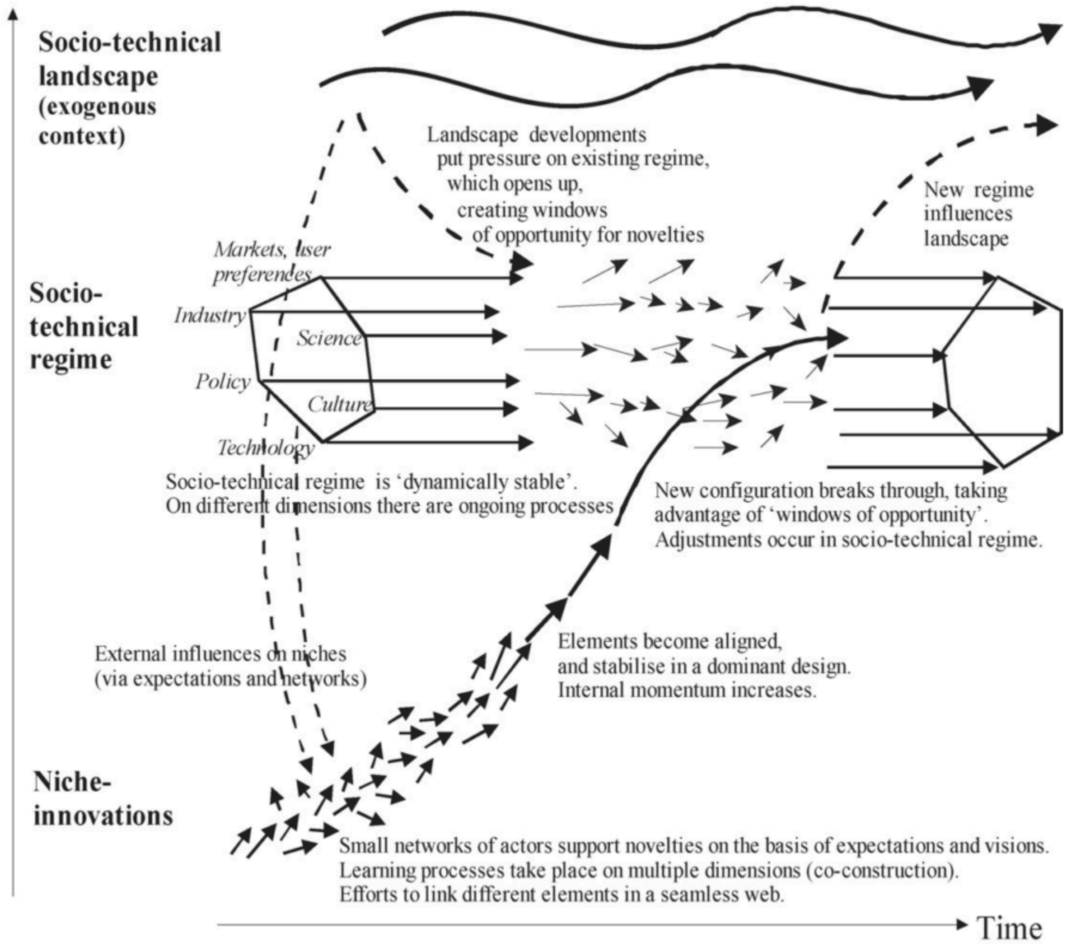
1.5.3. Multi-level Perspective (MLP)

The Multi-level Perspective (MLP) builds on the understanding that there are dynamic interactions between the niche and regime level of SNM. MLP adds the landscape level, which includes political economy, environment, and culture (see Figure 1.7). MLP on socio-technical transitions argues that a transition occurs as a result of alignments between a multiplicity of actors at the niche, regime, and landscape-level (Geels, 2002; Geels & Schot, 2007; Smith et al., 2010). Therefore, in the MLP, there are three levels organized in a nested hierarchy: niche, regime, and landscape. Furthermore, "The MLP developed out of explanations for historic transitions to new socio-technical systems for mobility, sanitation, entertainment, food, lighting and so on. Successful systems are constituted from networks of artefacts, actors, and institutions and gain stability and path-dependence as particular 'socio-technical regimes' (e.g. the regime of centralised power generation on the basis of fossil and nuclear fuels)" (Smith et al., 2010, p. 436). Similar to SNM, the niche innovators and actors attempt to break into the socio-technical regime to create a new regime. A notable critique of the MLP is the focus on the agency of the niche to be the primary source of the intervention of the regime (Smith, 2007). However, the MLP also adds a temporal dynamic to transitions by emphasizing windows of opportunity between the niche, regime, and landscape. For instance, the regime may be altered by interactions with the landscape and niche by creating windows of opportunity for niche developments to destabilize the incumbent regime and insert itself into a newly formed socio-technical regime (Geels, 2014). In other words, through a combination of national politics and regulatory policies (landscape level), institutional transformations (regime level), and technological innovations and culture (niche level), socio-technical regime change can occur.

Consider the example of London and its delayed, but eventual, transition to a centralized electricity system. In the early 1900s, London, England, had a strong emphasis on the need for electric power. London was a significant industrial power, and a supply of reliable and affordable electricity seemed a good fit. However, London was lagging behind similarly sized cities like Chicago, USA and Berlin, Germany, that had a much more centralized and ordered electricity supply (Hughes, 1983). Berlin and Chicago had a universal electricity system, and London did not. At the time, "Greater London had sixty-five electrical utilities, forty-nine different types of supply systems, ten different frequencies, thirty-two voltage levels for transmission and twenty-four for distribution, and about seventy different methods for charging and pricing" (Hughes 1983, p. 227). The MLP perspective explains the resistance of the socio-technical transition to niche innovations. There were significant challenges with the socio-technical regime in London that did not exist in the same way for Chicago and Berlin. London had administrative complexity and a long history of tradition within the government, which both presented significant obstacles (Hughes, 1983). At the socio-technical landscape and political level, there was a philosophical debate and controversy over the ownership structure of city-level electricity. The notable Fabian Society rose at this time and argued that the electric utilities should be municipally owned (Hughes, 1983). Additionally, “Parliamentary law forbade the institutional amalgamation of utilities” (Hughes 1983, p. 255). Put together, this posed a significant challenge for London to transition its electrical system, although there were readily available technologies to facilitate this transition. This can be juxtaposed to Chicago's politics of technological development and economic growth and Berlin's focus on collaboration and cooperation between stakeholders. The results were dramatically different pathways in electricity system development with Chicago and Berlin surpassing London with a robust and reliable centralized electricity system.

Figure 1.7

A Dynamic Multi-level Perspective on Transitions



Source: (Geels, 2002; Geels & Schot, 2007)

Within the MLP framework, there are four transition pathways (Geels & Schot, 2007; Martens, 2015). These four pathways, developed by Geels and Schot (2007), explain the temporal alignments that can occur and create the window of opportunity for a transition to a new socio-technical regime. They are *(1) Transformation, (2) Technological substitution, (3) Reconfiguration,* and *(4) De-alignment and re-alignment*. A summary of each of the transition pathways is found below.

(1) Transformation path

The transformation path occurs when there is a transformational change at the landscape level that makes way for opportunities for niche innovations to enter the regime. This can take form as large-scale social movements that "can mobilize public opinion and lobby for tougher regulations" (Geels and Schot 2007, p. 406). In this path, the niche need not be fully developed. The pressure from the landscape may be strong enough to encourage the further development of the niche. As Geels and Schot (2007) note, the development of sanitation systems in the 1870s to 1880s within cities is an example of this process. Cleanliness and hygiene became of high public concern and this placed significant pressure on the regime and niche to develop the necessary technologies and solutions.

(2) Technological substitution path

The technological substitution path occurs when radical niche innovations are fully developed, but the regime remains stable and resistant to the infiltration of the niche. In this path, temporary pressure from the landscape, or a "shock" creates an opportunity for the niche to break through the existing stable regime. Incumbents are highly resistant to this process, and the niche innovation would disrupt or displace actors within the regime. British shipbuilding is an example of this process (Geels, 2002). At the time, the 1850s to 1860s, steamships were relegated to the niche but proved to be superior, in terms of speed and reliability, to their sailboat counterparts (Geels & Schot, 2007). Incumbent actors within the regime were resistant to their uptake. However, a shift in the landscape in the form of a subsidy for steamships made them cost-competitive, and they soon substituted sailboats as the primary form of waterway transport in Britain.

(3) Reconfiguration path

The reconfiguration path occurs when there is a synergistic alignment between the niche and the regime but would, in turn, cause a reconfiguration of the regime. In this path, the niche emphasis is on replacement, alteration, or addition of a component of the regime. In this way, the regime would be changed but not as fundamentally as the other pathways. Furthermore, "The reconfiguration pathway is especially relevant for distributed sociotechnical systems that function through the interplay of multiple technologies (agriculture, hospitals, retailing). In these distributed systems, transitions are not caused by the breakthrough of one technology, but by sequences of multiple component-innovations" (Geels & Schot, 2007, p. 411). The United States' development of mass production of factories from the 1850s to the 1890s would be an example of this pathway (Geels & Schot, 2007). Mass production did not evolve with complete replacement of the traditional factory but instead involved component changes. New sources of energy supply like electricity gave way to increased convenience via lighting and reliability. Interchangeable parts facilitated by new machine tools increased the speed of assembly (Geels & Schot, 2007). These are just two of a long list of examples that illustrate the reconfiguration path with mass production in American factories. The premise is that the regime would remain relatively intact while seeing an organizational restructuring with novel components.

(4) De-alignment and re-alignment path

The de-alignment and re-alignment path occurs when landscape pressure destabilizes the regime; however, there are no sufficient niche innovations to fill the window of opportunity in the regime. As a result, multiple niche innovations develop and compete for their place within the regime. This is similar to the transformation path in that the landscape is the main instigator of regime instability. In the transformation path, however, the regime remains intact, and regime incumbents can still be resistant to the niche. In the de-alignment and re-alignment path, "Incumbents lose faith in the potential of the regime to respond" (Geels & Schot, 2007, p. 408). This uncertainty creates space and opportunity for competition and experimentation at the niche level. Geels and Schot (2007) point out the American example of horse-drawn carriages. With the expansion of urbanization, concerns for hygiene and cost created significant landscape pressure on the regime. This resulted in a de-stabilized regime open to many possible niche developments. At the time, this included several innovations like electric trams, electric and gasoline automobiles, and bicycles. Eventually, the gasoline automobile took hold and was able to attend to the concerns of hygiene, cost, and travel distances from urbanization; and entirely replaced the use of horse-drawn carriages.

1.5.4. Technological Innovation Systems (TIS)

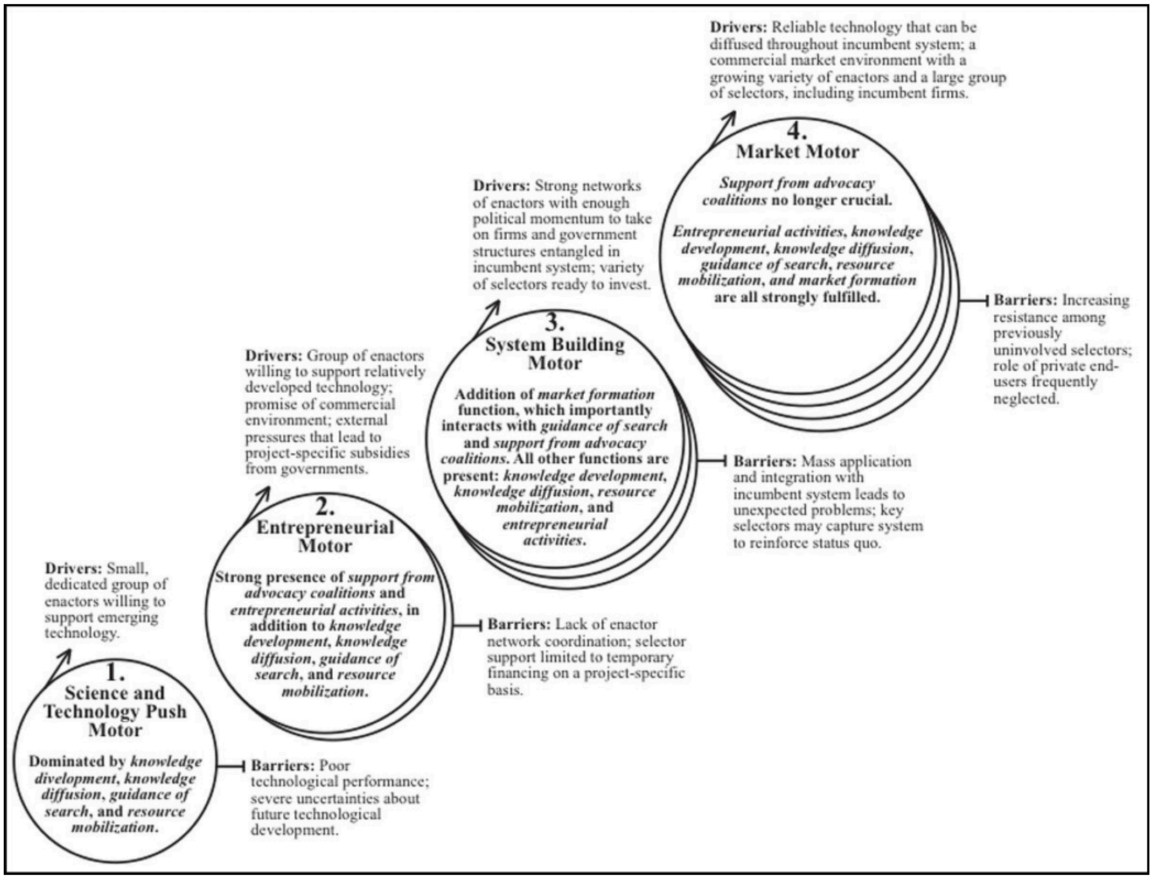
TIS uses a different form of interpretation than the previous STs. TM, SNM, and MLP have been described as quasi-evolutionary, whereas TIS is more a structured interpretation of socio-technical transitions (Martens, 2015). To begin, the TIS focus of analysis is at the innovation system, which is the process by which novel innovations can be both developed and entered into the market. The innovation system resides in the niche of the MLP focusing on a particular technology or industry (Bergek et al., 2008). According to Bergek et al., TIS is a "socio-technical systems focused on the development, diffusion and use of a particular technology (in terms of knowledge, product or both)" (Bergek et al., 2008, p. 408). In contrast to the previous STTs, TIS considers the development of innovations in a more linear process, although there can be non-linear pathways as well. There is an emphasis on points of failure, or "system failure," with the TIS model. There are often structural impediments to the successful implementation of innovative and disruptive technology. These failure points could be infrastructural, institutional, the interaction of networks, and the capabilities of actors (Bergek et al., 2008).

Bergek et al. (2008) has outlined six steps in the TIS process: *(1) Starting-point; defining the TIS in focus; (2) identifying the structural components of the TIS; (3) mapping the functional pattern of the TIS; (4) assessing the functionality of the TIS and setting process goals; (5) identifying inducement and blocking mechanism;* and *(6) specify key policy issues*. In step (1), the focus is on defining the TIS as well as establishing an operational framework. In step (2), the intent is to identify key actors and networks within the TIS. Step (3) focuses on determining to what extent the functional components of the TIS are developed, "…by searching for external economies in the form of resolution of uncertainties, political power, legitimacy, combinatorial opportunities, pooled labour markets, specialized intermediates, as well as information and knowledge flows"(Bergek et al., 2008, p. 418). Step (4) assesses the functionality of the structural components of the TIS. Step (5) attempts to identify barriers and driver. Step (6) focuses on the development of policy issues.

Building on these steps, Martens (2013) and Suurs (2009) highlight four motors that are successively sequenced as a cumulative causation (see Figure 1.8). These four motors focus on the major barriers and drivers within TIS. They are *(1) science and technology push motor; (2) entrepreneurial motor; (3) system building motor;* and *(4) market motor*. Details of each of these motors and the associated drivers and barriers are highlighted in Figure 6. In sum, TIS is a “cumulative causation” model based on development support for the growth of an innovation system (Suurs, 2009, 26).

Figure 1.8

Sequence of Technological Innovation Systems Motors



Source: (illustration by Martens, 2015 as adapted from Suurs, 2009)

1.6. Dissertation Structure

The dissertation and the manuscripts chapters that accompany it are positioned within the sustainability transitions tradition (discussed above). This dissertation is prepared as a series of five manuscripts that interlink with one another around the topics of decentralized energy, sustainability transitions, energy justice, and governance. The dissertation is structured with decreasing levels of abstraction from exploratory, to theoretical, and to empirical. The five papers address the two research questions in various capacities. The first manuscript, *Chapter Two*, begins with an overall discussion on DE: its opportunities and justice considerations. The format of this paper, a peer-reviewed comparative book review, allows for sufficient flexibility to explore the typologies of energy justice related to energy decentralization. The next manuscript, *Chapter Three*, compares governance impacts of DE transitions in three medium-sized northern cities. *Chapter Four* uses the same comparative case studies but from an energy futures perspective. The remaining two manuscripts, *Chapter Five* and *Chapter Six* focus on a single case study of solar energy in Saskatchewan. Whereas the previous two chapters focus on the broader implications of DE, these remaining chapters explore the last research question, "How can an understanding of this dynamic further accelerate social and technical change?". In *Chapter Five*, the paper explores the idea of effective public engagement and considers the energy justice issues that arise from DE transitions. *Chapter Six* builds from the previous chapter and argues for practical suggestions to accelerate DE transitions based on observations from the public engagement activities and a discussion on decision-making. Abstracts and summaries of the manuscript chapters and conclusion are presented below.

Chapter Two: Decentralized Energy: Justice, Prospects, and Transitions

The first manuscript chapter is a peer-reviewed comparative book review addressing the concept of DE. The purpose of this paper is to replace the conventional literature review. Each manuscript in this dissertation has separate literature reviews associated with each chapter. Chapter Two, instead, serves as an exploratory literature review of the concept of DE. The paper concludes with justice considerations and a need for the social sciences to be included in analysis of DE transitions.

This has been peer-reviewed paper and is currently published in the journal of *Energy Research & Social Science*.

Chapter Three: Governance and Decentralized Energy Transitions: A Comparative Case Study of Three Medium Sized Cities in Sweden, Canada, and the United States.

This study aims to compare the sociotechnical conditions that contribute to innovative DE projects across five governance dimensions: (1) utility market structure, (2) multi-sector collaboration, (3) decision-making capacity and autonomy, (4) multilevel governance, and (5) public perceptions of climate change. Knowledge of how particular jurisdictions and their governance arrangements influence these transitions can help strengthen and contextualize divergent trajectories of decentralized energy transitions and—most importantly—reveal the role of geographical context in policy change. In particular, this study aims to draw from international comparisons of urban energy transitions.

This paper compares the uptake of decentralized energy transitions in three cities in three different countries—Luleå (Sweden), Saskatoon (Canada), and Anchorage (United States). The jurisdictions in each city has unique governance contexts pertaining to electric utilities, regulations, public policy, and public acceptance. By comparing these transitions, this study highlights the governance considerations for decentralized energy transitions and asks how does governance impact the acceleration of decentralized energy transitions in cities? To answer this question, a total of 60 interviews were conducted with actors involved in decentralized energy projects and whose interests spanned multiple sectors (government, non-for-profit, business, utility, academic, and environmental activists). Interviews were thematically analyzed with the five governance dimensions.

The conclusions reveal that interactions between the five governance dimensions can partially explain the divergent trajectories of accelerated decentralized energy transitions. In addition to providing a more contextual understanding of these patterns of transitions in cities, the results show that multi-sector collaboration, broad public acceptance for climate change, state or national support for local projects, and local capacity serve as drivers for accelerating decentralized energy in cities. The results also suggest that regulated utility market structures, unstable political cycles, siloed integration of sectors, and decision-making autonomy serve a limited driving role.

This paper has been peer-review and is currently published in the *Central European Review of Economics and Management*.

Chapter Four: Northern Urban Energy Futures in Saskatoon, Luleå, and Anchorage

Cities in the North have unique challenges. Cold temperatures, remoteness, and low winter daylight hours create constraints in the Northern context. Given the climate urgency, energy infrastructure in cold or northern cities must respond to climate change while promoting economic and social well-being. However, there is a limited investigation in the literature on how energy transitions can be pursued in the North. By developing a future-oriented transitions approach, we will present findings from comparative work from three northern cities: Luleå, Sweden; Anchorage, Alaska; and Saskatoon, Saskatchewan. These cities are all medium-sized but have starkly different governance and ownership structures related to their electrical infrastructure. Luleå, Sweden, has a municipally-owned heating and electric utility that is part of the Nordic energy system. Anchorage, Alaska, has three vertically integrated electric utilities, two cooperatively owned and one municipally owned. Saskatoon, Saskatchewan, has a municipally-owned utility for a portion of the city, which is connected to a monolith vertically integrated crown corporation that serves the province of Saskatchewan. All three cities are in a transitional phase with their energy system and are considering alternatives and opportunities for the future. Based on extensive stakeholder interviews in the cities, this study explores their energy futures. The results suggest that actors within Luleå, Sweden, had more coordination and a shared vision for the future energy system than in Anchorage, Alaska, where many silos and disjointed visions coexist within the regime. Using a case study comparative method, this paper argues that northern cities have unique contexts that impact their visions for the future and the unfolding of their energy transitions. Moreover, the findings suggest that the regime should serve a more prominent role in energy futures envisioning.

This is a co-authored publication with Joni Karjalainen has been peer-reviewed and accepted to a volume titled “More than ‘Nature’: Research on Infrastructure and Settlements in the North*.*

Chapter Five: Solar Energy Justice: A Case-Study Analysis of Saskatchewan, Canada

This paper investigates solar energy justice in the province of Saskatchewan, Canada. In 2017, a colleague (Brett Dolter) and I were engaged by the Saskatchewan Power Corporation (SaskPower), a government-owned electric utility, to conduct stakeholder engagement workshops for the development of new solar energy programs in Saskatchewan. In coordination with SaskPower, we developed a deliberative dialogue approach to the consultation process. Select stakeholders were invited to participate in a half-day workshop. In this workshop, participants were asked for input on the principles that would guide SaskPower's solar energy strategy, the barriers that prevent solar energy from being installed in the province, and their ideas for effective solar energy programs. Participants worked in small groups to design solar energy programs, creating opportunities for mutual learning and deliberation. This research is the first application of deliberative dialogue to the design of solar energy programs of which we are aware and offers an example of due process in the program design stage of energy planning. We use the energy justice decision-making tool (Sovacool & Dworkin, 2014) to evaluate the process of designing SaskPower's solar energy strategy and the content of recommendations made by participants to answer the question, can due process help to achieve energy justice? Participants in our deliberative dialogue suggested guiding principles that were similar to the dimensions of the energy justice decision-making tool. The deliberative process also highlighted tensions between dimensions of the energy justice decision-making tool. In this paper, we suggest avenues to improve the deliberative dialogue process and conclude that centering due process as a core element of the energy justice decision-making tool can help to achieve energy justice. Our results contribute to the growing field of study on how deliberative dialogue can allow for better decisions in complex fields such as energy policy.

This is a co-authored publication with Brett Dolter submitted to the journal of *Renewable Energy and Sustainable Energy Reviews.*

Chapter Six: **From transitions to decisions: moving decentralized energy forward by filling the gap between public engagement and decision-making**

To meet the challenge of climate change, extensive behavioural changes are required. Consequently, public engagement is essential in influencing energy transitions. A growing literature on public engagement is improving strategies to garner public opinion and assess support for policy changes. However, little is known about how public engagement processes inform public policy decisions. This knowledge gap is concerning because public engagement is time-consuming and costly, and positive sentiment towards public entities can deteriorate if engagement processes are not meaningfully incorporated into decision-making. Decentralizing energy, key to the global energy transition, involves coordination of industry, the public sector, and the general public. This involvement of multiple stakeholders makes public engagement particularly important.

This case study analyzes a public engagement process and decision on new solar energy programs in the province of Saskatchewan, Canada. Coordinating with Saskatchewan's electric utility, we conducted a public engagement process to gather stakeholder input on new solar programs. A year later, the electric utility unveiled its new solar energy programs. We analyze the resulting program decisions and compare these decisions to our recommendations. This study had two main findings: 1) Because incorporating decentralized energy disrupts the utility's business model, it is undertaking incremental changes to existing programs rather than pursuing transformative change. 2) An expectations gap exists between solar stakeholders and the provincial electric utility. We conclude with our suggestions for improving public engagement related to energy transitions and avenues for further research.

This has been peer-review and is published in the journal *Applied Energy* as a co-authored publication with Brett Dolter.

Chapter Seven: Conclusion

In this final chapter, the major conclusions and contributions to this research project are summarized. This chapter also highlights the general limitations of the research and possible avenues for further inquiry. Finally, the concluding chapter will review the major ways this dissertation has addressed the original research questions and objectives.

Chapter Two: Decentralized Energy: Prospects, Justice, and Transition

A version of this chapter has been peer-reviewed and published in the journal of *Energy Research & Social Science*.

Reference: Boucher, M. (2016). Decentralized Energy: Prospects, Justice, and Transition. *Energy Research & Social Science*, *11*, 288–293.

Chapter Two: Decentralized Energy: Prospects, Justice, and Transition

Our current era marks a unique phase in human history where our social structures confront the physical limits of our environment (Crutzen & Stoermer, 2000). There is a consensus within the international climate community that thresholds of 2°C global temperature increase set at pre-industrial levels and 350 ppm of atmospheric CO_2 equivalent levels should not be exceeded to prevent significant risk to the environment and society from climate change (Rockström et al., 2014). Energy related anthropogenic greenhouse gases (GHG), including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), are projected to increase into the future and cross these thresholds if mitigation strategies are not implemented (IEA, 2014; Pacala & Socolow, 2004). According to the International Energy Agency (IEA) energy demand is expected to increase and they estimate that $1.3 trillion on renewables will need to be spent every year until 2040 to meet the 2°C target (IEA, 2014). Solutions to the current global energy regime require both a social and technical understanding (Sovacool, 2014b). None of this will likely come as a surprise to readers of the *Journal of Energy Research and Social Science*. However, what may be less well known is that we are in the midst of a fundamental energy transition capable of reconciling increased energy demands with climate change mitigation—a move away from the centralized energy regime of the past and a move towards a decentralized regime. The three books chosen for this thematic book review articulate different interdisciplinary visions for moving forward in our energy future.

The common thread that runs through these three books is that there are opportunities for a transition in the global energy paradigm. This review essay explores the various perspectives found in the books on energy generally and decentralized energy (DE) specifically. This paper will discuss the justice considerations, prospects, and the barriers and opportunities for a transition towards DE. Since these three books are quite different in their approach and content a brief introduction is provided to each of them separately and then the paper concludes with a critical analysis of their intersecting themes.

2.1. Summary of Books and Background

Christoph Burger and Jens Weinmann bring a mix of industry, public sector, and academic experience to their book *The Decentralized Energy Revolution*. Christoph Burger had many years of industry experience before his current appointment at the European School of Management as a Senior Lecturer and Senior Associate Dean of Executive Education. Jens Weinmann is the Program Director for the European School of Management's Customized Solutions and previously worked in various research and consulting capacities related to energy decision-making.

Burger and Weinmann took a unique approach in the construction of this book. Each chapter, which can be read independently of the others, is filled with extensive excerpts from industry energy experts, community leaders, and entrepreneurs from a predominately European perspective. As they noted, "This book contains the findings and extended narratives of a series of 17 semi-structured interviews with decision-makers working towards a decentralized energy supply" (Burger & Weinmann, 2013, p. 2). In this way, this book offers an in-depth perspective on many of the inner-workings of leading firms and organizations in the decentralized energy transformation. The authors paid little attention to solar and wind generation and choose to focus on upcoming DE technologies such as the use micro-CHP, micro-turbines, bioenergy, and storage technologies as elements in a transition towards more decentralization.

Distributed Power in the United States is edited by Jeremy Carl from the Hoover Institution at Stanford University, and includes input from numerous top-level players in energy policy and the electrical utilities industry in the United States. Along with being a prolific writer on energy, environment, energy security, and public policy, Jeremy Carl is director of research for the Shultz-Stephenson Task Force on Energy Policy and has advised groups such as the World Bank and the United Nations. This very concise and informative book serves as both a research piece and policy analysis on distributed power systems (DPS). The book starts off with an overview and cost-benefit analysis of DPS and then moves to current policies and research findings for the stakeholder interviews. The conclusion suggests policy recommendations for both the municipal, state and federal level. This book's focus is on the United States, as the title suggests, but the implications and the overall policy recommendations have global relevance. Another unique feature of this book is the attention paid to the military and security applications of DPS.

In the final book, *Global Energy Justice*, Sovacool and Dworkin skillfully connect justice theory to the myriad of energy issues faced globally. As well as being editor-in-chief of this journal, Benjamin Sovacool is a prolific writer, professor, and consultant on energy, technology, and environmental issues.

Also a prolific writer in his field, Michael Dworkin is currently a professor and director of the Institute for Energy and the Environment at the Vermont Law School. *Global Energy Justice* is a bit of an outlier from the other two books because it does not deal with DE directly and addresses broader energy justice issues. However, it was included because it offers a theoretical framework for thinking about energy issues that can bring useful insights into DE.

The book chapters are constructed using a structured three objective approach with the following headings entitled: How things are?, What is justice?, and What can be done? The scope of this book is impressive, with topics ranging from human rights, energy poverty, energy efficiency, to the posterity of energy decision-making. The book, "matches eight philosophical justice ideas with eight energy problems, and examines how these ideals can be applied in contemporary decision-making" (Sovacool & Dworkin, 2014, p. xviii). Sovacool and Dworkin also use applied public policy examples to illustrate global energy justice challenges and how conceptualizations of justice can help to navigate this complex terrain. This book addresses the important justice issues associated with energy decisions that are much too often ill considered. Sovacool and Dworkin end by connecting all of the different aspects of justice and illustrate the contradictions and difficulties with making fair energy decisions. Overall, the book provides a framework for critically assessing energy issues.

These books did not fall into the trap of many energy books of beginning with a scenario of environmental calamity. Rather, these books were solution oriented: *The Decentralized Revolution* focused on business strategies; *Distributed Power in the United States* focused on public policy solutions; and *Global Energy Justice* focused on fundamental justice considerations and policy solutions. Also, the books moved away from the conventional engineering and economics disciplines found in other books on this topic. The approach taken in all of these books represent a shift in thinking on these problems to energy issues. Two of the books, The *Decentralized Energy Revolution and Distributed Power in the United States* involved in-depth stakeholder interviews with industry, government, and regulators alike. The involvement of many perspectives on decentralization is illustrative of the interdisciplinary nature of this type of research. The third book, *Global Energy Justice* was also interdisciplinary and explicitly noted its interdisciplinary approach in the introduction (Sovacool & Dworkin, 2014). The interdisciplinary approach allows for connections across disciplines, in both the social and natural sciences, to place disciplinary research into the broader context. Table 1 outlines a summary of the books under review for the essay.

Table 2.1

Book review summary

Book	The Decentralized Energy Revolution	Distributed Power in the United States	Global Energy Justice
Research Type	Stakeholder Interviews	Cost-benefit analysis and stakeholder interviews/survey	Interdisciplinary Case Studies
Geographical Area	Europe (some focus on Asia)	United States	Global
Focus	Business Strategies	Public Policy	Justice Considerations and Policy Solutions

2.2. Decentralized Energy

Decentralized energy, sometimes described as the energy internet, has been described as a networked system of bidirectional and lateral energy flows (Rifkin, 2011). In terms of energy, a decentralization scheme can be broadly understood as the empowerment of individuals, communities, and regions to produce and distribute their own energy in an integrated fashion (Alanne & Saari, 2006c). In contrast to decentralization, centralized energy generation involves the use of large production facilities that distribute power from a main source to many consumption nodes. DE generation involves more mixed-scale production facilities with multiple nodes of production in the network. DE generation involves the integration of production and consumption nodes. Examples of decentralized electricity generation technologies include co-generation, biomass power, small-scale wind, photovoltaic power, biogas, and wind power (Bazmi et al., 2011; Keirstead, 2008a). They also include the use of demand side management technologies such as energy efficiency and conservation (Stadler & Bukvić-Schäfer, 2003). Also noteworthy, there is no consensus in the literature on the definition of the term decentralized energy, and many different terms are used interchangeably (Paliwal, Patidar, & Nema, 2014).

The differences in terminology and definitions of DE are also apparent in the books under review. In *Distributed Power in the United States,* distributed power systems (DPS) was defined as, "selected electric generation systems at distribution level voltages or lower whether on the utility side of the meter or on the customer side; and distribution-level electricity storage applications" (J. Carl, 2013, p. 15). The book's focus is on the decentralization of the generation of electricity. This is in contrast to *The Decentralized Energy Revolution* where decentralized energy was defined more broadly as a meta-concept that incorporates ICTs, mirco-scale generation, island systems, smart management, and conservation. These distinctions are most likely the result of the different geographical focus areas the two books drew upon. There is a North America and a European divide in the concepts of decentralized energy. Table 2.2 summarizes the major conceptual differences between centralized and decentralized energy.

Table 2.2

Conceptual Differences between Centralized Energy and Decentralized Energy

Centralized Energy	Decentralized Energy
Few large-scale energy production facilities	Many mixed-scaled energy production facilities
Command-and-control paradigm	Network paradigm
Vertical integration	Horizontal integration

2.3. Energy Justice and Decentralized Energy

The concept of justice has been discussed, debated, and analyzed since the advent of civilization. Sovacool and Dworkin noted that, "Thirty years ago, electrons, barrels of oil, and justice would have seemed like a jumble of topics, but now their combination makes sense" (p.1). *Global Energy Justice* used philosophies of justice from a wide array of thinkers—from Plato, Aristotle, Jeremy Bentham, Henry Sidgwick, Immanuel Kant. Thomas Jefferson, John Rawls, and to Milton Freedmen—that help bring understanding to the complexity of modern energy issues. Sovacool and Dworkin defined energy justice as, "a global energy system that fairly disseminates both the benefits and costs of energy services, and one that has representative and impartial energy decision-making" (p.13). It is not within the scope of this book review to outline all of the areas that *Global Energy Justice* addressed. Instead, this section will focus on the intersections between *Global Energy Justice* and aspects of DE in the other two books: *The Decentralized Energy Revolution* and *Distributed Power in the United States.* In the following sections, I look at the key characteristics of justice, libertarianism, egalitarianism, freedom, equity, and community empowerment related to DE. By comparing and contrasting the ideas presented, I will highlight aspects of DE that may present opportunities for energy justice.

Firstly, one of the more noteworthy links between DE and energy justice are the impacts that resource depletion and pollution may have on future generations. *The Decentralized Energy Revolution* and *Distributed Power in the United States* have argued, in part, that DE can maximize the potential for small-scale renewable generation to enter the grid and thus result in lower overall greenhouse gas emissions. The reduction of emissions is most likely one of the most attractive benefits of DE. But how does all this relate to energy justice? Sovacool and Dworkin dedicate an entire chapter, "Energy resources and future generations", to discussing the posterity of energy decision-making. From a theoretical justice perspective, this chapter focuses on the concept of resource egalitarianism from philosophers Ronald Dworkin, Brian Barry, and Edith Brown Weiss. For these philosophers, egalitarianism is extended to future generations.

There are indeed a myriad of complex issues associated with an energy justice framework based on resource egalitarianism. How far into the future? How much energy can we use? How are resources fairly distributed? However in terms of DE, once the infrastructure has been laid there can be zero marginal cost associated with its continued electricity production (Rifkin, 2011). This is in stark contrast to conventional centralized sources that are largely dependent on fossil fuels with negative consequences for future generations. In other words, the legacy to future generations under DE is much more positive. Additionally, it is important to determine who reaps the benefits of DE — such as the extremely poor. For instance, Nuru Energy, as discussed in the *Decentralized Energy Revolution*, provides affordable decentralized renewable energy to the extremely poor in rural Africa. This innovative business provides mini foot pedal generators that can be used to recharge LED lights, cellphones, and radios (Burger & Weinmann, 2013). Units can be rented or purchased with local microfinance agreements (Burger & Weinmann, 2013). This company illustrates the empowerment benefits of DE to the poor.

Some readers might find it surprising to discover there are many economic benefits associated with DE. Much of the emphasis of *The Decentralized Energy Revolution* was used to make this case. This may be why I found *The Decentralized Energy Revolution* much more optimistic about the economics of DE than the information presented in *Distributed Power in the United States.* It may seem that energy justice has no place in this case. However, Sovacool and Dworkin speak to this in Chapter 8 entitled "Energy subsidies and freedom" where they discussed libertarian economists Robert Nozick and Milton Freedman. The libertarian focus on justice is on the preservation of individual rights. Sovacool and Dworkin noted their criticisms of the libertarian philosophy: it does not explicitly address the poor or disenfranchised members of society. In the context of DE however, it does provide some explicative powers. Economic freedom is considered the mechanism to achieve personal freedom. Subsidies in libertarian philosophy are a violation of economic freedom—they can be an obstacle to clean energy too. For instance, Sovacol conducted a study that determined clean energy promotion was linked to the elimination of subsidies to energy corporations (Sovacool & Dworkin, 2014, p. 281), which is one of a plethora of studies showing the connection between subsidies and the centralized energy regime.

There are well known challenges to estimating the full economic costs of an energy system. For instance, many positive system externalities of DE are often not included in cost-benefit analysis (Burger & Weinmann, 2013). Burger and Weinmann noted that, “Domestic renewable energy sources provide an effective means to hedge against international price fluctuation and are therefore politically welcomed” (Burger & Weinmann, 2013, p. 14). Furthermore, security and reliability benefits were outlined in *Distributed Power in the United States* in Chapter 3 entitled “Security-Related Benefits of DPS”. Therein, Carl argued that “a decentralization of electricity infrastructure can allow for a more secure and reliable generation of electricity primarily by reducing the reliance on traditional centralized generation facilities” (J. Carl, 2013, p. 71). Carl did emphasize that many benefits associated with DE are not typically incorporated in many cost-benefit analysis. Carl noted that the generation of DE is location and time specific and did a comparison of the levelized cost of energy for DE (J. Carl, 2013, p. 47). He also noted that peak load may be reduced in a DE scenario (J. Carl, 2013, p. 47). One of the final recommendations of the book was about the importance of developing further research to understand the full benefits of DE (J. Carl, 2013). For instance, Carl mentioned that,

> A particularly tricky related issue is how to structure net metering rates for the customer side of the meter DPS owners who wish to sell back into the grid. Namely, should excess generation be simply deducted from total monthly energy usage, should the utility buy that energy at a set average price, or should the DPS owner see the same real-time electricity pricing as the wholesale market and potentially capture peak rate? Moreover, if a utility is buying power from a DPS end-user, what is a fair allocation of distribution system coordination and the service costs incurred in doing so? (p.116).

As illustrated above, it is not always easy or feasible to account for the full economic benefits and costs of DE. Therefore for the libertarian, justice quickly becomes a highly complicated process when evaluating DE.

The motivation for the uptake of DE are often non-economic with benefits often not internalized (Burger & Weinmann, 2013). Non-market benefits were addressed differently in each of the books. In terms of energy justice, in Chapter 4 entitled “Utility and energy externalities” Sovacool and Dworkin argued that a just society should focus on the appropriate division of benefits and risks. In this chapter, the just society according to Jeremy Bentham is one of utilitarianism by way of maximizing overall well-being. For Bentham total utility of pleasures and happiness should be the focus of a just society. John Stuart Mill and Henry Sidgwick built on Bentham's argument by adding elements of equality, impartiality, and posterity to Bentham's notions of utilitarianism. Useful policy tools can be used to encourage communities towards the utilitarian form of energy justice through the use of DE. For instance Carl noted that, "EID [Energy Improvement Districts] allows participants to share costs, benefits, and administrative requirements in financing and implementing energy projects" (J. Carl, 2013, p. 106). Also, utilities can have decoupling and lost revenue adjustment mechanism in order to create an incentive structure for the uptake of DE (J. Carl, 2013). Communities and individuals have become attracted to DE because it can also decentralize, democratize, and localize the control of energy services (Burger & Weinmann, 2013).

What Burger and Weinmann call the emotionalization of energy, decentralized energy has become a way to think global and act local. *The Decentralized Energy Revolution* dedicates a Chapter 3 entitled "The Rise of Island Systems" to the benefits of DE to community empowerment. The chapter noted that Somas, an island community in the Baltic Seas, has achieved energy autonomy through the implementation of DE technologies. Additionally bioenergy villages, of which Germany has over 90, incorporate the integration of cogeneration plants, biomass heating, and localized energy distribution and allows smaller communities more control over their energy services (Burger & Weinmann, 2013). Burger and Weinmann pointed out that in Germany "more than half of the capacity of renewable energies is owned by private persons and farmers" (p.8). Community empowerment can also occur at the city scale. In Abu Dhabi, Masdar City is an ongoing mega project that has set ambitious emissions reduction targets with the use of a plethora of decentralized energy technologies. The importance of community empowerment was discussed, in part, in Chapter 7 entitled "Energy poverty, access, and welfare" of *Global Energy Justice*. Sovacool and Dworkin focused on the justice issues involved with the lack of access to energy services for the poor and disenfranchised. According to Sovacool and Dworkin, for John Rawls justice is "not necessarily what is due to each person, but instead what competing preferences negotiate in a fair process—making justice limited by what everyone will accept, a pragmatic compromise rather than a virtuous and absolute ideal" (Sovacool & Dworkin, 2014, p. 242). Burger and Weinmann noted that Amartya Sen calls for the importance of freedom of choice and capabilities which can be defined as "the ability to participate in communal decision processes" (Burger

& Weinmann, 2013, p. 64). DE, with its ability to respond to community needs and democratize the decision making process has the potential of creating a high amount of well-being for large numbers of people. Burger and Weinmann noted that “A decentralized energy supply enriches the set of capabilities of the individual by offering an additional dimension of freedom or a valuable option they are able to choose” (Burger & Weinmann, 2013, p. 65). To motivate communities into the uptake of renewable energies, Sovacool and Dworkin noted that a, “productive way of involving communities is to incentivize their ownership of actual energy infrastructure such as wind farms, solar panels, and rural mini-grids. This tends to democratize energy production and use by placing more of it in direct ‘control’ of people and communities themselves, and it also cultivates environments with more trust and accountability and less social opposition to projects” (Sovacool & Brown, 2010, p. 219).

2.4. Transitions to Decentralized Energy

There was indeed a time when understanding our energy systems was a simpler affair, even as late as the introduction of electricity generation by Edison in 1882. Those days have long past and what we are left with is a system of immense complexity. These three timely and relevant works represent a shift in understanding our energy system. Modern innovations in information communication technologies, micro-grid technologies, and various renewable energy technologies are creating the opportunity for a transition in the energy paradigm. Sovacool and Dworkin are optimistic about this and mentioned that, “A slew of recent academic research has also confirmed both the technical feasibility and the social and economic desirability of 100 percent renewable energy systems” (p. 345). The suggestion being that there are considerations beyond simply the technical. A shift towards a more DE regime will indeed require a depth and breadth of understanding of social challenges associated with the transition. DE involves not only the physical infrastructure but also political, economic, and social considerations (Alanne & Saari, 2006c). What follows is a discussion of some of the technical and non-technical transition considerations to DE discussed in the books.

A number of different technical challenges and opportunities are described in the books. Technology improvements needed for a transition to DE include storage, smart-grids, and mirco-combined heat and power (micro-CHP). Burger and Weinmann noted that, “The pressures on the power system are compounded by two major trends that will have a profound impact on the provision and consumption of electricity: the integration of large amount of renewable energy generation capacity and the advent of the ‘smart grid’” (J. Carl, 2013, p. 1). Burger and Weinmann also argued that mirco-CHP may be a useful transitional technology in residential settings to move towards DE. In *Distributed Power in the United States*, the impacts to the reliability and security were highlighted as an important area of future research (J. Carl, 2013). In sum, both *The Decentralized Energy Revolution* and *Distributed Power in the United States* noted a number of technical obstacles. However what is also clear is the potential for incremental development towards DE. The books noted that many districts are not using DE to its full potential, even with current technologies. As we wait for technological improvements, it will be important to address the non-technical barriers that are hindering the use of DE to its full capacity.

At the interface between social and technical barriers to DE is the Negawatt. This is the low hanging fruit that both *Global Energy Justice* and *The Decentralized Energy Revolution* addressed. The Negawatt is a theoretical unit describing energy that is saved from energy efficiency and conservation initiatives; these can include both physical and behavioral modifications that result in a reduction in energy use. Negawatts are often an effective means of energy use reduction. For instance, building retrofits, a source of Negawatts, are often much more cost effective than expensive renewable energy projects (Burger & Weinmann, 2013). Negawatts are an essential component for a DE transition because they reduce overall electricity demand. In *The Decentralized Energy Revolution*, Chapter 6 entitled "Enabling Negawatts", addressed many of these important aspects of the Negawatt. Some of these include energy efficiency, split incentive structures, and energy performance contracting.

There are also non-technical barriers that the authors discuss regarding a transition to towards DE. Sovacool and Dworkin noted that a study of 180 interviews with industry and government experts indicated there were 38 non-technical "barriers to the deployment of distributed generation, renewable energy, and energy-efficiency technologies" (Sovacool & Dworkin, 2014, p. 104). They continued and noted, "Energy projects are often resisted by all levels of the business community because they perceive it as a "non-core activity that distracts personnel from more profitable ventures" (p.104). In the stakeholder survey results from decision-makers across the United States Carl noted that, "Nearly all respondents cited the lack of research and quantitative data on the costs, benefits, and effects of greater DPS penetration as a barrier" (p.133). Carl also discussed in the final recommendations a number of policy options that federal, state, and municipal governments should consider to improve the rapidity of change to DE. Although there are a different barriers outlined in each of the books, the root cause is the same. DE challenges a fundamental paradigm shift in the electricity infrastructure. The physical size, capital investment, and historical legacy of the physical and institutional electricity infrastructure of the current electricity regime act as a strong resistor to change. As DE increases in districts around the world, the institutional power of the incumbent utility begins to diminish. Institutional power is the crux of the challenges faced with a DE transition. According to Burger and Weinmann,“Paradigm shifts in large technical systems occur less frequently than in other fields of industrial activity because the technical interdependencies of system components, their standards, institutions, and routines create a high degree of path-dependency on the overall configuration of the system, in particular in grid-based energy services”(Burger & Weinmann, 2013, p. 9).

The possibility of a transition and the accompanying paradigm shift to DE was discussed in the books. In *The Decentralized Energy Revolution* it was argued that, “As much as human development was characterized by slow adaptation processes and sudden social or cultural revolutions, the shifts in energy use can also be interpreted as periods of slowly evolving, incremental progress and abrupt—and often radical—changes” (Burger & Weinmann, 2013, p. 7). Burger and Weinmann noted that, “Once a new paradigm has been established, a period of upheaval is followed by consolidation and continuity” (p. 12). They argued that there has been a transition from three main phases in electricity generation: engineering paradigm, economics paradigm, and the upcoming empowerment paradigm (Burger & Weinmann, 2013). According to Burger and Weinmann, “Empowerment is likely to be a key trigger for why a decentralized energy supply will achieve much higher penetration rates than a mere cost–benefit analysis would suggest” (Burger & Weinmann, 2013, p. 65). Carl also argued that, “when central governments hesitate and postpone policy action to promote the move toward a more sustainable society, progressive communities step in and implement measures on the local” (p.65). There are already significant developments towards DE around the world so it is clear that these predictions might come sooner than many anticipate.

A paradigmatic shift from centralized to more decentralized electricity production will pose significant multidimensional and complexity challenges (Karger & Hennings, 2009). Social, economic and environmental considerations are critical, and a literature on “sustainability transitions” exists in which they are linked to the technological challenges (Markard et al., 2012). The most prominent of these sustainability transition theories are transition management theory (Jan et al., 2001; Kern & Smith, 2008; Loorbach, 2010), technological innovation systems (Bergek et al., 2008; Hekkert et al., 2007; Jacobsson & Johnson, 2000), strategic niche management (Kemp et al., 1998; R. P. J. M. Raven & Geels, 2010; Smith, 2007), and multi-level perspective on socio-technical transitions (Frank W. Geels, 2002;

Frank W. Geels & Schot, 2007; Smith et al., 2010). These sustainability transition theories are used to understand and describe socio-technical regime-shifts towards sustainability goals. In this way, sustainability transition theories can provide a framework to interpret a transition to DE.

2.5. Conclusion

These three seemingly different books agree on one main premise—our energy system needs to change. These books are also examples of what the future of energy research could look like, and they have demonstrated the importance of an interdisciplinary approach to DE that is not parochially focused.

Energy-related carbon emissions are increasing at a rate exceeding planetary boundaries and increasing the need for mitigation strategies (Rockström et al., 2014). Technological advances associated with decentralized energy have resulted in the ongoing paradigmatic shift in the electricity generation and grid infrastructure. It is important that as we move forward, we imagine research on DE in a broader context. As this review has demonstrated, there is indeed a need for a broader discussion, outside of the engineering and economics disciplines, on DE. Put in context, the electricity grid is an infrastructure that is both costly and creates infrastructure lock-in. In other words, we are often stuck with the choices we make for many years or even generations that follow. Therefore, is it important to think very prudently on our electricity infrastructure and ensure its design, policies, and uses are well thought out. Based on the review of these three books and the perspectives and analysis found therein I recommend the following for future research on DE:

- Negative externalities and avoided costs need to be included in the accounting of DE and conventional technologies alike. This may demonstrate that DE technologies are cost-comparative or cost-competitive to conventional centralized sources of energy. Economic analysis of DE, and related technologies, should be inclusive of the full scope of costs and benefits.
- Openness to interdisciplinarity between various disciplines is needed to provide useful insights into the transition to decentralized energy. Solutions and new concepts are likely to be discovered outside of disciplinary boundaries.

- DE is not simply an academic venture. The insights from private and public stakeholders provide an invaluable understanding of transitions to DE. Academic research should include the perspectives, via interviews, surveys, or the like, of industry and government experts.
- Research should acknowledge the fundamental justice questions related to global energy issues and DE—energy is a justice issue. Sovacool and Dworkin wrote, "Economics is concerned with accounting, justice is concerned with accountability" (Sovacool & Dworkin, 2014, p. 363). The inclusion of justice into DE research will better equip decision-makers with the appropriate justice considerations of DE.
- As DE technologies become more apparent it may become increasingly useful to development more specific defining parameters to DE. This would include investigations into the institutions and physical infrastructure associated with DE.
- Further exploration of the use of sustainability transition theories towards DE might provide insight into the mechanisms of regime shift in the electricity infrastructure.

Chapter Three: Governance and Decentralized Energy Transitions: A Comparative Case Study of Three Medium Sized Cities in Sweden, Canada, and the United States.

A version of this chapter has been peer-reviewed and published in the *Central European Review of Economics and Management*.

Reference: Boucher, M. (2020). Governance and decentralized energy transitions: a comparative case study of three medium sized cities in Sweden, Canada, and the United States. *Central European Review of Economics and Management*, *4*(1).

Chapter Three: Governance and decentralized energy transitions: A comparative case study of three medium sized cities in Sweden, Canada, and the United States.

Innovative decentralized energy (DE) projects exist around the world —from solar co-ops with unique ownership structures and energy efficient and self-generating housing for low-income residences to integrated combined heat and power (CHP) systems that also provide community district heating to ambitious wind projects in some of the harshest weather conditions; however, what determines the success of these projects is often unclear. To explain the drivers and challenges of DE transitions, researchers have developed theories, models, and various types of analysis. Some have argued that DE projects are successful because of a combination support in the form of subsidies, research and development, or regulations (Kemp et al., 1998). Others have argued that DE innovation works when competitive market forces are unleashed, government intervention is minimal, and public support is high[2]. Yet another view claims that it is sustainability networks that drive these unique local energy innovations (Seyfang et al., 2013). Motivated by the pursuit for sustainability, the environmental community takes on projects and pushes its agenda on the public and private sector.

A robust interdisciplinary literature on sustainability transitions (Köhler et al., 2019; Markard et al., 2012), integrating expert knowledge from varied disciplines, has rapidly developed around these questions. This "socio-technical" approach has led to insights for pathways to overcome some of society's most contentious problems: overconsumption, GHG emissions, ocean acidification, social injustice, and, of course, climate change. Despite these insights, most studies on sustainability transitions of DE have focused on single jurisdictions, with little research comparing how different cities in different countries handle transitions. Of the few comparative studies on multiple jurisdictions, even fewer have investigated the governance factors of integrating DE into their energy systems. Building on the literature on sustainability transition theories, governance, and urban local energy innovation, this current study compares three medium-sized cities. Often overlooked in the literature, medium-sized cities have unique constraints and opportunities that make them ideal for such an analysis. On this basis, the paper asks the question: How does governance impact the acceleration of decentralized energy transitions in cities? To investigate this question, stakeholders (n=60) involved with each city's local energy system and decentralized energy projects (government, business, utility, non-profit, academic, and environmental community) were interviewed. This paper compares these results using

[2] The academic literature generally does not support the idea that only market forces can be used to drive decentralized energy—there is a general consensus that government intervention at some level is required. This sentiment, however, more often prevails in mainstream discussions on energy transitions.

five governance dimensions: (1) utility market structure, (2) multi-sector collaboration, (3) decision-making capacity and autonomy, (4) multilevel governance, and (5) public perceptions of climate change. After a discussion on the theoretical implications of the results, this paper concludes with recommendations for further research.

3.1. Cities and Energy

Half the world's population now live in urban spaces, a demographic trend that is predicted to continue (Jiang & O'Neill, 2017; United Nations, 2010, 2018). By 2050 the world's population is expected to be 9.6 billion, 68% in cities (United Nations, 2010, 2018). Although only 2% of the world's landmass is urban, these areas produce approximately two thirds of the GHGs (IEA, 2009). According to the IPCC (2007), half of all energy use and GHG emissions come from the built environment (IPCC, 2007) as buildings consume substantial energy and emit high emissions (Akorede et al., 2010; B. R. Hughes et al., 2011). However, the projected increase in urbanization presents an opportunity to reduce energy demand (Lin & Ouyang, 2014). For instance, the concentration of energy use intensity and public use of infrastructure creates opportunities to significantly reduce emissions.

Cities have potential to be drivers of innovation in the energy transition. Often centers of social progress, grassroots action, and experimentation, many cities are leading the fight against climate change (Betsill & Bulkeley, 2004, 2007; Bulkeley & Metsill, 2003; Wurzel et al., 2019). For cities, the energy transition is an opportunity to both reduce global emissions while creating opportunities for local autonomy and resiliency. National and international levels of government and policies have begun to recognize the importance of cities and their role in emissions reduction (Betsill & Bulkeley, 2004; Chittum & Østergaard, 2014; Compact of Mayors, 2015). Instead of waiting for national and international signals for environmental action, they are often flexible enough to transition quickly to renewable energy, (Droege, 2002) and are seeking ways to augment their local and alternative energy portfolios, particularly DE (Mulugetta, Jackson, & van der Horst, 2010).

Despite these initiatives, developing and implementing local DE projects in cities is not a simple matter. A shift to DE is multidimensional, with intersecting social, economic, political, and technological factors to be considered (Hodson & Marvin, 2009; Lesage, Van de Graaf, & Westphal, 2010). Although at all levels of government, energy transition is an increasingly challenging policy question, local entities, in particular, are often ill equipped to manage the challenge of energy governance (Florini & Sovacool, 2009). Technical problems are also challenging. Engineers are building an understanding of urban energy system models and learning how to integrate a portfolio of energy options within an urban context (Keirstead, Jennings, & Sivakumar, 2012). Urban issues and energy technologies, as a socio-technical system, should be the focus of further research (Hommels, 2005). In particular, a focus on gaining insights from stakeholders within local energy systems will better expose the challenges and opportunities of these complex interactions.

3.2. The Comparative Method and Case Study Selection

The comparative method is an established and growing research approach (Mill, 1843; Ragin, 2014; Rihoux, Alamos, Bol, Marx, & Rezsohazy, 2013; Tilly, 1984). This method can unlock causal patterns within complex systems (Byrne, 2005) necessary for comparative studies with few cases (Ragin, 2014). The following cities were selected: Saskatoon (Canada), Luleå (Sweden), and Anchorage (United States). Table 3.1 compares key aspects of these cities relevant to the case study.

Table 3.1

Comparative case study city selection

	Saskatoon	Luleå	Anchorage
Country	Canada	Sweden	United States
Population (Urban)[1]	246 376	75 832	291 538
Area	170.8 km^2	29 km^2	204 km^2
Density	1 3001/ km^2	2 619/ km^2	1 232/ km^2
Sunshine Hours in December	86.5	3	51.8
Average Temperature Range (Jan/July)[2]	-18.9 °C /25.7 °C	-12.9 °C /20.7 °C	-11.4 °C/18.6 °C
Latitude	52° 08’ N	64° 34’ 4” N	61° 13’ N
Local and Regional Electric Utility	Saskatoon Light and Power, SaskPower	Luleå Energi, Nordic Energy Market[3]	Anchorage Municipal Light and Power, Chugach Electric Association, Matanuska Electric Association
Electric Utility Ownership	Public/GTD Provincial Monopoly[4]	Public	Public and Cooperative
Heat Type	Gas (minimal electric)	District CHP (industrial waste)	Gas/Electric (minimal wood and oil)
Notable DE Projects	SES Solar Coop, Renewable Rides	LuleåKraft C.H.P., Biogas	Fire Island Wind, Low Income Housing Project
Tonnes CO^2e/capita[4,5]	15.1	30	28.9
Largest Source of Emissions[5]	Buildings and industry	Buildings and industry	Industry (steel manufacturing)

Notes:

1. Source: (Luleå Kommun, 2020; Statistics Canada, 2016; United States Census Bureau, 2018)
2. Based on average low for January and average high for July.
3. The major companies are Vattenfall, Fortum, Statkraft, E.on, Elsam, and Pohjolan Voima.
4. Data collection and GHG calculation methods differ significantly from each jurisdiction. In all three cities, their emissions inventory update in progress.
5. Source: (*Anchorage Climate Action Plan*, 2019; City of Saskatoon, 2014; Deerstone Consulting; Crimp Energy Consulting, 2016; Orttung & Zhang, 2019).

Several considerations informed the selection of these three cities: population size and density, location, experience with previous DE projects, language, and governance of local utilities. Medium sized cities of 50,000 to 300,000 from different countries were selected because cities of this size typically have the capacity to pursue innovative projects, lack the land use constraints of larger cities (Andrews, Boyne, & Andrews, 2016; Gargan, 1981) and are exposed to a similar range of DE technologies. By selecting cases that would presumably have the potential to pursue DE technologies in their city, a comparative approach can more precisely contrast the success and failures of projects. The cities chosen were in the north because northern cities have attributes that can be held constant in a comparative analysis such as the northern latitude, seasonal temperature variances, seasonal changes to sunlight hours, and cold temperatures. All the cities have predominately rural and low regional population densities and, because they are relatively isolated, are not influenced by the proximity of larger urban centres. Another consideration was commitment to reducing GHG emissions and experience with DE; all three cities selected had implemented at least two DE projects. For practical data collection purposes, English was spoken by all interviewees in the selected cities. Finally, the municipal governments of all three cities have public ownership in their local electric utilities.

In addition to similarities, differences among the cities enhanced their suitability for a comparative case study analysis. All have varied utility ownership structures, social cultural conditions, political systems, energy policies, and current implementation levels of DE. From a governance perspective, all three cities have highly different electricity systems. Saskatoon owns its own electricity distribution, although the province in which it is located—Saskatchewan— operates the majority of the generation, transmission, and distribution (Hurlbert, McNutt, & Rayner, 2010; Hurlbert, Osazuwa-Peters, McNutt, & Rayner, 2019). In Luleå, the electricity utility is integrated into a competitive Nordic energy market that includes Sweden, Demark, Finland, and Norway. In Sweden, the majority of electricity generation comes from hydro (44.1%) and nuclear (40.5%) (IEA, 2013). Anchorage Municipality operates a local utility for the downtown core, while two regional cooperatively owned utilities serve the remaining portions of the city and surrounding area. Unlike Sweden and Saskatchewan, Alaska does not have an integrated and centralized electricity system that serves the entire region; instead, there are competing utilities with regional interconnections across the Alaska Railbelt[3]. The three utilities in Anchorage operate as independent, vertically-integrated utilities, each with its own generation, transmission, and distribution networks within their respective districts.

[3] The Railbelt is a regional electrical grid that connects seven utilities in the most populous region in Alaska from Fairbanks, to Anchorage, and the Kenai Peninsula. Three of the seven utilities serve the City of Anchorage: MEA, ML&P, and Chugach.

3.3. Data Collection and Interview Methods

A total of 60 interviews were conducted with actors involved in DE projects (government, non-for-project, business, utility, academic, and environmental activism). Along these lines, stratified sampling was used to allow for intersecting perspectives from interviewees (Robinson, 2014). To ensure interviewee participation and comfort, interviews remained confidential (Lancaster, 2017; B. Saunders & Kitzinger, 2015; Tilley & Woodthorpe, 2011). A non-probabilistic sample size was used for each of the city case studies based on achieving data saturation (Fossey, Harvey, Mcdermott, & Davidson, 2002; Glaser & Strauss, 1999; Hennink, Kaiser, & Marconi, 2017). Saturation is the point at which no additional insights are garnered from the data collection (Baker, Waterfield, & Bartlam, 2018). Although saturation is essential in qualitative research (Moore, 1995), it is a subjective form of analysis; therefore, scholars have pointed out that research needs to be transparent and specific about what is meant by saturation (Guest, Bunce, & Johnson, 2006; Hennink et al., 2017; Morse, 1995) and operationalize the saturation process. (Aldiabat & Le Navenec, 2018; Malterud, Siersma, & Guassora, 2016). This saturation method includes provisions such as aim, sample specificity, use of theory, quality of dialogue, and analysis strategy as factors in determining sample size (Malterud et al., 2016). Table 3.2 outlines the details of the information power analysis that was conducted to reach sample size saturation.

Table 3.2

Information power sample size saturation

Criteria	Details related to study	Saturation metric
Aim	**Broad**: To compare the sociotechnical conditions that contribute to innovative DE projects	Enough interviews were conducted to inform the overall aim of the research[1]
Sample Specificity	**Dense**: Actors are limited to those with knowledge or connection with energy projects in their respective city.	Include actors from multiple sectors (political, business, advocacy, etc) that represent the major components of the energy system of each case study[2]
Use of Theory	**Applied**: Results will be used to develop theory	Enough interviews were conducted to answer the research question
Quality of Dialogue	**Strong**: Interviewer is very knowledgeable on topic and with conducting interviews. On-site face-to-face interviews to be used.	Individual interviewees have no additional comments to share on the topic[3, 4, 5]
Analysis Strategy	**Cross-case**: This is a comparative study with three cities.	Enough interviews so that thematic analysis could be conducted between the case studies.

Notes:

1. Selection of participants was based on background research on their involvement with the local energy system and their suitability for the study aim.
2. A semi-structured interview guide was development in accordance with quality qualitative semi-structured interview methods of "(1) identifying the prerequisites for using semi-structured interviews; (2) retrieving and using previous knowledge; (3) formulating the preliminary semi-structured interview guide; (4) pilot testing the interview guide; and (5) presenting the complete semi-structured interview guide" (Kallio, Pietil, Johnson, & Kangasniemi, 2016: 2961). Changes in terminology and clarifying follow-up questions were added after receiving preliminary feedback.

3. In the case that more information was needed to be shared than an additional interview was conducted with that participant or follow up questions were asked.
4. Face-to-face hour-long dialogues were used for the majority of the interviews. As well the majority of the interviews were conducted at the interviewees' place of work. All interviewees were provided an information sheet on the project prior to the interview so they could be appropriately prepared for the interview.
5. Prior to conducting the interviews in each of the case study cities, thorough background research was conducted. This included in-depth documents analysis of academic and non-academic literature including books, reports, council minutes, official government website entries, and news articles.

Prior to starting the research, it was determined that a target of 15 interview participants for each city would meet the saturation requirements. Although an interview target was established, achieving information power saturation was the goal. For instance, in Anchorage (n=32) the sample size was double that in Saskatoon (n=12) and Luleå (n=16) because it was more difficult to achieve saturation. To buttress interview saturation, contemporaneous notes and journaling were also used during the interview process to ensure key insights and gaps in knowledge were accounted for (Annink, 2016; Janesick, 1999; Ortlipp, 2008; Watt, 2007). I conducted month-long site visits to better understand the cultural contexts that may have impacts on the institutions, norms, and organizations of the cities[4]. Face-to-face hour-long dialogues were used for the majority of the interviews. Where face-to-face interviews were not an option, telephone interviews were used instead. Research on telephone interviews has demonstrated that they are an effective alternative to face-to-face interviews for data collection (Block & Erskine, 2012; Holt, 2010; Schober, 2018; Watt, 2007). Two telephone interviews were used in Alaska, none in Saskatoon and Luleå.

3.4. Results and Analysis

I conducted a thematic analysis specific to governance considerations from the interviews, journal entries, and city specific academic and grey literature. Themes were selected after all interviews were conducted. I used a modified approach based on Auerbach and Silverstein (2003) in their book *Qualitative Data*. This approach consisted of the following steps:

(1) *Identify repeating ideas* — If two or more interviewees mentioned an idea related to governance considerations for their DE transitions there were noted for potential consideration as a theme.

(2) *Identify potential themes* — I then grouped and re-grouped themes based on idea clustering.

[4] The lead researcher and author of this paper resides in Saskatoon.

(3) *Aggregate and group themes* — Final selection of governance dimensions were reviewed to arrgregate potential theme and sub-themes. City specific academic and grey literature was reviewed to coordinate the clustered ideas and to provide a basis for supporting analysis.

From this analysis, I selected five governance dimensions that impact DE transitions in cities: utility market structure, multi-sector collaboration, decision-making capacity and autonomy, multilevel governance, and public perceptions of climate change.

3.4.1. Utility Market Structure

Each of the cities operated within various utility ownership structures, regulated or deregulated electric utility markets, which had implications for DE transitions. Luleå's electric utility competes within the Nordic energy system. Anchorage has three vertically integrated electric utilities, two cooperatively owned and one municipally owned. Saskatoon has both a municipally owned utility for a portion of the city connected to a larger monolith vertically integrated crown corporation that serves the province of Saskatchewan. Interviewees in all of the cities noted a variety of opportunities and challenges with their jurisdiction's utility structures.

Of the three cities, Luleå is the only one that must compete within a deregulated market. Although Luleå owns its local electrical distribution utility, it is integrated into the broader Nordic energy market, or the Nordic Synchronized Area. For local energy in the city, the market structure provides an assortment of benefits, one of which is the potential for deregulated markets to better manage the challenge of intermittency. The ability to sell electricity in peak generation times when local demand is low increases the value of DE to the grid. An energy expert in Luleå noted that, "The reason why we can do the CHP is maybe that we can […] sell electricity on the grid" (Luleå Interview #10). The same interviewee noted that "it's not that the city balances the power grid. They care about the district heating. That one they have to supply because district heating is local, but the power they sell to the spot market" (Luleå Interview #10). By selling electricity to the spot market, Luleå is able benefit from its overproduced electricity, allowing projects like Luleå's CHP system to be viable. Within the Nordic Synchronized Area, hydropower and pumped hydro storage, located in Norway and Sweden can serve as storage to balance local intermittent DE projects.

Saskatoon and Saskatchewan have a traditional regulated market. Although there are peaks and valleys in the demand profile in Saskatchewan, there is no spot market or capacity market within the system that local energy projects can leverage. In the Saskatchewan context with its regulated market, the financial justification for self-generation in community and roof-top solar is different[5]. From the perspective of the electrical utility, DE can be antagonistic to its profitability and business model (Dolter & Boucher, 2018). An energy expert in Saskatoon noted that there is a fundamental business challenge to the local utility to sell electricity with the current net metering program.

> There's absolutely no benefit to Light and Power [SL&P]. So, for every kilowatt solar panels that are installed, Light and Power [SL&P] loses money. So, with the production it does mean, so whatever's coming on, whatever's not used onsite and comes onto the grid through the net meter that does offset bulk power purchases. But it also eliminates that revenue opportunity for Light and Power [SL&P]. If you take the loss revenue opportunity and you subtract the avoided bulk power purchase, it's still a significant net loss for every kilowatt of solar that comes on the grid (Saskatoon Interview # 9).

Similarly, another energy expert mentioned that there is an economic challenge to local energy development from the perspective of SL&P.

> [I]t's not quite as clearly defined as their [SL&P] mandate to make money. And the mandate to make money for the utilities is somewhat in conflict with the mandate to do renewable energy projects because… they buy most of their electricity from SaskPower for pretty cheap (Saskatoon Interview #2).

One of the major issues for intermittent renewable energy in a regulated market is cross-subsidization. In fact, a report to council in Saskatoon from the local utility noted that, "The financial impact for each kilowatt of solar installed is estimated to be a reduction in revenue of $185.25 per year. With these programs doubling in size every two years, the financial impact continues to grow proportionally. The loss of revenue opportunity from the existing programs in 2017 was estimated at $92,625" (City of Saskatoon, 2017)[6]. A deregulated market structure for DE can create an economic environment that better manages the issues of cross-subsidization.

The utility landscape in Anchorage and Alaska is disjointed and, in some instances, dysfunctional. Whereas Luleå's jurisdictions are deregulated and interconnected and Saskatoon's are interconnected and regulated, Anchorage's are neither. Discussed widely during the interviews in Anchorage was the lack of cooperation between the utilities along the Railbelt and the need to move towards a consolidated model that rationalizes the transmission system discrepancies. A government official discussing the seven Railbelt utilities noted that,

---

[5] Chapter Five and Six provide an analysis of the policy landscape and decision-making challenges from the perspective of the utility of self-generation programs in Saskatchewan.

[6] The issue of solar cross-subsidization in Saskatchewan was analyzed in more depth by Dolter and Boucher (2018).

> Each organization [Railbelt utility] grew up as a standalone organization, right? And then you operate them together. You look at it, well that's nuts. Well you would never have designed it that way if you just designed it altogether (Anchorage Interviewee #7).

The interviewee continued by arguing that, “there are significant savings to be had by operating this unit as one” despite the “disagreement between utilities” (Anchorage Interviewee #7). Because of the lack of cooperation between the Railbelt[7] utilities in Alaska, there is overcapacity embedded within the entire system. Interviewees emphasizes that this lack of integration has resulted in overcapacity of electrical generation buildup that would otherwise be required if there was greater integration between the utilities (Anchorage Interviewees #2, 6, 7, 13, 14 17, and 24).

As it pertains to DE in Anchorage, a lack of integration between the utilities creates obstacles. For instance, according to the Committee on Railbelt Operating and Reliability Standards “to the extent practical, interconnecting entities should not be allowed to degrade the performance or reliability” (The Intertie Management: Committees’ Railbelt Operating and Reliability Standards, 2017). Reliability is challenged by the uptake of DE on the grid. A business leader in Anchorage noted that,

> The utilities for the longest time were not particularly friendly to the idea of somebody undermining their business case by reducing the amount of energy that they're purchasing from the utility. Now they're trying to kind of thread the needle and they recognize that their consumers will not accept that. So now they're trying to figure out what new technologies, how to do net metering more effectively, and then how to balance that with the cost of their existing grid. Because again, you know […] now you've got the consumer electric grid, which is residential, commercial and some industrial in Anchorage. Okay. So, who's paying to maintain that grid? (Anchorage Interview #2).

Similarly, a representative from one of the utilities in Anchorage noted that,

> If there's a dip in the availability of wind because of a gust or because the wind falls off, it's harder for our system to absorb those fluctuations. And so, we then have to have more reserve capacity online. We have to have more fossil generation. How we handle it, right now, we have more fossil generation spinning, which means that the economics aren't as good because we still have to be burning fuel (Anchorage Interview #13).

[7] As of February of 2019, four of the Railbelt utilities, included all of the Anchorage utilities made a request to the RCA for the formation of a transmission utility (Company, 2019).

In response to the growing concern of the transmission system in Alaska, the Regulatory Commission of Alaska (RCA) has requested that the Railbelt develop a model in which the utilities increase cooperation. This is not a new discussion and there has been a longstanding debate between the seven utilities in Alaska connected in the Railbelt on models for integration. As early as 1998, a report prepared for the Alaska Public Utilities Commission highlighted the importance of power pooling and central dispatching (Alaska Public Utilities Commission, 1998). Interviewees also emphasized that integration would allow Anchorage to sell its excess and relatively inexpensive electricity to Fairbanks, also connected to the Railbelt, which is experiencing higher electricity costs. Integration of the utilities would allow for greater penetration of DE on the gird in Anchorage.

3.4.2. Multi-sector Cooperation

Sweden, Saskatchewan, and Alaska have differing approaches to multi-sector cooperation and these differences impact local DE projects in Luleå, Saskatoon, and Anchorage. According to the interviewees, Luleå had a high level of multi-sector cooperation between public and private entities, whereas Anchorage and Saskatoon had a low level of integration.

The extent to which there was multi-sector cooperation was a source of success for projects in Luleå. Interviewees attributed their cooperation to the success of their DE projects. A political leader in Luleå emphasized that this integration has impacted the political scene in the city and opportunities for local energy innovation.

> The steel production is the backbone of the city [...] Everybody who lives in the city, and especially we who are in the ruling party, understands the importance of the industry and the need to find the collaboration with the industry in different ways. So I think that over the years, the solutions that have been made that are many of them, before I was born or before I was active in politics, they are made of the, of the mutual trust that the city and, and the industry has an extremely strong link between each other and the necessity to understand the work together (Luleå Interview #15).

A business leader in Luleå similarly emphasized how production processes are adapted to adjust to heating demand profiles in the city. As well, this business leader discussed the importance of maintaining steady production for the city during the coldest days in the winter to ensure that the city's district heating system has enough heat to continue operations.

> We have for many reasons to avoid [having] stops in production if it's very cold outside. But one of the reasons is that we really need energy to the heating system for the town [Luleå] for when it's cold outside. There are other reasons. […There is a] risk of freezing up parts of the plant here if it's too cold outside and we have a stop. We also have to think of […] supply[ing] the district heating (Luleå Interview #12).

Long-term agreements were often part of the multi-sector cooperation in Luleå. An energy expert in Luleå emphasized that long-term agreements between the public and private sector were important for the success of the existing district heating network that exists in the city.

> The fact that we did compile a really long-term agreement early on in the process when it comes to the price of the waste gas […] they put a very low price to begin with on the waste gas. Because [it is a] local energy company, we're supposed to be given the opportunity to invest in the district heating network. They had to allow this because there were no district heating network. There were small networks in the new built housing areas and perhaps here in there, but they had to build all those together and the steelworks found that reasonable (Luleå Interview #8).

Whereas Luleå had a managerial approach to its integration, Anchorage and Saskatoon had a more facilitation role. This is not to say that there are no partnerships in Saskatoon and Anchorage, but the breath and the long-term nature of the partnerships are not as prevalent. To this point, a business leader in Anchorage noted that, "the energy base of Anchorage and the region has kind of grown up organically over time without really any significant long-term planning until the last 20 years" (Anchorage Interview #2). What has resulted from this has been a more siloed approach. Similarly, in Saskatoon, the interconnections between the public and private sector are more limited. Recently, however, there have been notable projects in Saskatoon and Anchorage — the Fire Island Wind project in Anchorage and the SES Community Solar project are both such examples of multi-sector collaboration.

Although Luleå has had many examples of multi-sector cooperation, there was a perception amongst interviewees that there were few new actors entering the system. When asked if there were new actors in the energy system in their city in the last 10 years, interviewees in Saskatoon and Anchorage said that there were many new actors while most interviewees in Luleå mentioned that there were none in their city. In Saskatoon and Anchorage, interviews emphasized that there were many new businesses in all areas of the energy system. This contrasted Luleå where there was little mentioned of new businesses.

3.4.3. Decision Making Capacity and Autonomy

Each of the cities have different levels of autonomy relative to their decision making. Anchorage has a strong mayoral form government, Saskatoon has less mayoral powers with a stronger council, and Luleå has a cabinet-based government, which operates as a party-based legislative municipal assembly[8].

[8] The mayoral form distinction exists primarily in the United States. Cities in Sweden and Canada don't have this distinction.

Despite the strong mayoral form of government in Anchorage, local decision making on energy is spread among the three utilities through membership cooperative boards. This gives the cooperative utility board much autonomy to make decisions, which was highlighted as an opportunity. On the topic of this co-op system, a political leader in Anchorage noted the following when comparing the ML&P (the municipally owned utility) and the utility co-ops:

> It [ML&P] is run like a separate individual utility and in fact it has profit requirements. It has to generate a certain amount of value for the municipality. The co-op model has a lower requirement and in fact the co-op model for energy production if it's done properly the intent there is to keep prices low. That's actually its core mission is to generate power as cost effectively as possible. So, it's that non-profit model but with a strong value on keeping the price proper […and] competitive. (Anchorage Interview #1).

A business leader in Anchorage emphasized the decision-making autonomy of Anchorage and how the city is motivated to move forward with energy efficiency regulation.

> The state has no authority to any significant degree. They grant a broad set of brush stroke authorities that a city can adopt, but they leave it to the cities to choose what parts that they're going to adopt. Plus, there are national standards that are related to insurance that have to be adopted and finance that have to be adopted. So, you've got a fairly complex set of things that are influencing a city policy on building codes and energy efficiency. That's an interesting interaction. Well part of it is the city's got a motivation in this and the fact that they want their citizens to have more money in their pocket books so that there'll be a little more willing to. It also increases the value of the homes so your tax base goes up (Anchorage Interview #2).

Ownership over the local utility was emphasized as an opportunity for a local DE project. A political leader in Saskatoon on the role of SL&P noted that,

> I think there's a risk by us not being out in front providing opportunities for people to do things like solar because we're moving in that way. And I think if we're not part of that conversation, then we lose out on all of that revenue as well (Saskatoon Interview #3).

3.4.4. Multilevel Governance

The impact of policies from state, provincial, federal, or national government was emphasized as important by the interviewees in each of the cities. In Saskatoon and Anchorage cities are creations of the province or state, respectively. Therefore, the federal governments in Canada and the United States have a limited direct impact on city autonomy. This contrasts with Luleå, where cities are within the jurisdiction of the national government. Therefore, the national government of Sweden has much greater impact on cities. There are a number of ways that higher level governments can support DE. However, supportive policies were perceived as less or more stable in each of the jurisdictions, which impacted decisions on DE projects.

Whereas Luleå has been a paragon of policy stability and support, the dynamic in Anchorage was one of a fluctuating policy environment. In the state of Alaska, a large portion of public revenues are from the natural resources sector. Since 2008, the price of oil has fallen and so to have the revenues associated with that support (Alaska Department of Revenue, 2017).

In Anchorage for instance, there is financial support from higher level governments for tax credits. In particular, part of the justification for the energy efficiency and renewable energy projects for the Cook Inlet Housing Authority support through the Greater Opportunity for Affordable Living (GOAL) program. The GOAL program is applied based competitive process between developers of low to medium income housing that is administered by the Alaska Housing Finance Corporation (AHFC). As part of the selection process, points are allocated for the provisioning of conservation and renewable energy initiatives (Alaska Housing Finance Corporation, 2018). An interviewee noted that, "One of the reasons why we do alternative energy is to get points to build these projects, right? Because our end goal in this whole thing is to create homes for people. So, to do that, we got a win money. And to do that we've got to do alternative energy because we get points for it" (Anchorage Interview #21). The same interviewee emphasized that the environment for funding has become increasingly competitive and funds are more difficult to receive.

3.4.5. Public Perceptions of Climate Change

Public support for environmental initiatives and norms around climate change differed in the jurisdictions of each of the cities. At the city level in all cities, there were targets for emissions reductions under the Compact of Mayors. Public support for climate change within a jurisdiction can have positive impacts on the uptake of local DE projects. In the interviews, climate change was mentioned as a major driver in Luleå but not in Anchorage and Saskatoon.

When discussing the steel business and the CHP system in Luleå, a business leader emphasized that the steel industry is strongly motivated to reduce its emissions.

> Not only from the government but […] the climate discussions […] there is of course the pressure to reduce the climate impacts. And, as we are one of the major emitters of carbon dioxide in Sweden to reach the goals that are set up by the politicians we [the steel industry] have to do something (Luleå Interview #12).

A political leader in Luleå mentioned that there is political support for spending public funds on climate change, "I think that we have to take the tax money […] to help climate change so that our generations after us could stay [and] live here on this planet. (Luleå Interview #7). These sentiments about the importance of climate change were heard throughout the interviews in Luleå. Nearly every interviewee mentioned the importance of climate change. This is also consistent with survey data in Sweden, which shows that there is widespread support for combating climate change (Gullers Grupp, 2018).

In contrast, a lack of broad public support was mentioned as a major barrier to DE projects in Anchorage and Saskatoon. A representative from the environmental community in Saskatoon mentioned that a lack of leadership on climate change makes it difficult for the city to move forward with local energy initiatives.

> Unfortunately, none of the political parties are doing a ton, but in Saskatchewan in particular the need to oppose anything the federal government is doing, the need to […] deny climate change issues leads to no leadership from the province. And so, in terms of energy generation, energy conservation […] there's very little happening. And then from the municipal point of view, I think one of the resistances is the amount of work it could take for the city to do something on their own without the support from the province. So, for example, building code, the city municipalities can set their own building code, but Saskatoon's like, oh are you kidding me? The amount of work to have our own building codes separate from the province is just kind of too much. And then they also worry about things like people building outside of the city instead of in the city to save a few bucks on construction (Saskatoon Interview #2).

Climate change was minimally mentioned in Anchorage. Of the 32 interviews, only two talked about the attitudes towards and worries about climate change as impacting DE in the city. This contrasts with interviews in Luleå, where nearly all interviewees emphasized the importance of climate change. One interviewee from Anchorage, a representative for one of the utilities, discussed the importance of focusing on fuel savings instead of climate change to garner more support.

> There're definitely people in the state that don't agree with and believe climate change is happening. So, they don't want to pay more for their electricity around renewables. But if we can all agree burning less as is good, then everybody, no matter what their motivation is served. Whether it's cost, whether it's climate change, whether it's energy security, burning less fuel is good (Anchorage Interview #13).

3.5. Discussion

The purpose of this paper is to understand the governance challenges for DE transitions in cities. Based on interview data and grey literature review, the results below highlight the impacts of the five governance dimensions: utility market structure, multi-sector cooperation, decision-making autonomy and capacity, multilevel governance, and public perceptions on climate change. These governance dimensions and their impact on acceleration DE transitions will be explored in this section.

3.5.1. Utility market structure

Large technological systems like the electricity sector tend to move incrementally and are resistant to potentially disruptive innovations (Hughes, 1983; Markard & Truffer, 2006). However, the recent trend towards the liberalization and deregulation of electric markets have fundamentally restructured the operations of utilities, as in the case of Sweden. Market deregulation can be supportive to DE such as providing generation options and a market for selling local power (Carley, 2009; Muratori, Schuelke-Leech, & Rizzoni, 2014). Deregulation of the energy markets has also been shown to reduce R&D funding for innovative energy technologies (Dooley, 1998). Deregulated markets can permit new competition and differentiation of firms. Delmas et al. have found that this differentiation can result in consumer preference for 'green' energy options, however this result is contingent a public preference for these energy options (Delmas, Russo, & Montes-Sancho, 2007). The results from the interviews also suggest that utility market structure can impact the opportunities for DE projects (see Table 3.3). Consistent with the literature, there are both opportunities and challenges with the deregulation of the electric market.

Table 3.3

Competitive utility market structure

	Luleå	**Saskatoon**	**Anchorage**
Market type	Deregulated	Regulated	Regulated
Transmission functionality	Integrated	Integrated	Disjointed

More important than the market type is the transmission functionality. In Anchorage, the lack coordination and oversight of the transmission system drew significant challenges for DE. Each electric utility in Anchorage is vertically integrated with their own transmission system. This creates a collective action problem known as a prisoner's dilemma (Hardin, 1971). Voluntary cooperation of the transmission system between the utilities are disincentivized at the individual level to the detriment of all of the utilities on the Railbelt collectively. In other words, the benefits to act in one's economic self-interest are outweighed by the uncertainty that the other actors using this common pool, the transmission system, may defect and act in their perceived self-interest. This theory presumes that actors within this system operate solely within a rational economic cost-optimization model. Despite the clear logic of this theory, empirical and human evolutionary evidence suggests that actors are often inclined to cooperate and trust each other in such instances (Ostrom, 2000). Although it would appear that the utilities operated only within their self-interest, there have been decades long attempt by the Railbelt utilities to voluntarily cooperate and otherwise create a framework that would more efficiently coordinate the transmission system. For instance, there are already utilities on the Railbelt engaged in a loose power pool arrangement and have shared purchased agreements, which are managed and governed by the intertie agreement and the intertie management committee (*Amended and Restated*

Alaska Intertie Agreement, 2011; The Intertie Management: Committees' Railbelt Operating and Reliability Standards, 2017). This agreement, among others, is a start but not enough to facilitate a sufficient coordination of the transmission system to support a broader transition to DE. Given the longstanding inability of the utilities to cooperate, a combination of oversight by the state and self-organization would be necessary.

3.5.2. Multi-sector cooperation

Emphasized by the interviewees in Luleå was that the implementation of their DE projects can be attributed to their cooperative approach (see Table 3.4). Long-term agreements and cooperation with the private sector, multiple levels of government, and the academy facilitated robust multi-sector cooperation. As a result, the system in Luleå is a large, well-entrenched system of institutional actors. This contrasted to Saskatoon and Anchorage where there was moderate multi-sector cooperation and siloed institutions. However, Saskatoon and Anchorage had many more new actors in the DE arena in the last 10 years. Perhaps an offset to the lack of cooperation in Anchorage and Saskatoon was a surge in activity of new actors. Largely non-existent in Luleå, these actors were motivated to solve the principal-agent collective action problem that existed within their siloed sectors. There was a perceived benefit to be garnered by cooperating between public-private and public-public entities, and these actors were motived to build this capacity within their city.

Table 3.4

Comparative institutional integration

	Luleå	**Saskatoon**	**Anchorage**
Multi-sector cooperation	High	Moderate	Moderate
New actors	Low	High	High

But what can explain the lack of new actors in Luleå and the emergence of new actors in Anchorage and Saskatoon? Actors within a highly cooperative system as with Luleå create co-dependence and have increased overall actors (Emerson, 1962; Whetten & Rogers, 1982). In fact, cooperation can create an institutional structure that affords opportunity and power to those within the cooperative network—and not to those outside (Moe, 2005). The result of these interactions are stability of the system and a resistance to the emergence of new actors. Even facing failure, these interdependent actors persist (Klijn & Teisman, 2003). This was seen in Luleå with the failure of their waste-to-gas project. Actors on the periphery as well as those directly involved with the project recognized that this project was a failure. This did not stop the project from continuing despite revenue losses for a decade and alternatives (i.e. electric mobility) that would pose further risk to the project. This may explain the lack of actors in Luleå and the larger number of actors in Anchorage and Saskatoon.

Another explanation for the lack of new actors would be that the system in Luleå functions well and new actors may see less value in contributing to such a system—there is strong social self-organization in Luleå. My interviews and interactions with the environmental community in Luleå would support this claim. By virtue of their role in society, environmental activists are quick to point out flaws within systems and suggest alternatives. In Luleå, the environmental community spent little by way of critiquing Luleå's performance, which was a stark contrast to their counterparts in Saskatoon and Anchorage. The environmental community in Luleå focused their efforts on mining operations in the northern region of Sweden. When asked about the city of Luleå, they noted that the city was moving in the right direction. The perception that the city was progressing was supported by all interviewees in Luleå.

These two explanations can be mutually supportive. High levels of multi-sector cooperation could both facilitate the success of progress in the city while also leading to networks of interdependent actors resistant to new entrants. And the success of the network to achieve its goals leads in turn to new actors not seeing a benefit to disrupt the system. In this case, the success of the cooperative approach leads to an inherent weakness, albeit one that may not be overly concerning given the progress made in Luleå.

3.5.3. Decision-making capacity and autonomy

The three cities have varying degrees of decision-making capacity and autonomy. Swedish cities have considerable resources at their disposal, relative to their Canadian and American counterparts. Since the 1980s, the Swedish government has promoted increased local economic development which has afforded municipalities more responsibility over business development and innovation. The general differences of decision-making capacity and autonomy is summarized in Table 3.5. What can be said from this general comparison is that autonomy and capacity need to meet in order facilitate a DE transition. The Anchorage case demonstrates that autonomy alone without the underpinning capacity is not sufficient—which was evident from the interviewee's responses in Anchorage.

Table 3.5

Comparative decision-making capacity and autonomy

	Luleå	**Saskatoon**	**Anchorage**
Capacity	High	Moderate	Low
Autonomy	Moderate	Moderate	High

The ability for local entities to be involved in decision-making and have the capacity to execute DE projects is a strategy, purposeful or not, to mitigate the challenges of complexity. DE transitions are complex and how they emerge is diverse and locally specific. Local energy projects are a feature of their geography, infrastructure, and history. In Luleå, the district heating system is fed as a by-product from the local steel plant, the Swedish publicly owned company SSAB (Petrini, Sandstrom, Lundkvist, Grip, & Boden, 2004). There are further efficiencies within the system through a CHP system that also provides electricity to the local electric utility, Luleå Energi. Actors within the city would likely be the most capable facilitators to leverage their local attributes of these complex system interactions. This analysis is also consistent with recent comparative work on local energy transitions in towns. Bayulgen has pointed that municipal government structure has limited impact as a driver but bureaucratic capacity is a determinant driver (Bayulgen, 2020).

To be clear, decision-making capacity and autonomy are alone not enough—they are factors. It would be an oversimplification to suggest otherwise. In fact, research on collaboration between industry and municipalities in Sweden emphasizes that their success relies heavily on the people involved in the projects (Grönkvist & Sandberg, 2006), which was in particular the case in Luleå (Söderholm, 2018). But again, the foundation of this success in contingent on having both autonomy and capacity in place.

3.5.4. Multilevel governance

With multilevel governance, the implications are somewhat counterintuitive. On the one hand, policy stability and support from higher level governments can create a foundation for DE transitions to occur. Actors and institutions can plan and build the necessary capacity to move objectives forward. On the other hand, a lack of policy stability and fluctuating support from higher level government can create a window of opportunity for DE transitions. The results from this study suggest that support from higher-level government is important but not essential. In Anchorage, actors respond quickly to policy windows because there is uncertainty on the stability of newly adopted policies in Alaska, given the natural resource market fluctuations and state level decision-making.

Table 3.6

Comparative multilevel governance

	Luleå	**Saskatoon**	**Anchorage**
Policy stability	High	Moderate	Low
Support from higher-level governments	High	Moderate	Moderate

A potential explanation is that windows of opportunity can create openings for disruptive innovations to occur (Geels, 2014; Geels, 2002; Geels, Sovacool, Schwanen, & Sorrell, 2017). These windows of opportunity need to be severe and urgent enough to create a focusing event amongst actors (Brikland, 1998; Kingdon, 1984). The policy instability in Anchorage created a response by groups of actors wanting to fill this gap. The Renewable Energy Alaska Project (REAP), for instance, is a highly innovative and prominent organization that has had strong impact on public policy in the city and state.

These policy entrepreneurs[9] are often important actors in moving forward innovative policy (Christopoulos, 2015; Mintrom, 1997; N. C. Roberts & King, 1991). Amongst other accomplishments, REAP played a key role with the establishment of Bill 162 (which established the Renewable Energy Grant Fund), Bill 289 (which provided $360 USD towards energy efficiency), and Bill 306 (which included a 50% by 2025 renewable energy target). These changes at the state level had impacts on Anchorage's energy system and were a function of the political and policy ebbs and flows.

3.5.5. Public perceptions on climate change

The interviewees concern on the public perception of climate change (see Table 3.7) and the impact this has on policy is consistent with the literature. Similar to the results, perceptions of climate change vary from country-to-country (Wolf & Moser, 2011). In Sweden, there is large public support for climate change (Wibeck, 2014b). In both Alaska and Saskatchewan public support is moderate to low (Mildenberger et al., 2016).

Table 3.7

Comparative public perceptions on climate chance

	Luleå	**Saskatoon**	**Anchorage**
Public perception	High	Moderate	Low

Public acceptance of climate change can impact the governance of DE transitions. In Anchorage in particular, there were attempts by project proponents to reframe projects in terms of economic benefits, which changed the justification for projects to move forward. Whereas in Luleå, great emphasis was placed on emissions reductions benefits of DE projects as well as economic considerations.

Public support for climate change can motivate support for climate policies. For instance, research suggests that support for climate policy varies with type of policy (Rhodes, Axsen, & Jaccard, 2017; Shwom, Bidwell, Dan, & Dietz, 2010) and how the issues of climate change are framed (Feldman & Hart, 2018; Mccright, Marquart-pyatt, Shwom, Brechin, & Allen, 2016; Nisbet, 2009a; Shwom et al., 2010; Stecula & Merkley, 2019). Part of the reason this occurs is because people can psychologically resistant

[9] Policy entrepreneurs, "use several activities to promote their ideas. These include identifying problems, shaping the terms of policy debates, networking in policy circles, and building coalitions" (Mintrom & Vergari, 1996, p. 423).

to climate change (Swim et al., 2011; Van Boven, Ehret, & Sherman, 2018) and motivated by a particular political ideology (Mccright & Dunlap, 2011; Van Boven et al., 2018).

3.6. Conclusion

Cities do not operate as silos or islands. They are integrated within a jurisdictional context that has governance implications, which impact how DE projects unfold and the dynamics in which they are situated. The results of this study suggest that the examples of accelerated DE projects can be impacted by cities' governance differences. The jurisdictions from which cities reside have political, cultural, legal, and policy practices and norms that can enable or hinder DE transitions. This paper asked the question: How does governance impact the acceleration of decentralized energy transitions in cities? To investigate this question, this paper compared five governance dimensions with their impact on DE transitions in cities: 1) utility market structure, (2) multi-sector collaboration, (3) decision-making capacity and autonomy, (4) multilevel governance, and (5) public perceptions of climate change. The results from this research and the analysis showed potential determining factors within the governance dimensions. Public perception of climate change, supportive and stable government interventions, multi-sector collaboration, and local capacity are potential determining factors to DE transitions. The results also showed that there are elements of the five governance dimensions that are not a determining factor in all cases, such as local autonomy, utility ownership structure, new actors.

This paper began by suggesting that governance hierarchies, markets, and networks have all been used to explain DE innovations and asked the question, "How does governance impact decentralized energy transitions in cities?". The multi-sector collaboration in Luleå and the policy communities in Saskatoon and Anchorage show the potential that networks of actors can motivate DE transitions. It is also the case, though, that direct support from public institutions was important. In all cities, in fact, there was financial and managerial support for innovative DE projects and interviewees consistently emphasized that much of this support was necessary as it reduced the upfront financial burden of their projects. And finally, actors and organizations were able to capitalize on markets to move DE projects forward, the utility market structure in Luleå as the obvious example. Actors in Anchorage, particularly in the business and advocacy organizations, were able to deliver innovative DE projects despite a lack of direction from higher-level governments and weak actor networks.

In answering this question of governance and DE more precisely, I would bring this discussion back to the governance work from two decades ago. It was Powell who challenged the notion that governance falls within a continuum between a market and a hierarchy and suggested that governance can also fall within a third category: a network (Powell, 1990). He observed that some sectors in society function well because of their network governance structure. His work laid the foundation for future research on network governance and a deeper appreciation of less formal organizational interactions and the power of human reciprocity. Powell's astute observation that we should consider a multitude of governance arrangements is correct. However, it could be expanded. His work focused on organizational sectors which is limited for an analysis involving multi-sector arenas like DE transitions. My observations have shown that interactions between governance dimensions may be just as relevant as the three categories of governance. There is a multiplicity of governance arrangements that can drive or hinder DE transitions. This work has outlined five governance dimensions but there are likely more. But the more promising insight is that the interactions of these governance dimensions may offer a more powerful explanation for DE transitions.

A revised focus on governance interactions can lead to further questioning. For instance, to what extent does the interaction between public perceptions of climate change and multi-sector collaboration facilitate DE transitions? Are policy communities more effective at facilitating DE transitions in regulated or deregulated utility markets? How much does city level autonomy and capacity impact DE transitions when there is strong support from higher-level governments? These questions, among others, that focus on the interactions of governance dimensions can be explored to offer further insights into the conditions that facilitate DE transitions.

I must end with a note on the limitations of this work. This research involved only three cases and therefore it is difficult to make generalizable claims. Ragin has presented a caveat for such instances, arguing that "case-oriented researchers are always open to the charge that their findings are specific to the few cases they examine, and when they do make broad comparisons and attempt to generalize, they often are accused of letting their favorite cases shape or at least color their generalizations"(Ragin, 2014, p. *ix*). Although I was cautious not to fall victim to Ragin's caveat of favouritism bias, there were a limited number of cases and therefore the major claims in this analysis leave it open to understandable scrutiny. The claims presented in this analysis should be considered a starting place for further inquiry on the question of comparative research on urban energy transitions and governance.

Chapter Four: Northern Urban Energy Futures in Saskatoon, Luleå, and Anchorage

A version of this chapter has been accepted as part of an edited peer reviewed volume titled *More than 'Nature': Research on Infrastructure and Settlements in the North* as a co-authored paper with Joni Karjalainen.

Contribution Statement: Boucher contributed over 90% of research and writing activities. Boucher conceived, planned, designed, conducted interviews, and analyzed data. Karjalainen provided feedback on interview questions. Boucher took the lead on writing the manuscript. All authors discussed the results and contributed to the final manuscript.

Chapter Four: Northern Urban Energy Futures in Saskatoon, Luleå, and Anchorage

The futures of northern cities and the evolution of their energy systems provoke many types of imaginations. Northern and cold regions are changing with many unprecedented long-term implications affecting human habitats. Climate change is impacting the Arctic temperatures at nearly twice the rate than the global average. Permafrost thaw, erosion, and increases in seasonal temperature variances are putting pressure on crucial infrastructure developments (Berman & Orttung, 2020). Amidst many sparsely populated areas and long distances are cities in the North reliant on unsustainable patterns of energy use. When energy systems are in transition, seeking sustainability (Köhler et al., 2019), attention has to be paid to their particular characteristics and demands. Heating is required in cold winter temperatures, and sunlight is present only for limited amounts during the day. The future of urban energy use will also be influenced by the diffusion of global innovations, novel lifestyles and technologies.

Anticipated changes, and climate change in particular, are driving a push for resilient low-carbon alternatives, co-evolving with changes in established socio-technical systems and infrastructures. Here, the transformation of the energy system, as an energy transition, is expected to play a crucial role. Renewable energy, energy efficiency, and smart cities are assumed as a part of the developments also in the North (Arruda, 2018), and even increasingly radical departures from the present are envisioned. The beyond business-as-usual approaches consider decentralized energy (DE), large-scale electrification, increasing shares of variable renewable energy, and novel technologies (Boucher, 2016). Such pressures that span multiple levels also challenge conventional planning approaches, often criticized for lack of viable alternatives (Schmitt, 2013), and call for ways of innovative governance over governmental silos.

Therefore, it may be argued that the futures of northern and cold cities and any changes to their energy systems need to be anticipated. While these increasing and simultaneous pressures call for a new type of thinking and also open up novel opportunities, they need to be contextualized (Pierre, 2014). This chapter discusses the futures of municipalities in three northern and cold cities. As a way of interpreting them, the views of experts and decision-makers about near-term developments in three urban regions – Anchorage in Alaska (United States), Saskatoon in Saskatchewan (Canada), and Luleå in

Sweden, that each has distinct histories, institutional landscapes and modes of governance, are portrayed and analyzed.

The next section describes the three cities – Anchorage in Alaska (the United States), Saskatoon in Canada, and Luleå in Sweden, which follows with a section on our analytical framework of multi-level perspectives that is used to analyze transitions intertwining with anticipated urban energy futures. The following section presents the methods that were used. The results present the perceptions of stakeholders and experts. The implications of these views, framing the related challenges and novel opportunities, is presented in the discussion section, before we conclude our argument in final section.

4.1. Comparative case selection and background

The purpose of the case study selection was to elicit insights into the governance characteristics that impact DE transitions. On this basis, cities from three different countries with different governance dimensions. City selection was based on a number of factors. The main factor for selection was the existence and experience with DE projects. At least two DE projects per city had to demonstrate accelerated transition, defined as 10 years from project concept to implementation. In Luleå, there was a district Combined Heat and Power system and a biogas facility for their municipal vehicle fleet. In Saskatoon, there was a solar cooperative and renewable rides program. In Anchorage, there was the Fire Island Wind project and the Cook Inlet low-income energy efficient housing developments. Other considerations included language spoken, population, city density, local utility governance structure, and regional utility integration. Northern and cold cities also have unique characteristics that aid in comparative analysis such as high wind speeds, low sunlight hours, temperature variances, and relative isolation. These environmental characteristic place constraints on technology choice that enable the analysis to hold these obstacles as constants. For further details of case study selection refer to *Chapter Three* and Table 4.1 below.

Table 4.1

Comparative case study city selection (Boucher, 2020)

	Saskatoon	Luleå	Anchorage
Country	Canada	Sweden	United States
Population (Urban)[1]	246 376	75 832	291 538
Area	170.8 km^2	29 km^2	204 km^2

Density	1 3001/ km^2	2 619/ km^2	1 232/ km^2
Sunshine Hours in December	86.5	3	51.8
Average Temperature Range (Jan/July)[2]	-18.9 °C /25.7 °C	-12.9 °C /20.7 °C	-11.4 °C/18.6 °C
Latitude	52° 08′ N	64° 34′ 4″ N	61° 13′ N
Local and Regional Electric Utility	Saskatoon Light and Power, SaskPower	Luleå Energi, Nordic Energy Market[3]	Anchorage Municipal Light and Power, Chugach Electric Association, Matanuska Electric Association
Electric Utility Ownership	Public/GTD Provincial Monopoly[4]	Public	Public and Cooperative
Heat Type	Gas (minimal electric)	District CHP (industrial waste)	Gas/Electric (minimal wood and oil)
Notable DE Projects	SES Solar Coop, Renewable Rides	LuleåKraft C.H.P., Biogas	Fire Island Wind, Low Income Housing Project
Tonnes CO^2e/capita[4,5]	15.1	30	28.9
Largest Source of Emissions[5]	Buildings and industry	Buildings and industry	Industry (steel manufacturing)

Notes:

6. Source: (Luleå Kommun, 2020; Statistics Canada, 2016; United States Census Bureau, 2018)
7. Based on average low for January and average high for July.
8. The major companies are Vattenfall, Fortum, Statkraft, E.on, Elsam, and Pohjolan Voima.
9. Data collection and GHG calculation methods differ significantly from each jurisdiction. In all three cities, their emissions inventory update in progress.
10. Source: (*Anchorage Climate Action Plan*, 2019; City of Saskatoon, 2014; Deerstone Consulting; Crimp Energy Consulting, 2016; Orttung & Zhang, 2019).

4.2. Case study regime dynamics

In this section, we highlight the relevant historical contexts and current status of each of the case studies, particularly as they pertain to the ownership structure of the utilities and opportunities for local energy projects. In each case, we highlight two examples of existing local energy projects to provide context and depict the present direction.

4.2.1. Luleå

Socio-technical context

Sweden's electricity system is integrated within the Nordic Energy Market, making the energy system in Luleå highly regulated. Past investment in hydro and nuclear power in Sweden, along with a low price on carbon within the European Cap and Trade system, has meant that electricity rates have not risen significantly. In recent years, electricity prices have decreased. What is more, Sweden is currently a net surplus provider of electricity, a trend that is expected to continue. This trend has created a highly competitive atmosphere for small scale electricity producers.

At the municipal level, Luleå is integrated into a system of intertwined actors and institutions (Stoyanov, 2019). This coordination has led to Luleå having the cheapest heating retail rate and one of the cheapest retail electricity rates in Sweden (Wiederholm, Castegren, Ulaner, & Persson, 2017). There are four main institutional actors part of the energy system: Kraftproducent (Vattenfall), Svenskt Stål AB (SSAB), Lulekraft AB, and Luleå Energy AB. Luleå Energy provides district heating and electricity to all of Luleå. It was partially owned by Vattenfall until 2009 before the city decided to buy all shares in the company. SSAB is a Swedish owned publicly traded steel company with major steel production operations located in Luleå. SSAB and Luleå Energy AB formed Lulekraft AB in 1977 as co-owners, intending to use process gases from SSAB's steel plant to produce district heating to Luleå (see Luleå Local Energy Project #1 for further details). Lastly, Vattenfall is a Swedish owned electricity generator and distributor. They provide electricity distribution services across Sweden. In Luleå, however, they serve as a wholesaler and retailer with Luleå Energy as the sole electricity distributor.

Luleå Local Energy Project #1: Industrial Waste District Heating Combined Heat and Power System

In Sweden, Combined Heat and Power (CHP) systems, although typical (European Environmental Agency, 2015), rarely employ the use of industrial waste heat as in the case with Luleå. Despite its relative novelty, Luleå's CHP district heating system has a long history, as discussed by Söderholm (2018). In 1951, SSAB, then Domnarvets Ironworks, opened its first blast furnace in Luleå, which would lead to a growing steel manufacturing industry in the region. At the time of Luleå Energy's formation in 1971, there was already small-scale district heating and an impetus for increased district heating from the Government of Sweden. Before the 1973 OPEC crisis, there were public discussions on the potential for a collaboration between the local steel plant, Norrbottens Järnverk AB (NJA), and Luleå Energy. After the crisis, energy policy was quickly put on the public agenda, and the Government of Sweden provided support to residents for reducing oil use. The national government offered payments to households to switch away from oil for heating. In Luleå, this created an economic push to transition from individualized heating sources to one integrated into a district heating network. As a result, by 1976, 43% of multi-family buildings were connected to the district heating system, which led to creating enough heating demand for the waste gas CHP system. In 1982, Luleå Energy commissioned the CHP project to use industrial waste gas from the steel plant. As a result of this effort, Luleå became one of the successful municipalities in Sweden to reduce its reliance on oil. Now, the majority of the heat used by residents and businesses in Luleå comes from this district heating system. Luleå Energy's district heating system is one of the largest in Sweden, both in terms of the amount of district heat provided by a single source and the size of the network.

Luleå Local Energy Project #2: Biogas Public Transport

Luleå owns a biogas company that provides biogas fuel for the majority of its municipal fleet and a portion of its public buses. Eight of the 69 buses in the Luleå Lokaltrafik AB (LLT) fleet and approximately half (over 150) of municipally-owned service cars run on biogas. Through a publicly-owned company, the city develops the biogas through the off-gases from municipal sewage waste.

4.2.2 Saskatoon

Socio-technical context

The city of Saskatoon is served by two publicly owned electric utilities at the municipal and provincial levels: Saskatoon Light and Power (SL&P) and Saskatchewan Power Corporation (SaskPower). SL&P services the inner portion of the city while SaskPower services predominately the suburban periphery. SL&P is owned and operated by Saskatoon and operates the transmission and distribution within its district. It purchases the majority of its electricity from SaskPower. In recent years, it has begun operating its own generation facilities, although these represent a minor contribution to the general supply. SaskPower is owned by the province of Saskatchewan and is a vertically integrated monolith corporation operating the majority of generation, transmission, and distribution in the province.

The city of Saskatoon is one of only two cities in the province that run their own electrical distribution network. Although Saskatoon has, in the past, considered selling its electric utility, it has remained publicly owned. As elaborated by White (1976), this trajectory can be traced to 1928 when the city was confronted with a challenge many other towns and cities in the province were facing: a power supply gap. This gap meant that the city council needed to consider its options: take out loans to invest in new generating facilities, enter into a purchase agreement with a private enterprise, or reach an agreement with the province. At the time, the province was implementing its plan for a provincially owned central utility based on the recommendations for the Power Resources Commission of the Province of Saskatchewan. Saskatoon was central to their plan because it was one of the tri-cities, along with Moose Jaw and Regina, that would form the foundation of the transmission infrastructure and power pool. Therefore, the province wanted to ensure that Saskatoon's electric utility ownership would not move to private hands. In the end, Saskatoon and the province reached what would end up being a unique and robust deal for Saskatoon. The province was to purchase the city's generating facilities, but the city would be permitted to run the distribution. This compromise allowed Saskatoon to reduce its debt load while still benefiting from the local distribution revenues, which, at the time, had more generous profit margins than their capital-intensive generation options. In other words, the province assumed most of the risks of this agreement, while the rewards made their way to the public coffers in Saskatoon. This agreement paved the way for the ownership structure that exists to this day.

Saskatoon Local Energy Project #1: Solar Coop

The Saskatchewan Environmental Society (SES), a provincial environmental organization based in Saskatoon, initiated a solar cooperative in 2015. This consumer cooperative sells non-tradable shares purchased by any member for a price of $950.00/share. The solar cooperative pays dividends to its shareholders through the revenues of solar electricity generation sold to its two utilities (SL&P and SaskPower). The board of directors of the solar cooperative determines shareholder dividend payments and capital reinvestment. Most of the solar cooperative revenue is derived from lease agreements with building owners, who, in turn, may have net metering agreements with the utility[10] . The solar cooperative is the first in the province of Saskatchewan and is one of the more innovative solar cooperatives in the country. In a few years, the solar cooperative has been able to develop projects and innovative partnerships across the city with businesses, community organizations, a credit union, the City of Saskatoon, research institutes, and the local electric utility. Contract agreements within each partnership range significantly.

Saskatoon Local Energy Project #2: Renewable Rides

Another innovative local energy project is the Renewable Rides project, a partnership with the Saskatoon Solar Co-operative. Initiated by the Saskatchewan Environmental Society, the solar cooperative partnered with the Renewable Rides to offer solar energy generation to charge their electric

---

[10] Residents in Saskatoon who are permitted to net metering solar electricity generated on their roof. The utilities, both SL&P and SaskPower, provide a 20% rebate (to a limit of $20,000) on solar installations costs.

vehicles. The Saskatoon CarShare Co-op is the first carshare in Canada with electric vehicles powered by solar energy. They can power the electric vehicles through a virtual net metering agreement with SL&P, with the 37.8kW of panels placed on a local cohousing development (called Radiance Cohousing).

4.2.3 Anchorage

Socio-technical context

Similar to Saskatoon, Anchorage operates with multiple electric utilities within its city boundaries. The city has a unique configuration of three independently operated and vertically integrated electric utilities, with one public and two cooperative utilities servicing its population. The Anchorage district is served by Municipal Light and Power (ML&P), Chugach Electric Association (Chugach), and Matanuska Electric Association (MEA). ML&P is a vertically integrated utility owned by the City of Anchorage with a service area wholly within city boundaries. Chugach and MEA are both cooperatively owned vertically integrated utilities with service areas both within and outside the city boundaries.

Anchorage's trajectory into electricity was marked by rapid population growth, industrial activities, and a pragmatic "do it yourself" desire to serve the local energy needs. In 1915, Anchorage began as a tent city for the construction on the railroad and post office. The population in Anchorage remained small, approximately 20,000, for several decades. As a result, Anchorage was a latecomer to the incorporation of reliable and centralized electricity service. After the United States entered the war in 1941, Anchorage saw a population boom. Shortly after the war, Alaska experienced an oil boom, which brought further interest in the city because it could serve as a strategic military hub. At the time, the municipal electric utility did not have sufficient capacity to manage the extra load from the increase of residential and industrial electricity use. As a result, the city was slow to expand its service area to the city peripheries, instead prioritizing the city core. In 1947, citizens outside the city boundaries formed a cooperative electrical utility to service their own needs. The Rural Electrification Act of 1936 provided support for local rural-based utilities. Under the Act, Chugach received a loan of $500,000 (in 1948 dollars or approximately $5.4 million in 2020) to support the development of a rural electric cooperative. This support was used as seed funding that supported the growth of electric utilities across Alaska. Shortly after Chugach, MEA was established, supported by similar funding. The city of Anchorage and the borough eventually merged in the late 1970s, but the existing electrical utilities did not merge.

Since then, Anchorage's population has dramatically expanded and now includes the service areas within Chugach's and MEAs distribution jurisdictions.

Anchorage Local Energy Project#1: Fire Island Wind

Fire Island Wind is a 17.6MW wind project developed by Cook Inlet Region, Inc. (CERI) on Fire Island and is the largest wind project in the state. The project is located five kilometres off the coast of Anchorage, which required the development of an undersea double circuit 34.5kV transmission cable. The owner and developer of the project, CIRI, is one of 12 Alaskan Native Corporations in the state formed under the Alaska Native Claims Settlement Act of 1971. There is a 25-year power purchase agreement with Chugach for a flat price of $97 (USD)/MWHr.

Anchorage Local Energy Project#2: Cook Inlet Housing Authority Low-income Energy Efficient Housing Communities

The Cook Inlet Housing Authority (CIHA) is a nonprofit low- to medium-income development authority serving CERI, which includes the Anchorage region. Designated in the 1970s as a housing authority, CIHA has expanded to be a leading housing developer in the city, building approximately 100 housing units a year. In recent years, CIHA has developed projects with a focus on energy efficiency and self-generation. CIHA develops many of the city's most innovative local energy housing projects—from insulation to community solar to heat pumps, CIHA has developed communities with a focus on energy efficiency and self-generation across Anchorage.

4.3. Analyzing Northern Urban Energy Futures

The analytical framework combines two related approaches: the multi-level perspectives (MLP) and the anticipation of alternative future developments. The MLP is commonly used to elaborate on the change pressures of energy systems, while foresight adds a temporal lens to the study. Sustainability transitions focus on the co-evolutionary interplay of three different socio-technical levels oriented as an interdependent hierarchy: *(1) the niche, (2) the regime,* and *(3) the landscape.*

The *niche,* sometimes framed as "a protected space", consists of technological and social innovations that have not yet achieved social legitimacy in the mainstream, often involving new actors and innovations protected via a range of policies such as subsides and regulations (Smith et al., 2010) or transition experiments (Kemp et al., 1998; R. Raven, Kern, Smith, Jacobsson, & Verhees, 2016; R. P. J. M.

Raven & Geels, 2010; Weber, Hoogma, Lane, & Schot, 1999). As Geels and Schot (2007) suggest, niches occur at the "micro-level" where "radical novelties," are initially formed as "unstable" and underperforming technologies (p. 400). Niche actors attempt to disrupt and infiltrate the regime using various processes such as political pressure, technological outperformance, social transformation, and activism (Smith et al., 2010). The *regime* consists of the existing and dominant system occupied by incumbents. A regime consists of the reigning institutions, technologies and regulations currently in place (Geels, 2002). Incumbents are assumed to be resistant to the niche actors or novel technologies, which may disrupt their role within the regime, creating path dependency or lock-in. However, the regime is not always stable, and windows of opportunity can create spaces for the niche to upend the regime (Bosman et al., 2014). The *landscape* characterizes the macro level. The landscape consists of broad economic policies, environmental constraints, political ideology, and culture (Geels & Schot, 2007). The landscape analogy was initially used to suggest the rigidity and resistance to change one may expect of the physical environment. Both slow and rapid landscape changes place significant pressure on existing regimes.

Connecting these three levels is the multi-level perspective (MLP) framework that aims to describe how socio-technical transitions can occur as a result of alignments between a multiplicity of actors at the niche, regime, and landscape levels (Geels, 2002; Geels & Schot, 2007; Smith et al., 2010). Taking a systems approach, the MLP aligns the three levels in a nested hierarchy, and adds a temporal dynamic to the analysis of the transitions. A standard application of the approach assumes that the niche developments begin to destabilize the incumbent regime and insert themselves, ultimately, into a newly formed socio-technical regime (Geels, 2014). The MLP scholars have emphasized that there are multiple pathways, or typologies through which new or altered regimes can be created (Geels et al., 2016a; Geels & Schot, 2007).

The MLP has been criticized for its focus on niche actors as the principal agents of intervention (Smith, 2007) because regimes can also be the source of endogenous change and do not always resist. Recent literature has advanced this understanding of the regime and upends this notion of a clear delineation between the levels (Berggren, Magnusson, & Sushandoyo, 2015). Boundary spanners, as niche-regime interactions, show that actors cannot be compartmentalized within one level and instead have dynamic agency within the systems in which they operate (Smink, Negro, Niesten, & Hekkert, 2015). In response to this conceptual deficiency, scholars have introduced the dimensions of politics

(Hess, 2016), governance (Hodson & Marvin, 2012; Smith, Stirling, & Berkhout, 2005), and the policy process (Kern & Rogge, 2018; Kivimaa & Kern, 2016), which also affect the dynamics between these levels. Of specific note is the work on multi-level governance interactions of cities and their corresponding jurisdictions (Ehnert et al., 2018; Hodson & Marvin, 2012). This study considers both the "hard power" that government entities exert and the jurisdictional context for the regime. An appropriate framing is critical when using the MLP framework (Smith et al., 2005). This study will add context to the regime by illuminating urban DE transitions in disparate jurisdictional contexts.

Comparing urban DE transitions across jurisdictional contexts may help in interpreting how diverse short-, medium- and long-range developments (Samet, 2013) are morphed in specific local contexts. After all, historical, institutionalized norms and practices create “a meta-institutional context”, an entrenched layer that underpins how novel technologies are adopted, as argued by Bell and Feng (2014). Other scholars also see socio-cultural aspects to embed energy systems and their governance as a deeply interactive part of any related developments (Miller, O’Leary, Graffy, Stechel, & Dirks, 2015). As transitions take place in the middle of uncertainty, these features may affect any made claims about the future and related interpretations (Sovacool, 2016). While the MLP provides a useful framework for the elaboration of the patterns of change, futures research has a range of techniques and tools (Minkkinen, Auffermann, & Ahokas, 2019; Poli, 2017) for the anticipation of future developments. Rather than foreseeing the future as a continuation of the present or a single fixed point in time, it advocates an open and wide approach that recognizes a range of possible developments, affected by actions in the present. Transitions take place in an increasingly complex world, and in certain instances minor or incremental changes are seeds for more profound changes. When used in a systemic way, a futures-oriented stance can also help grasp latent possibilities and envision desirable scenarios. Exercises that aim to analytically map futures should recognize *plausibility*, that any possible end states of expected developments are analytically sound and socially viable (Trutnevyte, 2014).

4.4. Methodology

The views of stakeholders and experts can be considered as one source of information regarding the futures of northern and cold cities. As key informants in each of the respective cities, their views represent present and unfolding assumptions and mindsets of what the future can or should look like. Their views illustrate the diverging views of possibility, probability and preferability in each of the three cities. Even if expert views may hold particular bias, contrasting their perspective with actors in all levels of the MLP and compared with other cities can provide critical insights into urban energy futures in the North.

Semi-structured interviews (n=60) were conducted with actors within all levels of the MLP (business owners, managers, content experts, NGOs, politicians, and environmental organizations). For Anchorage, there were 32 interviews, 12 interviews for Saskatoon, and 16 interviews for Luleå. Anchorage required more interviews than Saskatoon and Luleå because there was more complexity with the governance and institutional dynamics of the energy system that necessitated further inquiry[11]. First, an overview of the northern energy approaches is presented from the interviews, observations and photos during site visits, to depict the context of the study. What then follows is an analysis of how the interviewees envision possible changes in the future in their cities.

Because action (or inaction) in the present can imply path dependencies, the interviewees were asked how they envisioned their city's energy future in the next 10 years, which are assumed to be of crucial importance for climate action. Although some futures studies adopt very long timespans (i.e. 30, 50 or even up to a 100 years), cognitive research suggests that people have biases—such as the valence effect, overconfidence bias, and planning fallacy—that limit their ability to think clearly about the future in the long-term. So, we began each interview with a discussion on passing energy project success, as a strategy called reference class forecasting. The questions addressed the desirability of future developments, which often are ignored when focusing on probabilities. Specifically, they were asked three questions:

- What kinds of developments are *possible* for the local energy system in the next ten years? Why?
- What would you see as *probable future* developments for the local energy system in the next ten years? Why?
- What would you see as *preferred* developments in the future for the local energy system in the next ten years? Why?

The aim of the study was to learn from the experts' views in the present, and by interpreting their responses, to identify what they have to say about the possibility of an urban DE transition over the long-term. After a careful consideration of their responses, we used the qualitative comparative method

[11] For a more detailed account of the interview and saturation methods see Boucher (2020)

for constructing a thematic analysis (Mill, 1843; Ragin, 2014; Rihoux et al., 2013; Tilly, 1984), which is used to decipher causal patterns within complex systems (Byrne, 2005) and necessary for comparative studies with small sample sizes (Ragin, 2014). Using Mill's Method of Agreement to provide an overarching structure (Mill, 1843), we conducted a thematic analysis to elaborate on the interviewees' stance on the energy futures in the respective cities. Themes were selected after all interviews were conducted. We used an adapted version of Auerbach and Silverstein (2003), which consisted of the following steps:

(1) *Identify repeating ideas* — If two or more interviewees mentioned an idea related to futures for their DE transitions there were noted for potential consideration as a theme.

(2) *Select potential themes* — We then grouped themes and clustered similar ideas.

4.5. Results

This section first provides an overview of the unique northern characteristics and approaches, depicting examples of particular challenges and local adaptations.

4.5.1. A Northern Approach to Municipal Energy

Energy transitions require overcoming obstacles and discovering innovative approaches to solve locally specific problems. Interviewees discussed the common challenges and potential adaptations unique to northern cities related to solar PVs, EVs, system reliability and heating loads.

Solar Photovoltaics

There was a strong desire amongst interviewees in all three cities to expand the provisions of solar energy. Experts in solar energy technology highlighted notable challenges with solar PV such as lower winter sunlight hours, snowfall, and northern latitude angles (Anchorage Interviews # 9, 11, 21, 30, and 33; Luleå Interviews # 6 and 10; Saskatoon Interviews # 1, 9, and 12). There were several adaptations pursued to overcome these challenges (see Figure 4.1, 4.2, and 4.3). For instance, Anchorage uses vertically installed solar PV panels to capture the optimal solar irradiance angle (see Figure 4.1. of CIHA buildings). Although solar PV installations in Luleå were minimal, the lowest of the cities, there was interest in moving forward with increased solar (see Figure 5.2.1. of solar canopy installation). Saskatoon, although at a lower latitude relative to Anchorage and Luleå (see Table 4.1.), experimented with optimal array angles as part of the SES and SL&P joint project (see Figure 4.3). There were also opportunities with solar energy in cold climates. Interviewees emphasized that solar PVs operate with increased efficiency under lower temperatures (Anchorage Interviews # 3, 9, 11, and 23; Luleå Interview # 10; Saskatoon Interview # 9), which is supported by research that shows a linear correlation between a decrease in temperature with improved PV efficiency (Dubey, Sarvaiya, & Seshadri, 2013; Mussard, 2017).

Figure 4.1

Photos of vertical PV panels at CIHA properties in Anchorage

Figure 4.2

Photos of solar canopy panels at Luleå Energy headquarters in Luleå

Figure 4.3

Photos of ground-mounted SES solar co-op panels at SL&P in Saskatoon

Electric Vehicles

In all cities, there was a desire to expand EV capabilities, despite having minimal EV infrastructure compared to their southern counterpart regions. Although there were limited EV charge stations, all cities had recent installations (see Figures 4.4, 4.5, and 4.6). Expanding EVs, however desirable, posed challenges. Given the colder temperatures, adaptations were needed to accommodate EV infrastructure. Travel distances for EVs are shorter during winter months because, in part, of the heat loads (Riess, Walter, Weiherer, & Groper, 2018). For instance, Luleå is developing an EV bus route of which would require a non-electric heat source to ensure sufficient battery life (Luleå Interview #14). Similarly, in Saskatoon, a member of the CarShare as part of the Renewable Rides initiative noted that due to cold winter temperatures, “vehicles that are being underutilized when it was extremely cool the battery would die, and then the vehicles would not start even though the car is plugged into the wall” (Saskatoon Interview #7).

Figure 4.4

Photo of an electric car charging station in Saskatoon

Figure 4.5

Photos of biogas fill station and demonstration model of EV charge station in Luleå

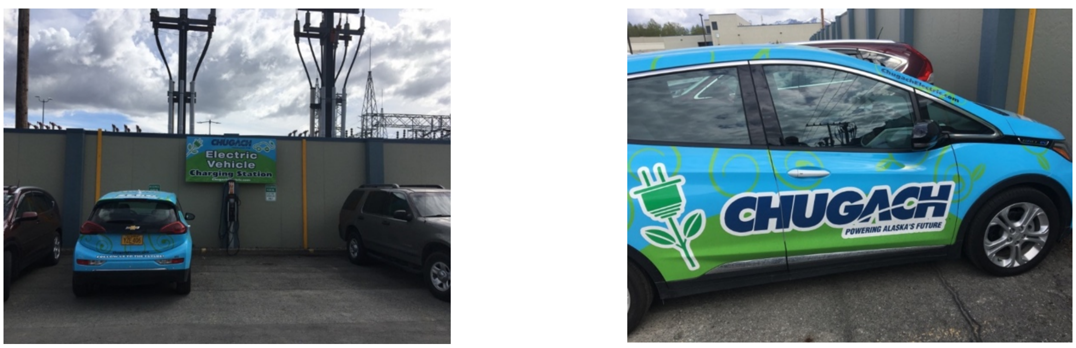


Figure 4.6

Photos of EV and charging station at Chugach in Anchorage

System Reliability and Heating Loads

Interviewees highlighted reliability as a significant constraint in northern and cold cities. Providing a reliable energy system is important in most jurisdictions. However, the necessity for reliable service in cold climates is essential. Northern and cold cities also face additional challenges to their infrastructure (see Figure 4.7). Unlike most northern cities and towns, the three cities had relatively affordable heating services.

Ensuring affordable energy, and in particular, heating, was seen as important to improve livability and businesses in the region (Anchorage Interviews # 2, 5, 19, 20, 22, 29; Luleå Interviews #3, 4, 6, 7, 10, and 12; Saskatoon Interviews #1, 4, 5, and 10). In all the cities, the primary source of heating is non-electric. Saskatoon and Anchorage were heated primarily from natural gas, while Luleå was heated primarily through their district CHP system. Examples of adaptations include advancing building insulation and energy efficiency. For instance, the Alaska Housing and Finance Corporation has programs for weatherization (Anchorage Interview #5); Saskatoon is exploring a proposal for an augmented local energy building code for buildings (Saskatoon Interview #2, 3, 4, and 5), and Luleå Energy recently installed a low temperature (approximately 65 degrees) district heating system in a recently developed community (Luleå Interview #1 and 3). These examples are not exhaustive but illustrate the approaches and emphasis placed on ensuring system reliability and management of winter heating loads.

Figure 4.7

Photo of hoarfrost on powerline in Luleå

4.5. Futures Analysis

An analysis of the respondents' views on potential future developments in their cities enabled us to identify four distinct futures imaginaries: technology is on its way, let's do this together, we need the right public policy, and status quo (see Table 4.1 and 4.2), and to compare their breadth in each city.

Table 4.1

Thematic criteria sets and descriptions

Thematic futures imaginaries	**Description**
Technology is on its way	Technologies like EVs, batteries, and microgrids will penetrate the local energy system.
Let's do this together	Increased collaboration amongst actors across industry and government will facilitate local energy development.
We need the right public policy	Public policy will facilitate local energy development.
Status quo	It is too difficult, and ten years is not enough time for much to change. Little or nothing will change.

Table 4.2

Comparative agreement table of Luleå, Saskatoon, and Anchorage

Thematic futures imaginaries	Luleå	Saskatoon	Anchorage
Technology is on its way	present	present	present
Let's do this together	absent	present	strongly present
We need the right public policy	absent	present	present
Status quo	absent	absent	present

Notes:

1. Thematic area was considered present if at least one interviewee mentioned this theme
2. Thematic area was considered strongly present if more than 50% of interviewees mentioned this theme

Technology is on its way

Consistent amongst the cities was a sentiment that there would be technological advancements, which will create positive impacts on the energy system, as illustrated in the previous section. However, the direction and specifics of how these technological advancements would impact each city differed.

In Saskatoon, technological advancement was largely focused on the level of the homeowner and business. A business person and energy expert noted that there would be more penetration of local distributed energy options. The business person envisioned that many people in Saskatoon would have an "Energy efficient house, solar PV, and eventually, a Tesla power wall. The only thing you are going to need the city for is water and sewer backup power" (Saskatoon Interview #10). Similarly, an energy expert noted that "you could also have EV owners that subscribed to demand control and you could have vehicle-to-grid storage" (Saskatoon Interview #9). A representative from the City of Saskatoon noted that "the city of Saskatoon is investing largely in solar and it is going to be a lot of solar in development" (Saskatoon Interview #12).

Contrasting Saskatoon, interviewees in Luleå envisioned a technological future that would augment their already integrated system and expand this integration across services. An interviewee from the City of Luleå noted that advances in solar cells and low-temperature district heating "would be new technology that makes it possible to change the whole system" (Luleå Interview #1). A political leader in Luleå emphasized that there would be increased industrial demand in the city, resulting in increases in solar and wind development.

> We have a steel plant because you have a lot of minerals that are needed for electric cars and the batteries up in the North that will probably be processed from here. So, you will probably have more heavy consumers, more data centers, more consumers in industry. So, we [will] have

> a huge demand for electricity. I guess there will be much more production from solar panels and wind (Luleå Interview #15).

The focus in Anchorage was more mixed with an emphasis on incorporating both small- and large-scale renewable energy on the electrical grid. An energy expert in Anchorage captured this sentiment by arguing that,

> Building out the rest of the Fire Island Wind capacity, having large solar installations, and even having some electrical vehicle infrastructure and charging stations (Anchorage Interview #11).

Let's do this together

Collaboration across sectors and actors was emphasized as an essential component of the local energy system in all cities. A key difference in the cities arose, however, when discussing their urban energy futures. In Luleå, there was less emphasis on the need to work together. This focus on collaboration was likely because there were already high levels of integration across actors and institutions. Interviewees mentioned that the success of their current projects was primarily due to their collaborative approach (Luleå Interviews #1, 5, 6, 7, 10, 12, 13, 14, and 15). In Anchorage, there was great emphasis on the need for more effective coordination among utilities (Anchorage Interviews #1, 2, 6, 7, 14, 18, 21, and 29). Whereas in Saskatoon, increased collaboration was seen as important but not to the same degree as in Anchorage.

The focus on collaboration in Saskatoon was on community-oriented initiatives and fostering connections between institutions. A representative from the administration of the City of Saskatoon noted that,

> We might also be creating new ways to community participation, whether it's virtual net metering or community solar. And there's also possibilities for having co-ownership with partner organizations (Saskatoon Interview #12).

Similarly, a political leader in Saskatoon noted that,

> I ultimately want to see our emissions going down proportionally as we get a decade in because we don't have much time. I mean, I guess I'd like to see some strength in partnerships with SaskPower and expanding some of those partnership opportunities (Saskatoon Interview #3).

A significant point of emphasis in Anchorage was the need for increased collaboration across actors and institutions. In particular, there was a common sentiment amongst interviewees that collaboration between the Railbelt utilities would open up opportunities for local energy development (Anchorage Interviewees #2, 6, 7, 13, 14, 17, and 24). An expert from Anchorage emphasized the importance of having coordination amongst the utilities as a way of facilitating more local energy generation.

> One utility that was making power standby decisions based on a single utility load as opposed to two separate utilities, which creates a larger base of backup required by regulatory decisions from the RCA [Regulatory Commission of Alaska]. You can have a smaller backup capacity with one utility, and then you can start to retire out a lot of the older rolling stock of turbines (Anchorage Interview #2).

Similarly, a business leader in Anchorage improved cross-sectoral collaboration between actors would be beneficial.

> I think we could see more robust groups forming that are really actively driving action collectively. I think we've got like pieces of that happening but less of it than we need. And I also think that we've had, if we're talking about collaboration, between, you know, government, academia, nonprofit and business, I think we have less of the business part then I wish we did (Anchorage Interview #19).

We need the right public policy

A view that there was a need for the right public policy was present in Saskatoon and Anchorage. In both instances, interviewees had specific policies in mind. What differed was the level of consistency amongst interviewees as to their suggested policy visions.

In Saskatoon, there was an emphasis on carbon pricing (Saskatoon Interviews #1, 2, 3, 4, 8, and 12) and Property Assessed Clean Energy (PACE) financing (Saskatoon Interviews # 1, 2 3, 4, 5, and 8). For PACE, this change would require a modification of the Saskatchewan Cities Act to allow cities to undertake this decision. A political leader in Saskatoon mentioned that the city is interested in pursuing PACE financing and has made a request to the province the amend the Cities Act (Saskatoon Interview #3). A business leader mentioned that PACE financing would be an optimal approach for the province and city to consider.

> PACE is a really good example of something that could work for the current housing stock. So, we're looking at some of options there. And one, you know for our market, that would be a stellar activity to keep people working. We have a lot of small businesses in the industry right now who are suffering. It's a way to incentivize that improvement in a way that brings benefit to the homeowner (Saskatoon Interview #5).

In Anchorage, there is financial support from federal and state-level governments in the form of tax credits. In particular, part of the justification for the energy efficiency and renewable energy projects for the Cook Inlet Housing Authority support through the Greater Opportunity for Affordable Living (GOAL) program. The GOAL program is an application-based competitive process between developers of low to medium-income housing administered by the AHFC. As part of the selection process, points are allocated for the provisioning of conservation and renewable energy initiatives (Alaska Housing Finance Corporation, 2018). An interviewee noted, "One of the reasons we do alternative energy is to get points to build these projects, right? Because our end goal in this whole thing is to create homes for people. So, to do that, we got a win money. And to do that, we've got to do alternative energy because we get points for it" (Anchorage Interview #21). The same interviewee emphasized that the funding environment has become increasingly competitive, and funds are more difficult to receive.

In stark contrast to Saskatoon and Anchorage, interviewees in Luleå did not discuss public policy. However, they did discuss their support for the direction of current public policy at the national level. As part of Sweden's Climate Act passed in 2017, the country has an ambitious target to reach net-zero emissions by 2045, which includes a portfolio of supportive policies. Luleå interviewees, rather, focused on the technological aspects that would facilitate the transition away from high emissions energy sources.

Status quo

The only city where the *status quo* perspective was present was Anchorage. The sentiment was that ten years is too short for any significant change to the energy system. In ten years, the local energy system would likely still be the same. A politician in Anchorage noted that there are significant challenges for the utilities because there have been substantial investments in infrastructure and generation units, which will put the utilities in a position to want to recoup their embedded costs. When discussing the high capital costs, this politician noted, "you still have this massive, like this massive infrastructure, [and] capital costs that have to be paid [...] No matter how you look at it we've developed more than we can use" (Anchorage Interview # 22).

4.6. Discussion

As shown in the responses above, visions of what the future holds for each city differ. This may not be so surprising considering the different histories, infrastructures and political culture, as meta-institutional contexts. Despite the differences, the technological components in their visions were surprisingly similar. Lessons from all three cities point to the importance of collaboration and supportive public policy in the future. We outline our explanations of the differences and similarities in their visions below.

The regime as a visionary

A typical presumption within transitions literature depicts an antagonistic or agnostic regime, while niche actors are the presumed visionary innovators pushing the regime. Based on our materials, it seems that not only the niche but also the regime has a role in driving a vision forward. In fact, the interviewed regime actors in all three cities were empathic in their desire for change and even radical and system-level changes. Our findings align with more recent scholarship on the MLP, which has begun to recognize the role of regime actors as important driving actors (Geels, 2019). Openness to change at the regime-level suggests the importance of other factors influencing the transition such as encouraging collaborative initiatives, policy change through higher level government, and providing expertise on potential obstacles.

Consistent or disjointed visions

Multiple visions coexisted within each city, but the extent to which they were different was also observable. In Luleå, there was much more similarity across actors. The existing projects in Luleå were primarily the result of collaboration initiatives (see Section 2) and there was also more consistency with regards to what actors saw as a potential future. In comparison in Anchorage, there was high disjointedness on visions for the future, and the focus was much more on specific projects surrounding the actors. Recall as well that Anchorage required nearly twice as many interviewees to reach saturation in part because there was little consistency amongst actors. This may explain the emphasis on increased collaboration in Anchorage and, to a lesser degree, to Saskatoon.

Visions as overcoming obstacles and changing public policy

Upon starting this research project, we anticipated that interviewees would exclusively present technologically oriented futures and describe novel technologies in place in the next ten years. Therefore, it was surprising to observe that interviewees also presented public policy-oriented visions. In addition, in Anchorage and Saskatoon, there was a focus on crucial obstacles to be overcome through public policy. The focus in Anchorage was on solving the institutional and governance issues associated with a lack of integration of the Railbelt utilities. Most actors recognized that moving forward with increased local energy development would necessitate solving this problem, and the state government would need an expanded regulatory role over the transmission system. Whereas in Saskatoon, the focus was on a highly localized distributed generation future. The obstacles to overcome were largely policy-oriented towards incorporating PACE financing and the concerns over incorporating a pricing mechanism for emissions in the province (see Section 5.2). Given the consensus in Luleå, the interviewees presented a vision of deeper integration of services with little discussion on specific public policy.

Urban energy futures and infrastructure in the North

Urban energy infrastructure in the global North is constrained, unlike in more southern cities. Of such constraints in Anchorage and Saskatoon[12] was the lack of integration of the electrical grid. Luleå's electrical grid is integrated across cross-border networks and the Nordic energy market, but most cities in the Circumpolar North are not integrated into transnational electrical networks and therefore have more pressure to ensure reliability. Given the cold temperatures of these regions and the impact that unreliable energy services would have on its population, protecting the reliability of their energy infrastructure is essential. Therefore, energy transitions in the North must approach quick changes in the energy infrastructure with reasonable caution. These unique circumstances can both hinder or drive innovation and regime shifts. As evidenced by the existing local experiments and the emerging socio-technical visions, the cities and their governing actors demonstrate resilience and remarkable willingness to adapt to technological advancements.

[12]Saskatoon is integrated into a provincial network (SaskPower) with limited interprovincial and international trading.

From near-future dynamics to long-range horizons

Adapting the MLP framework to a futures framing opened up fresh insights about transitions. The methodology employed probed the experts' perceptions of the possible and desirable changes in the near term. These views may be indicative of the underlying dynamics that, if triggered, can act as a predecessor to deeper changes. Notably, our expert interviewees aimed at responding to the questions with a high degree of precision, often pausing to consider what might be reasonable within ten years. This might explain our unique findings that included a focus on specific public policy instruments and a desire for increased actor collaboration. It also implies that methodological designs that probe even more radical changes may be necessary.

Considering our interest in northern urban energy futures in three remarkably different jurisdictional contexts, the common technological elements suggest certain alignment and joint perceptions in the regime actors' visions. At the same time, the institutional rigidity, reflected in their thinking, partly makes transitions such complex and long-term endeavors.

4.7. Conclusion

The discussions with experts are illustrative of the interplay of many factors perceived to have an influence on the future of the energy systems in northern and cold cities. In general, the respondents were motivated to pursue solutions to climate change and energy security in their cities, which accentuates the belief of novel solutions and frameworks to be adopted also in harsh northern conditions. By looking at the perceptions of actors, this chapter has shown that studying the regime's dynamics can be highly valuable, when carefully interpreted. The comparative approach across three cities, one in the Nordic region and two in North America, provided a more granular view of these cities' energy futures.

The study recognizes that stakeholders in all three cities, including the regime actors, show a willingness to introduce novel energy infrastructure. The technological viewpoints somewhat converge (a common belief in EVs, charging infrastructure, large-scale adoption of renewable energy, in particular solar PVs) irrespective of regime. The regime actors even seem somewhat willing to consider radical solutions with wide-reaching impacts. However, there is a major divergence in the regime dynamics, as illustrated by the more coherent public policy approach in the Nordics compared to the one in either Canada or the U.S. These differences may affect how future energy infrastructures in the North in the 2020s are accepted, adapted, and imagined.

We emphasize the idea of anticipating a multiplicity of futures. Thinking in alternatives can stimulate futures thinking and long-term approaches that allow preparing for many types of developments.

Chapter Five: Solar Energy Justice: A Case-Study Analysis of Saskatchewan, Canada

A version of this paper has been peer-review and is published in the journal *Applied Energy* as a co-authored publication with Dr. Brett Dolter.

Reference: Dolter, B. D., & Boucher, M. (2018). Solar energy justice: A case-study analysis of Saskatchewan, Canada. *Applied Energy*, *225*.

Contribution Statement: Boucher contributed approximately 45% to the research and writing activities. Boucher and Dolter conceived, planned, designed, conducted stakeholder events, and analyzed data. All authors discussed the results and contributed to the final manuscript.

Chapter Five: Solar Energy Justice: A Case-Study Analysis of Saskatchewan, Canada

Renewable energy installations have significantly outpaced expectations by notable forecasters (Nyquist, 2015). To advance a more sustainable future it will be important to incorporate energy technologies that are more environmentally benign. However, technological innovations within the electricity system have significant societal impacts (Bakke, 2016; T. P. Hughes, 1983). Traditional approaches to analyzing renewable energy have often focused on engineering and economics. A focus on the energy justice implications of technologies like solar panels will likely improve social outcomes as these novel technologies are incorporated into the electricity system (Miller, Iles, & Jones, 2013; Sovacool, 2014b). In this vein, our study applies an energy justice framework to a case study of solar energy program design. The aim of our paper is twofold: first, we provide a case study of a solar energy program design that embodies the energy justice principle of *due process*; and second, we assess the value of Sovacool and Dworkin's energy justice framework by applying it in a real-world policy-making context (Sovacool & Dworkin, 2014).

In January of 2017 we were engaged by SaskPower to conduct stakeholder engagement workshops for the development of new solar energy programs in Saskatchewan. In coordination with SaskPower we developed a deliberative dialogue approach to consultation. Select stakeholders were invited to participate in a half-day workshop. Participants were asked for input on the principles that would guide SaskPower's solar energy strategy, the barriers to solar energy, and their ideas for effective solar energy programs. Participants worked in small groups to design solar energy programs, creating opportunities for mutual learning amongst themselves. This deliberative approach was novel in the Saskatchewan context. In the past, public consultations in the province have been top-down and, "typically one-way communication with minimal deliberation" (Martens, McNutt, & Rayner, 2015, p. 20). Our deliberative dialogic approach offers an example of due process in the program design stage of energy planning. We use the energy justice decision-making tool (Sovacool & Dworkin, 2015) to evaluate the process of designing SaskPower's solar energy strategy and the content of recommendations made by participants to answer the question, can due process help to achieve energy justice? We then suggest areas where the energy justice framework could be improved.

5.1. Growing Interest in Solar Energy

Solar photovoltaic (PV) technology promises energy independence, income generation, community development, and reductions in greenhouse gas (GHG) emissions (Hoffmann, 2006). As a result, this energy source has seen significant uptake globally. The International Energy Agency (IEA) reported that 75 GW of new solar PV capacity was installed globally in 2016 —the highest level of annual investment ever (International Energy Agency, 2016). What's more, solar PV technology is continually improving and has reached a record efficiency of over 26% as of 2017 (Yoshikawa et al., 2017).

Installations of solar PV panels have been increasing in the Canadian province of Saskatchewan. The Saskatchewan Power Corporation (SaskPower), a provincially owned electric utility, offers two main options for installing solar power projects less than 100 kilowatts (kw) in size:

- *Net metering* allows customers to use the electricity generated by their solar PV installation for their own energy needs, and to send any extra solar electricity back to the electricity grid in exchange for credits on their electricity bill (SaskPower, 2017d). Enrollment in the net metering program grew from nine customers in 2010 to 578 in 2016 (SaskPower, 2017a).

- The *small power producers* program allows solar energy proponents to develop solar energy projects and sell all or part of the electricity generated to SaskPower at a price of 10.83 cents/kWh, escalating at 2% per year (SaskPower, 2017d).[13] At year end in 2016, 14 projects had been installed under the small power producers program, and another 25 were waiting in the queue (SaskPower, 2017a).

5.2. Disruptive Potential of Solar Energy

A growing interest in solar energy represents both an opportunity to expand the production of zero-emissions, renewable energy in the province, and a disruptive threat to the SaskPower business model. Solar PV technology is unique in that it can be installed at the point of electricity demand. The transmission lines created in the early years of SaskPower were necessary to transmit electricity from

[13] This rate is lower than the residential retail rate of 13.74 cents/kWh and the business rate of 11.58 cents/kWh (SaskPower, 2017b).

power plant to distant electrical loads. With a population of 1.17 million spread over a landmass of 650,000 km^2, Saskatchewan now possesses one of the most dispersed electricity service areas in the world. Billions are being spent to maintain and upgrade the transmission lines that transect the province (SaskPower, n.d.). Solar PV can be installed on homes, businesses, farms, and in fields on or near the site of energy demand. This distributed energy potential throws into question the need for a centralized grid controlled by a monopoly utility.[14]

Solar PV technology is also unique in that individual solar panels are small-scale and modular. This means they can be installed privately, without the need for expensive engineering expertise. The business case for solar energy self-generation has become more attractive in Saskatchewan in recent years, largely for two reasons. First, electricity rates in Saskatchewan have been increasing on average by 3% per year due to the need to expand supply, maintain and upgrade transmission lines, and lower greenhouse gas emissions. Second, the cost of installing solar PV technology has been falling. In the United States, the median total installed cost of solar PV panels has fallen from \$12/W_{DC}[15] in 2000 to less than \$4/W_{DC} today (Bardose & Darghouth, 2017). As the economics shift, SaskPower's net metering and small power producer solar energy programs begin to look more desirable to customers (see Figure 5.1).

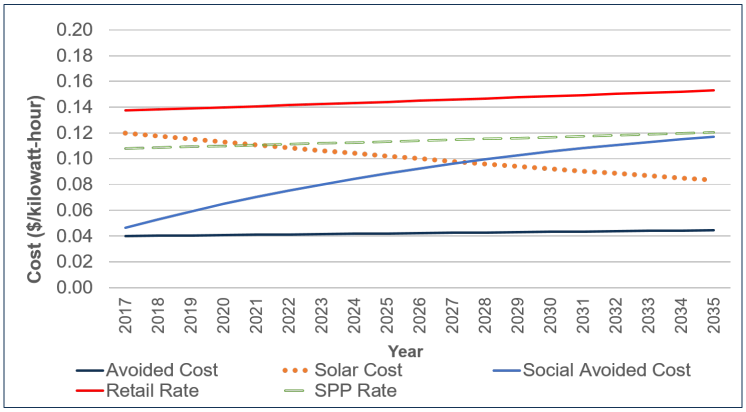
---

[14] The role that solar energy will play in local energy systems will depend on the nature of the other aspects of the local energy system. Solar energy production is variable and so a mix of energy storage, flexible demand response technologies, and dispatchable generation is required to respond to this variability. Solar PV panels also require 1 km^2 of available land or roof space per 32 MW installed capacity (Ong, Campbell, Denholm, Margolis, & Heath, 2013). A high concentration of local energy demand will require a large area of land or roof space to accommodate the necessary solar generation infrastructure and distribution lines.

[15] W_{DC} stands for watts of direct current, which is a unit a measure to compare electricity outputs.

Figure 5.1.

Private and Social Perspectives on Cross-Subsidization[16]



Like other utilities across North America, SaskPower is aware of the financial implications of expanding solar energy self-generation. When customers install solar panels and "zero" their meter with the net metering program, they reduce SaskPower's revenue. The more customers install self-generation, the more SaskPower must raise rates on existing customers to pay for existing generation, transmission and distribution assets. These assets are still used by solar energy self-generators when solar energy is not available (*e.g.* at night) or is inadequate to meet self-generators' power needs. However, net metering allows customers to lower their electricity bills to near zero (only a moderate $22 administrative charge remains) and avoid paying for these back-up system costs. As it stands, the current net metering program is not financially sustainable. As more customers adopt solar PV technology and zero their bills, and SaskPower raises rates to cover the costs of its extensive transmission and distribution network and increasingly idle back-up generators, it risks entering the "utility death spiral", a process that ends in bankruptcy for the utility (Ford, 1997). Knowledge of this risk is a key motivation for SaskPower to rethink its solar energy programs, and many utilities around North America are doing the same (Proudlove, Lips, Sarkisian, & Shrestha, 2017).

---

[16] Assumptions underlying this graph are as follows: avoided cost at $.04/kWh and increasing by .6%/yr solar cost at $.12/kWh (assuming an installed capital cost of $2300/kW) and decreasing at 2%/yr; system GHG intensity 661 tonnes CO2e/MWh, declining at 3%/yr; avoided cost of carbon value at $10/tonne, increasing by $10/year; social avoided cost = avoided cost + GHG reduction value (i.e. system GHG intensity * carbon value).

5.2.1. Solar Energy Potential in Saskatchewan

Adding to the desirability of solar energy is the high-quality of the solar resource in Saskatchewan. Southern Saskatchewan has the highest solar PV potential in Canada. Solar PV installations in communities such as Estevan and Coronach, home to the province's coal-fired power plants, generate nearly 1400 kWh of electricity per year for every 1 kw installed (1383 kWh/kw and 1379 kWh/kw respectively) (NRCAN, 2017). For comparison, this solar energy potential is nearly as high as Mexico City (1425 kWh/kw) and Los Angeles (1485 kWh/kw) (NRCAN, 2017). Solar PV output in the semi-arid southern part of the province is aided by clear skies throughout the year and cool temperatures in the fall, winter, and spring months that allow PV cells to convert solar insolation into electricity more efficiently.

5.2.2. The Need for Low-Emissions Electricity

In 2016-17 nearly half (49%) of all electricity in Saskatchewan was generated by coal-fired power plants (SaskPower, 2017c). The predominance of coal-fired power has meant Saskatchewan's electricity sector registers the highest GHG emissions intensity in the country (Environment and Climate Change Canada, 2019; Environment Canada, 2014; Statistics Canada, 2019). To reduce GHG emissions the Saskatchewan government has committed to expand renewable energy to comprise 50% of electricity capacity by 2030. With an anticipated capacity of 7000 MW, this promise means the province will soon contain up to 3500 MW of renewable capacity.

SaskPower currently has 889 MW of hydroelectric capacity with limited opportunities to expand this resource. Saskatchewan is home to 221 MW of installed wind capacity and by 2030 SaskPower anticipates up to 2100 MW of wind capacity on its system (SaskPower, 2017c). Power purchase agreements have been signed for the construction of an additional 177 MW of wind capacity in the near-term, and another 200 MW is scheduled to be built by 2020 (SaskPower, 2017c). Wind power has been assigned the heavy lifting of the renewable energy commitment because it is low cost. Wind installations in southern Saskatchewan can achieve annual capacity factors of 36-38% and achieve a levelized cost of 6 cents/kilowatt-hour (kWh) (Dolter, 2015).[17]

SaskPower anticipates that an additional 350 MW of renewable capacity will come from sources such as geothermal, biomass, and solar PV by 2030. At present, solar power makes up only 7.5 MW of capacity, largely installed on household and commercial rooftops and on farmland or farm buildings [13]. By 2021, SaskPower plans to install or purchase up to 60 MW of solar power: 20 MW will be installed as utility-scale solar farms; 20 MW will be installed in partnership with First Nations in the province; and 20 MW is expected from community-based projects (Dolter & Boucher, 2017). SaskPower may increase the contribution of solar energy to the 50% renewable target if solar PV costs continue to drop.

5.3. Paper Structure

Our research evaluates how SaskPower could best design solar energy programs that serve the needs of solar energy self-generators and contribute to the 50% renewable target. We explore the implications of solar energy program design for the financial sustainability of utilities like SaskPower and for solar energy justice in Saskatchewan. We use the findings of our research to suggest refinements to the energy justice decision-making tool proposed by Sovacool and Dworkin (Sovacool & Dworkin, 2014, 2015).

We carried out this research using a deliberative approach. In section 5.4 we outline the energy justice literature and the deliberative dialogue literature, which provide a theoretical basis for our work. In section 5.5 we outline the methods used in the solar energy deliberative dialogues in Saskatchewan. In section 5.6 we present the results of the dialogues. We then analyze these results using the energy justice decision-making tool and discuss the results in section 5.7. In section 5.8 we offer our concluding remarks.

[17] New wind turbine designs are likely to achieve capacity factors of 45-50% with a levelized cost of $43-48/MWh.

5.4. Literature Review and Background

5.4.1. Energy Justice

Energy justice is a growing field of scholarly inquiry[18] (Jenkins, 2018). As a scholarly discipline, it has its beginnings in environmental justice and climate justice. Energy justice came out of a recognition that the challenge of climate change is fundamentally energy related (Jenkins, 2018). Energy justice attempts to be broader than climate justice by focusing on the energy system, which includes the full impacts of energy development from mining of source material, transportation, distribution, and consumption of various energy services. This is consistent with the recent analysis by Jenkins who argued there are distinguishing features of energy justice that set it apart from climate and environmental justice. According to Jenkins, energy justice is, "(1) more targeted in its topic of concern and systems focus, and therefore has increased potential for policy uptake, (2) unlike environmental and climate justice, is not the outcome of anti-establishment social movements, and (3) is backed by a strong methodological traditional which shows a range of both academic and policy-relevant applications" (Jenkins, 2018, p. 120).

Energy justice attempts to fill in the gaps that a traditional engineering or economic analysis may overlook (McCauley, Heffron, Stephan, & Jenkins, 2013; Sovacool, Heffron, McCauley, & Goldthau, 2016a). The energy justice framework allows for the exploration of the tensions between the ethics, values, and philosophies that underpin energy decisions. It builds on the collective philosophies of history's great justice thinkers from Kant's concept of universal human rights, Plato and Aristotle's concepts of virtue, Nozick and Freidman's focus on libertarianism and freedom, and Rawls and Nussbaum's emphasis on welfare, and many more (Sovacool & Dworkin, 2014, 2015; Sovacool et al., 2016a). Non-western indigenous and eastern philosophies have also been included (Sovacool, Burke, Baker, Kumar Kotikalapudi, & Wlokas, 2017).

Energy justice in application has been defined as, "a global energy system that fairly disseminates both the benefits and costs of energy services, and one that contributes to more representative and impartial decision making" (Sovacool, Heffron, McCauley, & Goldthau, 2016, p. 4). 4In this light, energy justice refers both to a fair outcome, and a fair decision-making process (Jenkins,

[18] A basic search in Scopus indicates at exponential trajectory in academic publications in this topic. Published articles using the term "energy justice" in the title, abstract, or keywords were 24 in 2016, 12 in 2015, and 4 in 2014. It is clear that this research area is both new and growing.

Mccauley, Heffron, Stephan, & Rehner, 2016; McCauley et al., 2013). To ensure a fair process, energy system decisions must be based on input from citizens and stakeholders from diverse backgrounds, diverse organizational positions, and who hold diverse views. John Stuart Mill argued that, "He who knows only his side of the case, knows little of that" (Mill, 1856, p. 67). We believe our deliberative dialogue approach to solar energy program design stands as an example of a fair and inclusive decision-making process. By engaging stakeholders and the public our process demonstrated a commitment to *due process*.

Furthermore, energy justice is not only a conceptual tool, but the energy justice framework can be used as an analytical and a decision-making tool (Sovacool & Dworkin, 2014, 2015). We evaluated the outcomes of our engagement process through the lens of energy justice. *In particular, we used the energy justice decision-making tool developed by Sovacool and Dworkin* (Sovacool & Dworkin, 2014, 2015)*. Their decision-making tool outlines eight dimensions of energy justice: availability, affordability, due process, good governance, sustainability, intragenerational equity, intergenerational equity, and responsibility* (see Table 1*).* Energy justice is complex. Sovacool and Dworkin are the first to establish a way to think through this complexity with their decision-making tool. In what follows, we test the applicability of this tool in a case study of solar energy program design in Saskatchewan, Canada.

Table 5.1

Energy justice decision-making tool (from (Sovacool & Dworkin, 2015))

Dimension	**Explanation**
Availability	People deserve sufficient energy resources of high quality
Affordability	All people, including the poor, should pay no more than 10 percent of their income for energy services
Due process	Countries should respect due process and human rights in their production and use of energy
Good governance	All people should have access to high quality information about energy and the environment and fair, transparent, and accountable forms of energy decision-making
Sustainability	Energy resources should not be depleted too quickly
Intragenerational equity	All people have a right to fairly access energy services
Intergenerational equity	Future generation have a right to enjoy a good life undisturbed by the damage our energy systems inflict on the world today
Responsibility	All nations have a responsibility to protect the natural environment and minimize energy-related environmental threats

In our discussion, we offer a critical evaluation of the energy justice decision-making tool as it applies to solar energy. We highlight that a challenge with this decision-making tool is understanding the tradeoffs between the eight dimensions of energy justice. Of chief concern is the tension between *affordability* and *intergenerational equity.* Encouraging solar energy self-generation lowers

Saskatchewan's GHG emissions and helps to mitigate global climate change. However, depending on program design, solar energy self-generation can contribute to higher utility bills for non-self-generators, making energy less affordable to those with low incomes. When achieving GHG emissions reductions harms affordability, which dimension should be prioritized, affordability or intergenerational equity? We explore this tension further in section 5.7 and use the energy justice decision-making tool to evaluate the solar energy program design options generated by participants.

5.4.2. Deliberative Dialogue

In recent years our understanding of democracy has taken a "deliberative turn" (Dryzek, 2002, 2010). Citizens and scholars alike are not content to define democracy as the practice of voting in elections, but instead see the need for "substantive" citizen participation in decision-making, including "effective deliberation" of the choices faced by decision-makers (Dryzek, 2002, p. 1).

In a general sense, deliberation consists of "communication (that) induce(s) reflection upon preferences in non-coercive fashion" (Dryzek, 2002, p. 2). Deliberation embodies confidence that citizens can contribute valuable perspectives to the decision-making process. It also embodies the belief that through communication with others we may adjust or modify our preferences.

A deliberative dialogue promises to generate "shared understanding" amongst participants (van den Belt, 2004, p. 17). This could be a shared understanding of the issue being discussed, including its context and history, optional paths forward and the trade-offs faced by choosing one path over another, as well as shared understanding of the views and interests of fellow participants. This shared understanding can ensure that implementation of a final decision has broader public support.

The role of the researcher in a deliberative dialogue is to facilitate a structured conversation (Norgaard, 2007). A good deliberative dialogue provides participants with information about the issue they are discussing, and facilitates a learning conversation amongst the participants. A deliberative dialogue can then generate options for decision-makers to consider. These options are informed by a broader swath of subjectivities and knowledge than can be mustered by an individual analyst. As such, these options offer a better, and more democratic, basis for decision-making. In the next section, we outline our approach to creating a structured conversation on the future of solar energy in Saskatchewan.

5.5. Methods

In this paper, we seek to examine whether a deliberative dialogue process encourages consideration of energy justice in the design of energy programs. Below we outline the methods we took to carry out the deliberative dialogue. This engagement process is unique in the context of energy policy-making. As we noted above, energy policy engagement in Saskatchewan is "typically one-way communication with minimal deliberation" (Martens et al., 2015, p. 20). The process we designed sought detailed input from workshop participants. Workshop participants were also challenged to work with a diverse group of participants to design and create a solar energy program that all members of their group could agree upon. This practice of deliberation amongst diverse participants offers an opportunity for mutual learning and improved program design. This case study builds on previous work on renewable energy deliberative dialogues (Hindmarsh & Matthews, 2008; van de Kerkhof, 2006) and marks the first use of deliberative dialogue in the design of solar energy programs.

We also aim to test and refine the energy justice decision-making tool as a method of evaluating energy program design. Sovacool and Dworkin's framework is the first to offer a systematic approach to thinking about energy justice (Sovacool & Dworkin, 2015). By applying it to our case study we have an opportunity to learn how it works in practice, and suggest improvements.

5.5.1. Workshops

We held eight half-day deliberative dialogue workshops between February 16 and April 3, 2017. The major objectives of the workshops were to better understand the priorities and perspectives of participants with regards to solar energy programs in Saskatchewan and to provide meaningful input on future solar energy programs in Saskatchewan. Workshops were held in Regina (n=3), Saskatoon (n=4), and Swift Current (n=1).

5.5.2. Participants

Invited participants included organized groups that SaskPower typically communicates with on new policy or program initiatives. These groups included:

- Business organizations like the Saskatchewan Chamber of Commerce and regional Chamber offices;

- Environmental non-profit organizations like the Saskatchewan Environmental Society; and
- Governance organizations such as the Federation of Sovereign Indigenous Nations, individual First Nations, and urban and rural municipalities.

Invited participants also included representatives from the solar industry, including solar installers, and solar project developers like Bullfrog Power. Many of these organizations distributed the notice of the workshop to their members. Registration was open to all who expressed interest. Table 2 summarizes attendance at workshops in Swift Current (n=1), Regina (n=1), Saskatoon (n=2), a special workshop of representatives from rural municipalities also held in Saskatoon, two workshops held with university students (n=2), and an internal workshop of SaskPower employees. The participant mix was diverse and varied at the Swift Current, Regina and Saskatoon workshops, but was relatively uniform at the rural municipality, university, and internal SaskPower workshops. A total of 229 individuals participated in the workshops.

Table 5.2

Workshop Participants by Affiliation

Category	Number of Organizations	Number of Attendees
Business Organization	7	7
Business Owner	4	4
Construction & Engineering Industry	10	14
Coring Industry	2	2
Educational Institution	4	4
Electrical Contractor	7	7
Electrical Equipment Manufacturer	1	1
Electric Utility (not SaskPower)	2	6
Environmental Non-profit	7	11
Financial Institution	1	1
First Nations	5	7
Legal Firm	1	2
Provincial Government	3	6
Real Estate	2	2
Resident	15	15
Rural Municipal Government	16	27
SaskPower Employees	1	22
Solar Industry	31	37
University Students	2	27
Urban Municipal Government	3	8
Other	N/A	19
	124	229

5.5.3. Workshop Design

The workshop was designed to encourage openness and deliberation. Workshops began with an outline of the agenda and the laying down of ground rules. We asked participants to agree to adhere to Chatham House rules; information shared in the meeting could be repeated, but would not be attributed to any one person or organization. We also asked participants for their permission to facilitate the discussion and ensure that we heard from all voices in the room. Lastly, we asked participants to practice listening to the opinions of others ("you have two ears and one mouth, use them proportionately") and to practice civility ("please disagree without being disagreeable"). These ground rules were intended to establish an atmosphere of openness where all participants could express their thoughts without fear of reprisal. By asking for permission to facilitate the discussion we prepared participants for the possibility that one of our facilitators would intervene to ensure all participants had a chance to speak. This was a means of ensuring the conversation was not dominated by the loudest, most insistent voices.

SaskPower then introduced their planning context, explaining that solar energy programs had grown in popularity and needed to be updated to reflect growing demand. They introduced Saskatchewan's 2030 50% renewable target and explained that 20 megawatts (MW) of community solar power capacity would be developed by 2021. SaskPower then explained that they would use the feedback gathered in the meetings to help them design the next round of solar energy programs and committed to provide participants with a report summarizing the results of the workshops. These commitments were intended to assure the participants of the authenticity of the workshops. SaskPower was ready to listen.

Following these introductory segments, we proceeded to ask participants three questions:

1. What principles should guide the design of solar energy programs?
2. What barriers stand in the way of solar energy installations?
3. How would you design an effective solar energy program for Saskatchewan?

For each question, we organized a specific activity to gather input from the group. Throughout the workshop the focus alternated between the plenary, for example, when presentations were given, and breakout tables where we held small-group deliberative discussion. Participants were pre-assigned to breakout tables using numbers on their name tags. In assigning participants to tables we worked to ensure the greatest diversity of voices at each table. This meant assigning participants from the same organization to separate tables.

5.5.3.1. Guiding Principles

To gain feedback on the principles that should guide the design of solar energy programs we presented SaskPower's preliminary guiding principles in the plenary. We then asked participants to offer their suggestions for modifying existing principles or adding new principles. Participants each had a stack of "sticky-notes" and pens and wrote as many principles as they could think of in the ten minutes allotted. Facilitators collected these sticky notes and brought them to the front of the room where the lead facilitators organized them into grouped themes. The lead facilitators then led a discussion of the principles at the front of the plenary group, asking for further explanation or clarification when needed.

5.5.3.2. Barriers

We used a similar approach to collect participants' views on the barriers that stand in the way of solar energy installations in Saskatchewan, but this time we organized the discussion at breakout tables of 6-8 people. Each table had a facilitator who asked participants to list as many barriers as possible on sticky-notes. The table facilitator gathered the stick-notes, stuck them on flipchart paper visible to all, and then led a discussion with the group. This provided participants with an opportunity to begin to hear the perspectives and concerns of others around the table. The results of the barriers exercise are not included in this article but will be explored in a subsequent paper.

5.5.3.3. Program Design

In the final exercise, we asked participants to design their own solar energy program. Prior to this session a representative from SaskPower presented several approaches to solar energy programs commonly used in North America. Participants were then given a worksheet that presented fifteen questions to consider when designing a solar energy program. Questions included, "What payment method or mechanism will be used to value the electricity provided?" For this particular question participants were shown four possible answers: credits on an electricity bill, payment offered at a fixed rate, payment offered at a variable rate, or other. The worksheets were intended as a guide for discussion, but participants were also encouraged to consider options outside of those listed in the template. We then asked participants to form groups of three or four people and to design the solar energy program of their dreams. Participants were given 60 minutes after which they were asked to explain their solar energy program to the group in a plenary session.

5.5.4. Coding and Analysis

Following each workshop, we held a debrief with the facilitators and SaskPower staff. During this debrief we asked for reflections on the workshop; the ideas heard and novel ideas we had not heard at previous workshops. This was the first step in the analysis process.

5.5.4.1. Guiding Principles and Barriers

After the first two workshops, we conducted an initial analysis of the results. We transcribed each sticky note into a spreadsheet, indicating which workshop it was from and, for the barrier exercise, which breakout table. Each of us (both authors of this paper) then independently coded the results. To do this we used a modified version of the approach suggested by Auerbach and Silverstein (A. F. Carl & Silverstein, 2003) in their book *Qualitative Data*. This approach consisted of the following steps:

1. *Identify repeating ideas* – we grouped comments together with others that expressed a similar idea. Repeating ideas are those expressed by two or more participants (or represented on two or more sticky notes). For example, in the barriers exercise, cost was mentioned as a barrier 61 times. When presented in this paper, repeating ideas are conveyed using a representative quote in quotation marks.
2. *Identify themes* – we then grouped repeating ideas into higher-level themes. For example, concerns about the cost of solar panels (e.g. "Capital outlay - $20K+ is tough") were grouped with concerns about "access to financing" in a theme we called *economic*. Throughout this paper themes are indicated with *italics*.

After each of us had coded the results we compared our list of repeating ideas and themes to test inter-coder reliability. At this stage, there was close agreement on the repeating ideas identified, but wide differences in the themes. We deliberated which themes fit best, incorporating elements from each list of themes. We then developed a combined list of themes that served as the basis for coding the rest of the workshops.

We repeated the process of transcription and coding for the subsequent workshops. This iterative process led us to modify the original list of themes and reassign some of the repeating ideas into different themes. We again deliberated the final themes, arriving at a list upon which we could both agree.

When coding was complete we assembled all the coded comments into one file and counted the occurrence of each theme. For the guiding principles exercise counts were based on the number of workshops that expressed the idea. For the barriers exercise, because discussion occurred at breakout tables, we could count the number of tables that expressed an idea related to one of the final themes.

As a last step, and again following Auerbach and Silverstein (2003) we chose representative quotes that expressed each repeating idea and used these quotes to craft a narrative description of each theme (see Table 5.3). The goal of this step was to communicate the content of the theme using the words of the participants.

5.5.4.2. Program Design

The program design exercise provided us with 52 completed worksheets. We entered the responses from each worksheet into an on-line survey analysis tool and used this tool to cross-tabulate the results. We also coded each program design idea, noting whether it was representative of a higher-level program archetype. For example, programs that involved paying a fixed rate directly to solar energy producers were coded as exemplifying a *feed-in-tariff* type program. Using the on-line survey analysis tool, we could then cross-tabulate the mean compensation rate desired by groups that had proposed a *feed-in-tariff* type program. Like themes, program archetypes are presented using *italics* in the text below and in Table 5.4.

5.5.4.3. Analysis of the Energy Justice Decision-Making Tool

With the results of the workshops coded and analyzed we then contrasted the feedback from stakeholders with the eight dimensions of the energy justice framework. This step allowed us to evaluate whether a deliberative dialogue approach to solar energy program design helped to encourage consideration of energy justice. We then applied the framework as an energy justice decision-making tool to assess the extent to which the solar energy program ideas proposed in the workshop promote the eight dimensions of energy justice. Through this process inconsistencies and tensions between the dimensions of energy justice were revealed.

5.6. Results

5.6.1. Guiding Principles for Solar Energy Programs

Stakeholder participants were asked to provide feedback on SaskPower's mission, goals and guiding principles for solar energy programs. Workshop participants provided 260 distinct suggestions, which we coded into 16 principles and 2 goals (see Table 5.3). Representative quotes are included in quotation marks to provide examples of the repeating ideas coded under each guiding principle.

Table 5.3

Guiding Principles and Goals

Guiding Principle	**% (n=6)**	**Description**
Pro-Active Education	100%	In combination with solar energy programs, SaskPower should provide pro-active customer education to encourage "greater energy literacy." This could be done by "including information with regular bills" and creating "partnerships with public institutions." This information would "highlight the benefits (of solar energy) to all customers" and "break out cost and benefits of different generation sources." SaskPower could also encourage "installer training and certification" and "provide basic technical training to solar net metering customers."
Life Cycle Sustainability of Solar Energy	100%	Program should be "environmentally sustainable" over the life cycle of a solar energy project. To ensure sustainability, program should "consider the toxicity of panels and inverters." SaskPower should develop "principles around decommissioning" to ensure panels are "safe at the end of life." SaskPower should also ensure that solar energy programs "provide environment benefits" and "reduce environmental impacts", for example by reducing monthly meter reading trips and saving fuel. The utility may want to also consider offering higher incentives for "solar panel choices with low environmental impacts" and encourage "ethical sourcing of parts" that do not use "conflict minerals." [One participant opposed this concern stating, "Most solar panels are relatively greenly made, do not over-stress how they are made."]
Integrated Planning (including energy conservation, smart grids, and storage)	83%	In designing solar energy programs, "ensure solar is recognized as an important part of an overall energy program." An integrated energy plan should "include electrical energy storage goals", "smart meters", and "energy conservation." To achieve energy conservation, SaskPower should "encourage energy efficient products, buildings and usage," provide "incentives to reduce demand" and "promote social-cultural change through education." Investment in "storage and smart grids" can enhance grid reliability to allow "up to 20% solar penetration."
Community Participation	83%	Solar energy programs are designed to "enable community participation and empower local ownership". "Include First Nations communities" in solar energy programs and consider the legal land context of First Nations.
Program Design Improvements	83%	Participants also used the guiding principles exercise as an opportunity to suggest improvements to existing solar energy programs and propose new solar energy program ideas. Improvements included allowing "customers to receive any carbon credits" associated with electricity production, increasing the small power producer program cap "from 100 kw/application to 500 kw/application", increasing the length of net metering contracts "beyond 2 years", "paying for the extra energy generated" by net metering customers, and "maintaining or improving rebates." Participants also suggested financing programs where "the government pays for the whole system first (and the) customer will pay the money back by installments."
Foster Innovation	67%	Design solar energy programs to "foster innovation." This may include specific projects like a "design contest" for a solar farm, and pilot programs that can offer "proof of concept." SaskPower can also "encourage innovation by funding research."
Revise Cross-Subsidization	67%	Some participants took issue with the principle: "Minimize cross-subsidies from non-solar customers." Participants pointed out that "cross-subsidization exists for CCS (carbon capture and storage)" and other energy sources and for that reason cross-subsidization of solar energy "is bogus." Related to this pushback were calls for "Full Cost Accounting of Solar Value." As noted in that guiding principle, participants felt solar energy is under-valued by the utility.
Customer Focus	67%	This theme builds on SaskPower's initial guiding principle "Provide a quality end-to-end customer experience (SaskPower and partners)." SaskPower can "provide a quality consumer experience" by creating a "more streamlined application process" and "speeding up time for customer connection." In all their programs, SaskPower should ensure that "customer satisfaction comes first."

Encourage the Solar Industry	67%	Modify the guiding principle "Do not impede the growth of the Saskatchewan Solar Industry" to read: "Actively encourage growth of the Saskatchewan solar industry (not just fail to impede it)." One way this can happen is by providing "stable and predictable programs" that are "communicated in a way that doesn't send signals to wait for something better."
Ensure Quality	67%	Provide "quality assurances for solar" by certifying "qualified installers" and "sourcing technology" to "mitigate individual's risk". As part of quality control, there should be a "focus on safety", including solar energy safety education for customers.
GOAL*: GHG Reduction*	50%	Greenhouse gas emissions (GHG) reduction should be "a goal not a principle" of solar energy programs. Solar energy programs should help "meet (the) Canadian commitment to emission reduction" by "reducing the carbon content of the power mix."
On-going engagement	50%	This theme modifies SaskPower's guiding principle "Programs are informed by comprehensive stakeholder engagement and input (internal and external)" to request that programs be informed by "ongoing engagement", including "youth engagement." SaskPower should continue to "engage industry, solicit public opinion, feedback."
Full Cost Accounting of Solar Energy Value	50%	"Properly value the environmental and human health consequences" of solar energy, including the "cost avoidance value", the value of having "generation close to load", and the "GHG externality costs." Participants argued this full cost valuation would shift perceptions around cross-subsidization.
Accessibility for All	50%	Solar energy programs "are accessible to all customers" no matter their location, or the size of the project. They may be made accessible to those who cannot afford solar energy through a financing program.
GOAL*: Maximize Renewables*	33%	A goal of the solar energy program should be to "maximize renewable energy" on the Saskatchewan grid.
Affordable Electricity	33%	"SaskPower retains its commitment to the citizens for affordable electricity"
Decentralized Grid	33%	Solar energy programs should "encourage the development of micro-grids" and this "grid transformation" will lead to a "small is beautiful" model of "distributed solar development"
Industrial Solar Energy Generation and Revised Billing	33%	Programs should "encourage industrial customers to go solar" and also charge higher rates for industrial customers to "address lack of incentive for large power users to reduce their consumption."

(1) Guiding Principles feedback comes from six of the eight workshops. Condensed workshops for students at the University of Saskatchewan and for representatives of rural municipalities did not allow enough time to include the guiding principles exercise.

The desire for *pro-active education* was mentioned in each of the six workshops. Participants felt that SaskPower should take a lead role in increasing "energy literacy". Education (or lack thereof) was also a common theme expressed in the barriers exercise.

The desire to ensure the *life-cycle sustainability of solar energy* was also expressed in each workshop. Participants felt that while solar energy programs should reduce GHG emissions, they should also be sustainable over their life-cycle. To address this issue participants encouraged SaskPower to "consider the toxicity of panels and inverters" and develop "principles around decommissioning" to ensure panels are "safe at the end of life."

While not the most common themes expressed at workshops, two related themes stood out as particularly poignant. First, participants in three of the workshops took issue with SaskPower's principle "Minimize cross-subsidies from non-solar customers." In their presentation SaskPower explained that when customers using the net metering program reduce the energy payments on their electricity bills to zero, they no longer contribute to the cost of the existing electricity system. This is because the energy charges (the per kWh charge for electricity use) for residential and small commercial customers cover both the fixed and variable costs of the electricity system. In terms of fixed costs, the energy charges on SaskPower bills cover the capital cost of all the generation units and the cost of installing and maintaining transmission and distribution lines. In terms of variable costs, the energy charge covers the cost of fuel; for example, the coal burned in a coal plant. When a customer generates solar energy to send to the grid they offset the variable cost – for example by allowing coal and natural gas fired plants to burn less fuel – but they do not reduce the need for generation units or transmission and distribution lines. Due to the variability of solar energy production, these units and lines must still be available to provide electricity to the customer when the sun is not shining. When a net metering customer does not pay for these fixed costs, they are instead borne by the other SaskPower customers, whose energy charge rates must increase accordingly.

Upon hearing this description of cross-subsidization many of the participants responded negatively. They argued that other energy generation options in Saskatchewan receive direct subsidies. For example, the Boundary Dam Carbon Capture and Storage (CCS) plant cost $1.467 billion for 110 MW of electricity capacity. In comparison, SaskPower is building a 350 MW natural gas combined cycle plant without CCS at a cost of $680 million. Stakeholders asked why SaskPower would pay a high cost for the Boundary Dam CCS plant, but not pay more for solar energy.

Participants also expressed a sentiment that we list as the theme *full cost accounting of solar energy*. Participants argued that producing solar energy creates environmental and health benefits by offsetting the need to burn coal and natural gas. They argued these co-benefits should be valued by SaskPower (see for example the social avoided cost line in Figure 5.1).

Lastly, participants felt there was value to having "generation close to load". The distributed nature of solar energy production reduces losses in electricity lines. In a previous section, we discuss these tensions and compare these principles to the eight dimensions of energy justice proposed by Sovacool and Dworkin (Sovacool & Dworkin, 2014, 2015).

5.6.2. Solar Energy Program Design

The final exercise in the deliberative dialogue process was program design[19]. Participants provided a rich set of program design suggestions. We summarize the program archetypes in Table 5.4.

Table 5.4

Solar Energy Program Archetypes

Program	***Description***
Net Metering Plus	An enhanced version of the current Net Metering program. Self-generating customers would continue to receive credits on their bill for electricity they generate. The following enhancements would be made to the program: contract length extended beyond two years; excess generation purchased at the end of the year; 100 kW cap increased; more than one meter can receive credits for electricity generated; approval process simplified and made faster; and connection process made less expensive
Virtual Net Metering	This program would allow electricity customers to invest in larger community-size solar energy projects. Investors would collect credits in proportion to their investment. These credits would be applied to their electricity bills, reducing their costs. Investments would be repaid through utility bill savings
Feed-in-Tariff	The utility would purchase solar energy at a fixed price, ensure grid access, and prioritize solar energy in the merit order. This program concept resembles the Small Power Producers (SPP) program.
Regional Solar Auctions	The province is divided into regions and each region is allocated a set solar energy target (*e.g.* 10 MW solar capacity). In this model, the price of solar energy could be set by a regional auction or a request for proposals (RFP) process, or would be set at a fixed rate by the utility.
Pilot Projects	Sites would be selected by the utility to participate in a pilot project. Potential candidates for pilot projects would include: post-secondary educational institutions, schools, existing urban neighbourhoods, new urban developments, and First Nations communities.
Utility Owned Solar	The provincial utility would reduce the cost of solar energy by directly purchasing and installing panels. The provincial utility would achieve economies of scale through the bulk purchase of solar modules. An internal team would be dedicated to installing solar panels. By standardizing the solar panel installations, the need for inspection would be reduced.
Electricity Rate Restructuring	The rate structure for residential, rural, and commercial customers would be restructured. The goal would be to price services at their true marginal cost to enable economically rational decision-making. This rate restructuring would apply to all customers, not just self-generators.
Feed the Funnel	SaskPower would reduce the soft costs of installing solar energy projects by taking on the role of one-stop shopping centre for solar energy. In this role SaskPower would: promote solar energy on their website and on utility bills; accept applications from customers interested in self-generating; provide project financing; sign standing offers with solar energy vendors to pre-qualify them to install solar panels on behalf of SaskPower; issue tenders each week allowing solar energy vendors to bid on ready-to-install projects.
EV & Storage Programs	Stack self-generation programs with measures to encourage electric vehicles and energy storage.

About one-fifth (21%) of breakout groups suggested a program that improved upon the current net metering offering. This *net metering plus* program would address common concerns expressed by solar

[19] Prior to this exercise, stakeholders received a presentation outlining four solar program design archetypes and examples from other jurisdictions.

installers and customers. For example, the program would extend net metering contracts from the present two-year length to 20 years, providing more certainty of benefit over the life of the solar installation.

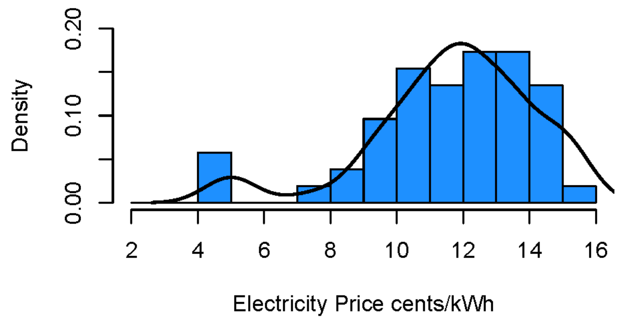
Another fifth (19%) of breakout groups suggested *a virtual net metering* program. Programs of this type allow people to invest in solar energy without installing solar panels on their own property. This is particularly useful for overcoming physical barriers to *solar access* like lack of a suitable roof space, and for allowing those who rent (rather than own) their home to invest in solar energy.

Almost half (49%) of breakout groups designed programs with *feed-in-tariff* qualities (and note that programs archetypes are not mutually exclusive, some of the program ideas fit in more than one archetype category). These programs pay solar energy producers for each kWh of solar energy produced rather than awarding credits to be deducted from electricity bills as is the case with net metering programs.

Feed-in-tariff programs can have more or less impact on electricity rates for non-self-generators depending on the price paid for solar energy. Figure 1 summarizes the distribution of desired payment prices expressed by workshop participants. The distribution centres on $.12/kWh with a mode between $.12/kWh and $.14/kWh. A smaller proportion of breakout groups desired solar energy to be valued at $.04/kWh to $.05/kWh, closer to the avoided cost of fuel for SaskPower, which likely ranges from $.03/kWh to $.07/kWh. Interestingly, when we cross-referenced those who selected a *feed-in-tariff* type program with the desired payment price for solar electricity, we found that half (50%) wanted to be paid at the residential retail rate ($.1374/kWh) or higher (see Figure 5.2). This has important implications for cross-subsidization, which we discuss in the next section.

Figure 5.2

Desired Payment Price from Program Designs



5.7. Analysis and Discussion

Above, we outlined the results of a deliberative dialogue on solar energy in Saskatchewan. In the following, we argue that there are important lessons to be learned from this dialogue from the perspective of energy justice. We pose a series of questions resulting from this deliberative dialogue exercise and analyze our results using the energy justice decision-making tool.

5.7.1. Can due process encourage consideration of energy justice?

In a previous section, we outlined the principles (and two goals) participants in the deliberative dialogues thought should guide the development of solar energy programs in Saskatchewan. We now compare these principles to the eight dimensions of the energy justice decision-making tool to answer the question, can due process encourage consideration of energy justice? (see Table 5.5)

In comparing the guiding principles proposed by participants (and coded by the authors) we find the two lists to be strongly aligned. For nearly every dimension of the energy justice decision-making tool there is a guiding principle that expresses all or part of the sentiment. Participants desired *affordable electricity*, which matches the *affordability* dimension. Participants asked for opportunities for *on-going engagement*, which is a key requirement for *due process*. *Pro-active education* was identified as a guiding principle in every workshop. This relates to one aspect of the *good governance* dimension; the call for “high-quality information” to be made available to citizens (Sovacool & Dworkin, 2014, p. 367).

Several guiding principles represent *intragenerational equity* concerns. Participants wanted *community participation* in the ownership of solar installations, wanted programs to be *accessible for all* citizens (including those without adequate *solar access* at their place of residence), and sought a restructuring of electricity rates so that industrial customers would pay a higher share of electricity system costs.

A focus on *intergenerational equity* was evident by the emphasis participants placed on *greenhouse gas emissions reduction* to address climate change. Additionally, calls for the inclusion of First Nations in the creation and ownership of solar energy projects (which we coded as belonging to *community participation*) reflect a concern with redressing historic wrongs committed against Indigenous Peoples (Daschuk, 2013; The Truth and Reconciliation Commission of Canada, 2015). As such, calls for First Nations inclusion can be interpreted as concern for addressing pre-existing intergenerational inequities.[20] This is consistent with the "two-hundred-year-present" concept proposed by sociologist Elise Boulding. The "two-hundred-year-present" proposes that starting from birth people are genealogically connected to three and a half generations—or approximately 100 years—of both past and future generations (Sovacool & Dworkin, 2014). Centenarians alive today demonstrate this connection to the past and in turn the future. In this way, it is possible to conceptualize intergenerational effects from actions over a time span of 200 years as being embodied in the present.

Sovacool and Dworkin conceive of *responsibility* as entailing four separate definitions (Sovacool & Dworkin, 2015). Of the four, we found support for the definition of *responsibility* as ensuring that polluters pay for the damage their pollution creates (Sovacool & Dworkin, 2015). Participants called for SaskPower to incorporate the value of preventing greenhouse gas emissions into the price paid for solar energy by pursuing a *full cost accounting of solar energy value*.

[20] We would like to thank an anonymous reviewer for comments encouraging us to consider concern for participation of First Nations and Indigenous Peoples as a concern for *intergenerational equity*. In the words of the anonymous reviewer "intergenerational equity goes into the future AND the past". In the context of solar in Saskatchewan, community owned solar developments could be a vehicle for sustainable economic development within First Nations communities. The social benefits promised by First Nations renewable energy development may justify public financial support for this strategy. Public funding would reduce pressure on electricity rates and alleviate concerns about the cross-subsidization of solar by non-self-generating ratepayers.

While *availability* was not a high-level guiding principle identified in the external stakeholder workshops, sub-dimensions such as resource adequacy and system reliability were highlighted in the internal SaskPower workshop.

Table 5.5

Comparing solar energy dialogue principles and the energy justice decision-making tool (from (Sovacool & Dworkin, 2015))

Energy Justice Dimension	**Guiding Principles**
Availability	(Concern for SaskPower staff)
Affordability	*Affordable Electricity*
Due process	*On-going Engagement*
Good governance	*Pro-Active Education*
Sustainability	*Life Cycle Sustainability of Solar Energy*
Intragenerational equity	*Community participation*
	Accessibility for All
	Industrial Solar Energy Generation and Revised Billing
Intergenerational equity	*Greenhouse Gas Emissions Reduction*
	"Include First Nations communities"
Responsibility	*Full Cost Accounting of Solar Energy Value*
Additional Dimensions	**Guiding Principles**
Engineering	*Integrated Planning*
	Ensure Quality
	Decentralized Grid
Economic Development	*Foster Innovation*
	Encourage the Solar Industry
Administrative	*Program Design Improvements*
	Customer Focus
Reaction	*Revise Cross-Subsidization*

The remaining principles identified by participants largely fit within the traditional technocratic dimensions of energy decision-making: *engineering*, *economic*, and *administrative*. A key takeaway from our results is that these traditional dimensions, while present, were only part of the conversation. When asked an open question regarding the principles that should guide solar energy programs, participants highlighted the eight dimensions of energy justice.

The close alignment of guiding principles expressed by participants and the dimensions of energy justice suggest that *due process* can encourage consideration of energy justice. From this we propose that the energy justice decision-making tool could be improved by reorienting the eight dimensions. *Due process* is a core, generative element of energy justice. A strategic focus on *due process* in decision-making has the potential to encourage consideration of the other dimensions of energy justice. This challenges the wisdom of a top-down directive for energy decision-making and builds on German sociologist and philosopher Jürgen Habermas' concept of deliberative democracy. He argued that a "legitimation crisis" occurs when the process of decision-making does not include the perspectives of the public (Habermas, 1976). In our deliberative dialogue process we centered *due process*. By centering *due process*, we reoriented decision-making power to the broader public and created an opportunity for a more representative set of values to embed themselves in the decision-making process. To answer our question, yes, we believe *due process* can encourage consideration of energy justice.

5.7.2. Can the energy justice decision-making tool help improve energy decision-making?

The energy justice decision-making tool allows decision-makers to preemptively account for justice considerations and tensions before a decision is made. As solar energy programs are designed, policy makers may benefit from using this tool to evaluate the suitability of their programs and foresee potential justice issues that would occur after implementation. To test the usefulness of the energy justice decision-making tool we evaluate the proposed solar energy programs archetypes using the tool (see Table 5.6).

The solar energy program archetypes largely attend to the *intergenerational equity* and *sustainability* dimensions by promising to lower GHG emissions and reduce the environmental and health impacts of burning fossil fuels. They vary in regard to the *availability*, *affordability, intragenerational*, and *responsibility* dimensions of the energy justice decision-making tool. Although participants highlighted principles that were in line with the energy justice decision-making tool in the first part of the workshop, efforts to design programs that aligned with these principles was not always apparent. This highlights the challenge of achieving solar energy justice in practice.

Evaluating program ideas with respect to *due process* and *good governance* is difficult because these dimensions largely depend on knowledge of details not considered in the program archetypes. For instance, a *utility owned solar* energy program may be one that follows principles of *due process* and *good governance* by incorporating institutional accountability and transparency. Alternatively, a *utility owned solar* energy program may be one that is exclusive, closed, and not accountable to the public. These details were not fully considered in the design of the program archetypes and relate more generally to the decision-making process through which the solar energy programs are designed and implemented. For this reason, we indicate uncertainty on these dimensions in Table 5.6.

Table 5.6

Energy justice decision-making tool and solar energy program archetypes matrix

	Availability	Affordability	Due Process	Good governance	Sustainability	Intragenerational equity	Intergenerational equity	Responsibility
Net Metering Plus	+/-	-	?	?	+	-	+	-
Virtual Net Metering	+/-	+/-	?	?	+	+	+	+/-
Feed-in-Tariff	+/-	-	?	?	+	+/-	+	+/-
Regional Solar Auctions	+	+	?	?	+	+/-	+	+/-
Pilot Projects	+/-	+/-	?	?	+	+/-	+	+/-
Utility Owned Solar	+	+	?	?	+	+/-	+	+/-
Electricity Rate Restructuring	+/-	+	?	?	-	+	-	++
Feed the Funnel	+/-	+	?	?	+	+/-	+	+/-

(1) The symbol "+" indicates that the program is likely to attend to the energy justice dimension. The symbol "-" indicates that the program is not likely to attend to the energy justice dimension. The symbols "+/-" indicate that the program may or may not attend to the energy justice dimension depending on further details on how the program is designed, or may achieve the dimension for some, but not all citizens. The symbol "?" indicates that the energy justice dimension was not explicitly considered in the design of the program.

(2) Note that there are many different types of pilot projects. This could include projects such as community micro-grids to innovative institutional structures with First Nations. The premise is that experimental configurations of solar energy and a portfolio of complementary technologies would be considered.

(3) Affordability is from the perspective of ratepayers in Saskatchewan.

(4) Sustainability refers to a reduction in overall environmental impact and GHG emissions.

(5) Intragenerational equity refers to programs that attempt to be inclusive and accessible to all.

(6) Intergenerational equity refers to programs that may have higher cost burdens in order to reduce environmental impact so as to protect the environment for future generations.

(7) Responsibility refers to programs that (1) attend to social externalities and (2) conduct full cost accounting of the value of solar energy.

Through the lens of energy justice, it becomes clear that a single program does not attend to all of the dimensions of the decision-making framework. For instance, the *net metering plus* program would attend to the concerns of *affordability* from the perspective of self-generators. Potential solar energy producers would have the opportunity to offset the cost of their electricity bill, and contract lengths and payment levels would be high enough to offer a reasonable return on investment. However, as discussed earlier, a generous *net metering* program could also lead to higher electricity rates for non-self-generators who are left paying for the fixed costs of the electricity system.[21] *Affordability* for self-generators could occur at the expense of *affordability* for non-self-generators.

Net metering plus would also fail to meet the *responsibility* test; although self-generators use the transmission and distribution grid, they would not pay for the cost of maintaining the grid.[22] Lastly, *net metering plus* does not achieve *intragenerational equity.* Those who live in an apartment or don't have sufficient solar access would not be able to participate in the *net metering* program. In this case, an additional program would be necessary to equalize solar energy investment opportunities.

A *virtual net metering* program would allow more individuals and businesses to participate and benefit. In this way, it attends to *intragenerational equity*. However, *affordability* remains a concern for low income individuals who cannot afford any initial investment and may in fact be burdened by increasing electricity rates resulting from cross-subsidization. A generous *feed-in-tariff* program would create similar cross-subsidization concerns.

Cross-subsidization is a key challenge in districts around the world, and the success of the solar industry is contingent on solving the cross-subsidization puzzle. Discussion of cross-subsidization within the deliberative dialogue demonstrated the tensions between energy justice principles. For non-self-generators, energy justice may be defined primarily in regard to *responsibility*; paying only for the costs related to one's own electricity consumption and avoiding paying subsidies to solar energy self-

[21] This is a hypothetical assertion projected into the future. Currently, SaskPower's solar program has negligible impact on utility rates in the province due to relatively low uptake.
[22] Here we define responsibility more broadly than paying for environmental impacts. Responsibility here is defined as paying the full cost of the utility services used by the customer (*e.g.* the cost of transmission and distribution lines and the cost of ensuring electricity is available when solar energy is not being produced).

generators. For self-generators, energy justice was defined primarily as achieving *intergenerational equity* by reducing GHG emissions.

The *electricity rate restructuring* program was suggested as a *responsibility* focused solar energy program. Electricity rates would be designed using the principles of economic efficiency and would reflect the locational marginal price (LMP) of electricity consumed or generated in any given hour and location (see (Perex-Arriaga & Knittel, 2016) for a discussion of LMP). When defined in a narrow financial sense, the LMP would be reflective of the avoided cost of burning coal and natural gas and any related congestion costs in the distribution lines. This value corresponds to the $.03-.07/kWh range of desired solar energy prices indicated by some in Figure 5.2. If paying only the private avoided cost of electricity, solar energy projects would simply not be built in Saskatchewan because they would not be economically viable (see Figure 5.1).

Remember, however, that participants argued that *cross-subsidization does not exist* when you *fully account for the benefits of solar energy*. They argued that electricity pricing generally fails to capture externalities such as the damage caused by GHG emissions and the health impacts of burning fossil fuels. When a value is placed on externalities, for example through the application of a rising carbon price, the social avoided cost implied by solar energy generation is increased. A truly *responsible* solar energy program is one that is paired with carbon pricing and an adequate valuation of avoided externalities. As shown in Figure 5.1, if the value of solar energy reflected the social avoided cost by incorporating the value of avoided GHG emissions, solar PV would soon be a socially and privately desirable investment.

In sum, the energy justice decision-making tool is useful in helping guide the evaluation of solar energy programs. As such, it can help improve decision-making. When using the tool, however, we must grapple with tensions between the eight dimensions. It is difficult to design a solar energy program that achieves each of the eight dimensions of energy justice. What is it to be done in this instance? We suggest that the energy justice decision-making tool is a useful way to highlight these tensions and trade-offs. We also suggest that *due process* in the form of deliberative dialogue and enshrined by *good governance*, can allow citizens to decide which trade-offs are acceptable.

5.7.3. What were the limitations of our deliberative dialogue?

There are notable limitations of our deliberative dialogue. First, stakeholders in this process were not representative of the Saskatchewan population. Instead they were invited for their expertise and interest in solar energy. Engaging a broader demographic in the deliberative dialogue would likely yield different results. The ratepayers who would be affected by the installation of solar panels were not well represented at the workshops. In focus groups related to this consultation process, reactions to cross-subsidization were muted. When randomly drawn from the Saskatchewan population, focus group participants could see both the advantages of installing solar energy projects, but also did not want solar installations by some to increase electricity costs for others. This highlights the limitation of a deliberative dialogue aimed at targeted “stakeholders” instead of the general public. Of particular interest for inclusion would be low-income individuals that may be more sensitive to future electricity rate changes and may have an alternative perspective than individuals and businesses that can afford the upfront capital required for solar PV installations.

Second, the process was limited to a single electrical generation source—solar energy. The electricity grid in Saskatchewan, and grids around the world, necessitate a synergistic mix of generation sources to function and provide a reliable source of electricity. This paper has focused solely on solar energy. A deliberative dialogue focused on broader energy system pathways could allow a deeper understanding of the trade-offs that exist when planning an energy future. In the end, the goal of energy system planners is not to ensure the most advantageous solar energy programs. The goal is to provide the most advantageous energy system. We suggest that future deliberative dialogues in Saskatchewan, or in other jurisdictions, consider the broader energy system.

Third, we would suggest that the deliberative dialogue would be improved if there was accountability on the part of the utility and the provincial government to implement the results of the workshops. A commitment to implement stakeholder recommendations would likely enhance citizen and stakeholder support for this process and could create a more democratic decision-making process.[23]

[23] We would like to add, however, that to our knowledge the utility does intend to act on the feedback from this process.

To ensure that *due process* authentically and effectively informs decision-making we suggest the need to enshrine processes like deliberative dialogue in a governance framework. A program review mechanism that is outside the purview of the utility would allow for increased transparency and accountability. We suggest entrenching a deliberative dialogue process in a quasi-legal governance framework similar to the Saskatchewan Rate Review Panel (SRRP). The SRRP was created by the government of Saskatchewan to review rate and tariff increases proposed by provincially owned Crown corporations. According to Sovacool and Dworkin "the SRRP reviews each rate application based on the criteria of reasonableness and fairness, and explicitly calls for public input and formal comments to be submitted via email, letters, and telephone messages. The SRRP then produces a transparent report and media release summarizing their views and recommendation to the appropriate government ministers" (Sovacool & Dworkin, 2014, p. 216). It is a point of pride that Saskatchewan has developed a notable model of *good governance* for electricity rate setting. A similar model based around a deliberative dialogue process would enhance *due process* and *good governance*.

Although our approach would likely have value in other jurisdictions, as a single case study we cannot make definitive claims regarding international generalizability. Electric utilities vary greatly from country to country and careful attention must be paid when drawing lessons from case study research. Further study using the comparative method, in line with Mill's method of difference (Sekhon, 2004), would help build upon and test our arguments. The literature on historical institutionalism highlights the usefulness of case study comparisons of large scale systems (Tilly, 1984).

As a final caveat, a deliberative dialogue process should be seen as complementary, but not a substitute, to meaningful consultations with Indigenous peoples. First Nations, Inuit and Métis peoples in Canada have Treaty and Aboriginal rights. These rights mean that project developers and government have a 'Duty to Consult' First Nations, Inuit and Métis communities when a project may impact those rights. Government agencies often interpret the Duty to Consult in a narrow fashion. For example, the Government of Saskatchewan's Duty to Consult guidelines state that a Duty to Consult applies to land-use activities related to hunting, trapping, and specific cultural and spiritual traditions (Government of Saskatchewan, 2010). Joly and Westman assert that the Duty to Consult requirement could be interpreted more broadly (Joly & Westman, 2017). A broad interpretation would see the Duty to Consult requirement triggered when a decision may impact the ability of First Nations, Métis, and Inuit people to maintain "a livelihood or a way of life", rather than just impacting a food source or a historic cultural use, and should include lands of "potential historic or future importance" rather than just "unoccupied" Crown lands. Arguably, the potential for solar energy programs to contribute to economic development for Saskatchewan First Nations could justify a Duty to Consult level of government-to-government consultation with First Nations around solar energy development in the province.

5.8. Conclusion

Solar energy is challenging utilities to rethink their business models and to find a balance between solar energy programs that enable self-generators to supply their own electricity while maintaining affordability for the rest of the customer base. This paper highlighted the value of deliberative dialogue in achieving *due process* when designing new solar energy programs for Saskatchewan. We suggest that *due process* should be at the centre of the energy justice decision-making framework. Through *due process* citizens can define their own principles to guide the creation of solar energy programs, reveal barriers that stand in the way of solar PV technology adoption, and design enabling solar energy programs. These processes should also, however, strive to involve a representative sample of the general population. This would ensure that solar energy programs are designed with a view to benefit the entire population. Conversations must also be broad enough to consider the social context in which decisions are being made. In our example, some participants noted that carbon pricing provides the means to *account for the full value of solar energy* while also *avoiding cross-subsidization*. What's more, it provides a mechanism for comparing a portfolio of low-carbon energy options in the pursuit of developing a fair and just energy system. A broad conversation allows for discussion of system-level parameters like pricing pollution.

Sovacool and Dworkin (2015) have identified eight dimensions of energy justice, but these dimensions are not created equally and at times they may conflict with one another (Sovacool & Dworkin, 2014). For example, in our case study solar energy programs like *net metering* or generous *feed-in-tariff* programs allow self-generators to contribute to sustainability by lowering GHG emissions but create *affordability* challenges for non-self-generators. Should a *net metering program* be implemented? In our view, that conclusion is best reached through *due process*. By providing a forum for deliberative dialogue, decision-makers can bring the knowledge of citizens and experts to bear, allowing them to point the way towards programs that best serve the local needs and context. Through *due process* it may not be possible to achieve consensus, but it should be possible to achieve shared understanding of the local context and of the logic that led to the eventual adoption of a specific solar energy program.

Our research was the first application of deliberative dialogue to the design of solar energy programs of which we are aware. It contributes to the growing field of study on how deliberative dialogue can allow for better decisions in complex fields such as energy policy (Edwards, Hindmarsh, Mercer, Bond, & Rowland, 2008; Fraune & Knodt, 2017; Hindmarsh & Matthews, 2008; Pellizzone, Allansdottir, De Franco, Muttoni, & Manzella, 2017). We encourage researchers to apply and replicate the methodology we outlined above in new contexts. Further research could work to identify whether deliberative dialogue processes in other regions and cultural contexts generate a similar concern for energy justice.

Chapter Six: From transitions to decisions: moving decentralized energy forward by filling the gap between public engagement and decision-making

A version of this paper has been submitted to the journal *Energy Policy* as a co-authored publication with Dr. Brett Dolter.

Contribution Statement: Boucher contributed approximately 60% to the research and writing activities. Boucher conceived of the manuscript. Boucher and Dolter planned, designed, conducted stakeholder events, and analyzed data. Boucher took the lead on writing the manuscript. All authors discussed the results and contributed to the final manuscript

Chapter Six: From transitions to decisions: moving decentralized energy forward by filling the gap between public engagement and decision-making

Climate change is a pressing concern. According to the Intergovernmental Panel on Climate Change, we will likely surpass the 1.5°C target between 2030 and 2052 unless countries implement extensive emission reductions strategies (IPCC, 2018a). Because the majority of emissions come from the energy sector, the global energy system is undergoing a significant transformation. Alongside a global urgency to find solutions to climate change, innovations in energy technologies are pressuring our energy system to become increasingly decentralized (Ruggiero, Varho, & Rikkonen, 2015). Even in the mainstream, renewable energy has high public acceptance and is increasingly being recognized as having reached a point of irreversible momentum (Abdmouleh, Gastli, & Ben-Brahim, 2018; Ediger, Kirkil, Çelebi, Ucal, & Kentmen-Çin, 2018; Kardooni, Yusoff, Kari, & Moeenizadeh, 2018; Ntanos, Kyriakopoulos, Chalikias, Arabatzis, & Skordoulis, 2018; Obama, 2017; Ribeiro, Ferreira, Araújo, & Cristina Braga, 2018). Innovations and new uses of older technologies are making way for new methods of organizing the energy system. Technologies such as solar, wind, storage, small modular reactors, information communication technologies, and energy efficiency are the building blocks of a transition to decentralized energy (DE) (Burger & Weinmann, 2013).

In response to these developments, the academic literature on DE has become a burgeoning space of inquiry, encompassing disciplines that range from engineering, economics and computer science to business, political science, and psychology. Recent research on the topic of DE has been prolific. In the last three years alone, research on DE has included work as varied as privacy and security issues of micro-grid developments (Zhumabekuly Aitzhan et al., 2016), management and simulations (Karavas et al., 2017, 2015; Kofinas et al., 2018; van der Klauw et al., 2017), the incorporation of battery technology (Murray et al., 2018), and developments in blockchain and how it can integrate with decentralized energy (Imbault et al., 2017). There is also a growing and recent literature on non-technical developments in DE, such as economics (Casey, 2018; Liu et al., 2018; Thomsen, 2018; Vimpari & Junnila, 2017), community investment and finance (Curtin et al., 2019), political dimensions (Aunphattanasilp, 2018; Burke & Stephens, 2018; van Veelen & van der Horst, 2018), ethical and justice issues (Boucher, 2016; Dolter & Boucher, 2018; Pinker, 2018), socio-technical transitions and public policy (Adil & Ko, 2016; Skjølsvold et al., 2018), and governance considerations (Delina, 2018; Lammers

& Diestelmeier, 2017). From all these efforts, our understanding of DE and the quality of research has dramatically improved.

What remains, however, is a gap of understanding in how the public and decision makers engage with these changes. The transition to DE will involve the coordination of public effort in new and innovative ways. The public are increasingly becoming direct actors within the energy system, generating their own electricity and changing their energy demand profiles—a trend likely to increase in the future. This social innovation within the global energy system impacts both public engagement and decision-making practices (Hoppe & de Vries, 2019). Public engagement is crucial to influencing energy transitions and climate change. Public involvement with decision-making can create social capital and help legitimize the final outcomes of a decision (Bryson, Quick, & Crosby, 2012).

There is a growing body of literature in the field of energy transition and climate change on engaging with stakeholders, communicating with the public, and coordinating with epistemic communities (Chilvers, Pallett, & Hargreaves, 2018; Corner, Markowitz, & Pidgeon, 2014; Devine-Wright, 2011; Jones, Hine, & Marks, 2017; Maibach, Nisbet, Baldwin, Akerlof, & Diao, 2010; Nisbet, 2009b; O'Neill & Nicholson-Cole, 2009; Whitmarsh, O'Neill, & Lorenzoni, 2013; Whitmarsh, Seyfang, & O'Neill, 2011; Wibeck, 2014a). But no matter how effective an engagement process might be, it still needs to move from engagement to decision-making, and there is little research on how public engagement translates into public policy decisions. Understanding the effect of DE on decision-making is particularly critical because DE has such immense implications for climate change, the public, and current business models. In this paper, we use a case study of a public engagement and decision-making process on a solar energy program in the province of Saskatchewan, Canada to ask how public engagement with DE can improve decision-making outcomes. The electric utility in Saskatchewan is facing challenges similarly faced by electric utilities around the world—managing the impact of DE, in particular solar energy, and figuring out how to meaningfully incorporate public perspectives into decision outcomes.

6.1. Public engagement

Public engagement has a long history in democratic societies. In ancient Greece, public participation was seen as critical in deterring the corrupting influences of the concentration of power. Democratic forms of government have now become widespread. Post-World War II thinkers on public engagement, notably Hannah Arendt, view democracy as a significant societal achievement and not as a natural human transition, and advocated for meaningful citizen engagement and citizen-centered politics (Arendt, 1958). Deviating slightly from Arendt's position, Jürgen Habermas argued that public engagement plays a legitimizing role for democracies (Habermas, 1976, 1984). In recent decades, the work of John Dryzek has added to the debate, arguing for a more authentic and deliberative turn for public engagement and presenting many practical suggestions (Dryzek, 2002, 2010; Ercan & Dryzek, 2015). Despite the progress made in the thinking on public engagement, the public administration of many countries has been dominated by a managerial or "top-down" model of policymaking. In this model, experts within the public administration are responsible for moving forward the common good on behalf of the public. However, the managerial model can be at odds with the democratic principles that the public administration is expected to uphold. To mitigate this potential abuse of power, the public has been increasingly included in the decision-making process. Since the 1960s, as more participatory and deliberative forms of public engagement have been encouraged by academics and policymakers alike, the field has become well-established. As Mutz pointedly argues, "It is difficult to exaggerate the current enthusiasm for deliberation," adding "the amount of time and money invested in it by governments, foundations, and citizen groups is staggering relative to virtually any other current social science theory" (2008, p. 535). As a result of this "enthusiasm," the literature on public engagement has continued to expand and has become increasingly sophisticated. The approaches to public engagement have matured and now take many forms such as public surveys, focus groups, workshops, citizen juries, citizen assemblies, and participatory budgeting.

The goal of public engagement has been to ensure that a broad spectrum of voices can be heard and used to inform decision-making. Engaging with the public is seen as a way to increase democracy—to democratize democracy. There are also practical reasons for this motivation. Blomgren, Nabatchi, and Leary have argued that the prominence of these new forms of engagement is in part an "evolutionary human response to complexity" (2005, p. 555). Decision-making, proponents argue, would be better informed and improved if the public were more directly involved in the decision-making process. This intention, however, differs depending on the vantage point of the stakeholder. For a public institution, the stakeholders may want public engagement to be used to incorporate the collective voices of the public into their policy decisions and implementation. For the public, public engagement enables them to express their concerns and perspective about issues that impact them and allows a forum for them to exercise their civic duty. For a researcher, public engagement can improve understanding of public acceptance, social change, and social psychology.

The literature outlines reasons for the attraction of public engagement and presents potential pitfalls. Public engagement can improve trust in public entities (Wynne, 2006) and bolster the legitimacy of incumbent institutions (Pateman, 2012). It can be used to reinforce incumbent approaches instead of creating an opportunity for an institution to develop new policies and approaches (Thorpe & Gregory, 2010; Wynne, 2006). In this way, it can be used to legitimize decisions and not necessarily impact or change their outcome. For instance, according to Pateman, on the topic of participatory democracy, "Ordinary citizens' voices are now being heard very loudly in a number of countries. But the outcome depends on whether anyone is listening; when actual budgets and policies are at stake, political elites rarely listen to citizens" (Pateman, 2012, p. 15). In general, rather than focusing on the outcome of public engagement, the literature has emphasized how it can improve the public engagement process—on the *means* instead of the *ends* (Stilgoe, Lock, & Wilsdon, 2014). The focus on process and not on outcomes is a gap in the literature on public engagement. This gap is concerning because it can be costly to conduct public engagement activities (Kleinman, Delborne, & Anderson, 2011).

Given its intent and aspirations, a key output for public engagement, one might expect, would be policy decisions. In other words, public engagement would factor into government decision- making. However, as shown by Macnaghten and Chilvers in their literature review of public engagement, there is a gap between the aims of those active in public engagement and those of policy actors, who often ignore the results of public consultation (Macnaghten & Chilvers, 2014). For researchers and policymakers, it is essential to address this gap to better understand how to design public engagement processes to most efficiently and effectively impact decision-making. Public engagement can be beneficial to the decision-making process. Beierle and Konisky point out that the quality of decisions is improved by incorporating public engagement and public values into the decision-making process (T. C. Beierle & Konisky, 2001). In their comprehensive book on the topic, Beierle and Cayford synthesize their findings from an extensive survey of public engagement case studies and outline the social value the process has created (T. Beierle & Cayford, 2002). There has also been research on the power dynamics of participants (van Oudheusden, 2011), and the challenge of reaching a consensus or compromise from public engagement (van den Hove, 2006).

In this paper, we address the gap between public engagement and decision-making in the context of DE. Decisions within the electrical sector can create branching off points that could impact low carbon transitions in the future (Rosenbloom, Haley, & Meadowcroft, 2018). Since approximately 70% of the global energy supply is financially supported, in part or full, by government entities, it is essential to understand how public entities impact decision-making (IEA, 2018). DE is an ideal phenomenon to use to analyze the connection between public engagement and decision-making because of the urgency of DE and the social innovations that are occurring around DE. Public engagement will allow the public to play an essential role in this transition, and there is a great benefit to having their perspective included.

6.2. Background

Saskatchewan is a large, mostly rural, province in Canada with a population of 1.1 million, spread over a landmass of 650,000 km^2. The electricity system in Saskatchewan services most of the province. Because of the province's size, billions of dollars are being spent to maintain and upgrade the transmission lines (SaskPower, 2018a). There are 159,000 kilometers of transmission and distribution lines across Saskatchewan, making it a large and dispersed grid (SaskPower, 2018d). Responsibility for the province's electrical system lies with the Saskatchewan Power Corporation (SaskPower), a publicly owned corporation that serves the majority of the population. SaskPower is a vertically-integrated electrical utility, with control over the majority of distribution, transmission, and generation in Saskatchewan. It has relatively limited interconnections with other regions and trades small levels of electricity with neighbouring Manitoba, Alberta, and North Dakota. Unlike the electrical jurisdictions in Europe and most of the United States, the electricity supply is predominately produced within the province.

SaskPower is accountable to the public indirectly through elected representatives in the provincial general elections. The Chief Executive Officer and President of SaskPower are accountable to the Board of Directors. The Chair, representing the Board of Directors, is accountable to the Minister responsible for the corporation, who is selected from elected members of the legislative assembly and occupies a position within the provincial cabinet.

6.2.1. A history of decision-making in SaskPower

SaskPower was incorporated in 1949 with a mandate to centralize the production and distribution of electricity and to electrify the rural areas of the province. Centralization allowed SaskPower to generate electricity using low-cost lignite coal in the southeast of the province and hydroelectric facilities along the Saskatchewan River system. As a publicly owned crown corporation, SaskPower could provide electricity service to rural customers who would otherwise be under-served by private interests (Dolter, 2015; White, 1976).

Throughout the 1950s and early 1960s, SaskPower purchased existing municipal power systems and regional distribution grids. Small, inefficient power plants were closed, and high-voltage lines were built to connect centralized power plants to distant load centres. Economies of scale and low-cost lignite coal allowed SaskPower to offer customers reduced electricity rates. These low rates drove increased electricity demand and led to the rapid growth of the integrated power system. A coal-hydro-crown socio-technical regime was dominant in Saskatchewan until the 1990s[24] (Dolter, 2015; White, 1976).

Beginning in the late 1990s, the province introduced the first public-private partnerships, which represented the first time that SaskPower had looked outside for the development and ownership of power projects. The 2000s were marked by expanded independent power purchase (IPP) agreements and a shift towards natural gas fired power plants and large-scale wind farms. In recent years, the coal-hydro-crown socio-technical regime has being replaced by a gas-wind-IPP socio-technical regime. The logic of centralization remains (Dolter, 2015).

6.2.2. A renewable future for Saskatchewan

Saskatchewan has ambitious plans to increase renewable energy. The province is motivated to reduce emissions, manage future demand growth, respond to federal regulations to phase out coal power, and adapt to current technological advances. Saskatchewan has the highest per capita GHG emissions in Canada (Environment and Climate Change Canada, 2019; Statistics Canada, 2019), and the electricity sector, in particular, is responsible for 19% of GHG emissions in the province (Government of Saskatchewan, 2017). SaskPower and the Government of Saskatchewan have proposals to reduce GHG emissions and increase their renewable energy portfolio with a goal to move toward 50% renewable energy capacity by 2030, a twofold increase in the capacity of renewable energy in the province

[24] A sociotechnical regime involves market preferences, culture, regulations, physical and knowledge infrastructure, or a particular technology, industry, or knowledge (Geels, Kemp, & Dudley, 2012; Martens, 2015). We use the term sociotechnical regime to refer to the technologies of coal-fired and hydro-electricity, the organization of the utility into a publicly owned monopoly, and the centralized nature of the electricity transmission grid.

(Government of Saskatchewan, 2017). While many electric utilities are experiencing demand reductions, SaskPower is experiencing an increase. In the 2017-18 fiscal year, net electricity demand rose by 5.96% relative to 2016-17 (SaskPower, 2018a). Renewables will play an essential role in responding to future electricity demand growth in Saskatchewan.

Part of SaskPower's plan to increase renewable energy generation includes provisions for encouraging investment in solar energy. Solar energy has seen dramatic cost declines along with efficiency improvements in the last decade (Kannan & Vakeesan, 2016). Solar energy is now a large part of the global energy transition. According to the IEA, solar capacity will surpass wind capacity by 2025 and coal capacity by 2040 (IEA, 2018). The world's most populous country, China, has seen significant growth in its installed solar capacity (He & Kammen, 2015). What is more, there is a significant desire by the public in countries around the world to support solar energy policies(Hai, Mekhilef, & Hossain, 2019; Hanger et al., 2016; Sütterlin & Siegrist, 2017). In Saskatchewan, solar irradiance levels in areas in the province are among the highest in the country (Macdougall, Tomosk, & Wright, 2018). SaskPower's solar energy programs make Saskatchewan one of the most attractive locations in which to invest in solar energy (Macdougall et al., 2018).

6.2.3. Self-generation programs in Saskatchewan

In 2017 there were two main self-generation programs offered by SaskPower: *net metering* and the *small power producers* program. The *net metering* program allowed customers to receive credits on their electricity bill for the electricity they produced (SaskPower, 2017d). Self-generating customers could lower the energy component of their bills to zero and bank excess credits for twelve months. The *small power producers* program allowed customers to generate electricity and sell to SaskPower at a fixed rate (SaskPower, 2017d). While self-generation of solar energy represents a small portion of the generation portfolio in Saskatchewan, SaskPower has seen exponential growth in both of these programs and expects the growth to continue (SaskPower, 2017a). However, the sustainability of both programs and of the SaskPower business model are in danger of being disrupted by the growing popularity of solar energy self-generation.

Recognizing the need to proactively improve their self-generation programs, SaskPower hired the two authors of this paper in 2017 to consult stakeholders on the future of solar self-generation programs in Saskatchewan. The results are presented below and in Dolter & Boucher, 2018.

6.3. Methods

6.3.1. Summary

From February of 2017 to March of 2017, we held an in-depth public engagement process to be used in the development of new solar energy programs for SaskPower. This process marked the first time that SaskPower had undertaken an in-depth public engagement process to inform its programs. It was also a departure from previous decision-making approaches used by SaskPower, which had consisted of "typically one-way communication with minimal deliberation"(Martens, 2015, p. 20; Martens et al., 2015).

According to Rowe and Frewer, public engagement involves three domains: "public communication, public consultation, and public participation" (2005, p. 285). Each of these represents the flow of information. For public communication, information is provided to the public. For public consultation, the public provides information. And, finally, for public participation the information exchange is bidirectional. The public engagement process used in this study included variations of all three forms of public engagement. For public communication, SaskPower used information displays on their website to inform the general public of their solar energy programs. For public consultation, online surveys and focus groups were used to obtain information from the public about their perspective on the solar energy programs. For public participation, we were hired to conduct deliberative dialogues with the public and interested stakeholders[25].

Table 6.1

Summary of Engagement Activities for SaskPower's New Solar Energy Programs

Format	Information Flow	Target Group	Public Engagement Type	Goal	Link to Policy Decision Outcome
Information Display on Website	One Way – SaskPower to Public	General public	Public communication	Inform the public about solar energy	Very weak
Online Survey	One Way – Public to SaskPower	General public	Public consultation	Receive general information from the public on solar energy	Weak

[25] For a detail list of stakeholders participants see Dolter & Boucher, 2018.

Focus Groups	One Way – Public to SaskPower	Representation of the general public	Public consultation	Receive in-depth public perspectives on solar energy options	Moderate
Deliberative Dialogue	Two Way – SaskPower to Public to SaskPower	Stakeholders in the solar energy industry	Public participation	Co-develop solar energy programs	Strong

The methods used to conduct each of the engagement activities and to analyze the results are outlined in detail in Dolter & Boucher, 2018 and in Appendix A. In this paper, we include one aspect of the analysis not previously published: an analysis of the perception of barriers to solar energy. We present these results below and ask two questions: 1) Did the revisions to the solar programs address the barriers outlined by stakeholders in the engagement process? 2) How were the results of our public engagement output reflected in the changes made by SaskPower to solar self-generation programs?

6.4. Results

6.4.1. Barriers to Solar

In the deliberative dialogue workshops, we asked participants to list the barriers to solar energy in Saskatchewan. Participants provided a total of 858 distinct responses. These responses were coded and summarized in the categories presented in Table 6.2. Phrases *in italics* represent direct quotes from dialogue participants. We used their direct quotes to create rich descriptions of the themes we identified. Participants provided input on barriers to solar energy in breakout tables at each of the eight workshops we ran. The total number of breakout tables in the public engagement process was 30 (n = 30).

Table 6.2

Barriers to Solar Energy[1]

Barrier	***n***	**Description**
Economic	100% (n=30)	The *cost of solar equipment* is a barrier to solar adoption. Solar customers may not *have access to financing* to overcome the high *upfront costs*. The *payback period* and *return on investment* also serve as barriers since *it's a lot of money to pay upfront when you have to wait so long for any returns*. Solar customers *need a 'top down' rate of return of 10 years* to justify investment. As it stands, *25 years is too long to wait to get your money back. It may also be too soon to invest in solar* given expected improvements to solar technology that may decrease the capital cost. Other costs that serve as barriers include *maintenance*, *insurance*, the *costs of solar upgrading repairs, inverters, and batteries*, and *interconnection costs*.
Education	93% (n=28)	There is a *lack of education about solar, solar development, and paybacks,* and for program success *people need to understand how it all works*. SaskPower could engage in *public education and promotion* to enhance customer understanding of solar. Pro-active education is required to encourage solar program uptake as *SaskPower can't expect people to setup solar if no one knows about it.* Along with public education, SaskPower could invest in *training* to ensure adequate *trained labour to match the anticipated growth* of solar.

Grid Integration	70% (n=21)	There are technical challenges surrounding grid integration of solar generation. The *present grid system* has a *rigidity of structure and lack of flexibility*. This makes it difficult to integrate *intermittent* energy from solar generation. This challenge is exemplified by the *duck curve*. *Gas peaking* plants can help to react to the *ramp-up* of solar energy production, as can electricity *storage*. An improved *east-west grid* would enable a *national policy for energy sharing among provinces*. Conversely*, a move to a broader distributed power grid also has benefits since a decentralized system ensures a more efficient power system*.
Corporate Culture	67% (n=20)	Some stakeholders felt SaskPower's corporate *culture is not supportive of solar*, while others felt there was a *lack of enthusiasm from SaskPower, though there is evidence of change* (e.g. the solar engagement process). Perceptions are influenced by *past active negativity from SaskPower*. This has some people asking, *Is SaskPower the right ambassador for solar?* Or does it face *institutional inertia*, a *lack of openness to change*, *entrenchment* in old business models and *doesn't want competition* from solar producers? To change perceptions of SaskPower, the company needs to *walk the talk* and demonstrate *leadership*. At the moment, staff recognize that *today SaskPower is not a leader* in solar.
Quality Assurance	63% (n=19)	Customers would benefit from *quality control standards* related to solar panels and installers. Potential solar customers worry about the risk of *unqualified contractors/electricians* and *fly-by-night* companies. SaskPower could provide *certification* for installers and products, and provide a *list of installers* so customers know *who to call*. SaskPower can also work to ensure the *safety* of installations by drafting *fire standards*, asking government to legislate *province-wide regulations for safety, code, and fire*, and drafting a *white paper on safety* for installers and customers.
Application Process	60% (n=18)	The current solar application process is *burdensome*, with too much *red tape*. The *slow approval process* may be due to a lack of *internal resources* and the *lack of a one-stop department to handle applications*. A more *streamlined* inspection process, would be possible and applicants could *send in a picture* rather than requiring SaskPower to *send an inspector*.
Customer Service	57% (n=17)	SaskPower needs to *put customers first*. Solar customers and vendors are looking for *collaboration and communication* with SaskPower. They want a *point of contact to 'talk to' about opportunities* but at present there is a *lack of sufficient SaskPower staff who are dedicated to solar transition and service*. This leads to *poor customer service*. One idea to overcome this problem is to have a *dedicated team at SaskPower* on the solar program file.
Negative Perception	50% (n=15)	Some people may not like *how it looks*. To overcome *aesthetic* concerns we should ask *can we make them look good?* Solar may also suffer from negative perceptions that *being green is nutty* and that solar is *seen as a tree hugger thing*. When proposing a solar development there may be *NIMBY* (Not-in-my-backyard) attitudes that reject solar projects, especially if there has been a *lack of community consultation*. Some also worry that *solar installation will impact the resale value of their homes* in a negative fashion.
Missing Synergies	53% (n=16)	When developing programs, SaskPower could explore synergies and take an integrated approach. Programs could incorporate *more energy efficiency goals* and consider *opportunities to combine renewable technologies* like *solar and wind* and *solar for heat production*. The *lack of storage* is a barrier to solar, and *SaskPower could invest in storage and promote Net Metering rebates on storage systems*. This energy storage could be *grid scale*, in *electric vehicles*, or in the form of stored *hydrogen gas*. If storage is installed SaskPower staff felt they *need to be able to control it* to ensure system reliability.
Lack of Accounting for Solar's Full Value	43% (n=13)	If SaskPower conducted *full cost-accounting* of the benefits of solar it would ascribe a higher value for solar electricity. These benefits include *reduction of greenhouse gas emissions*, *grid stability*, *contributing less to transmission losses*, and *investment/job creation for Saskatchewan residents*. The value of solar would also be enhanced with *carbon pricing*. SaskPower could capitalize on solar generation benefits by *spending the same on development of solar as on carbon sequestration*. As it explores solar generation opportunities, *SaskPower should look 5 years ahead for technology* and *remember that costs will continue to drop for solar and storage*.
Regulation	37% (n=11)	To encourage solar, the province needs to *change new building codes to require solar ready homes* and in general create an *energy code* for buildings. Changes are also necessary to the *Cities Act* to enable municipalities to create *property assessed clean energy (PACE)* programs for solar project financing. Federally, there is a need to remove *import tariffs* on solar panels. Generally, there is a concern that if solar increases property values, extra property taxation *would diminish incentives for solar*.
Solar Access	37% (n=11)	Due to *neighborhood orientation*, *inappropriate roof space*, and *solar access of buildings*, *solar is not an option for many people*. Municipalities can *lead the way* on solar by developing a *shadow policy* to protect solar access and carrying out solar-conscious *city planning*.
The Utility's Uncertain Role	30% (n=9)	There are questions surrounding SaskPower's role in the solar space. Is SaskPower *becoming a renewable energy company?* Is SaskPower's role as an electricity *supplier or grid operator*? The *public wants to know SaskPower's plan for solar*, whether it will be pursuing *centralized generation or distributed generation,* and its *future role* in the province.

Notes:

1. In the above table, n indicates the number of workshop tables.

The participants identified a broad range of barriers. The most common barrier noted was *economic*, with 100% (n=30) of workshop tables expressing this concern. Here, participants were predominately concerned with the initial capital investment of solar installations, as well as the overall return-on-investment. As well, contracts for the pre-existing *net metering* program were two years in length, and some stakeholders believed extended contracts would be beneficial to help secure long-term financing for projects.

Education was a concern at 93% of table groups (n=28). Participants wanted SaskPower to take an active role in providing public information about solar energy. Participants felt the programs would see greater success if SaskPower proactively communicated the benefits of solar energy to the public.

Participants acknowledged the grid integration challenges faced by SaskPower; 70% of workshop tables (n=21) indicated that grid integration was a barrier and that the electric grid was not flexible enough to accommodate variable energy sources like solar energy.

Participants also expressed some misgivings about SaskPower's support for solar energy; 67% (n=20) were skeptical of the motives of SaskPower and believed that the corporate culture of the utility was a barrier to solar installation. Participants thought this lack of support helped explain a *burdensome application process* for new solar projects (n=18) and *poor customer service* (n=17) for those pursuing solar self-generation projects.

Participants also wanted SaskPower to take an integrated approach to encouraging solar energy development. This integrated approach would place solar energy within SaskPower's broader GHG emission reduction plans. It would also include consideration of wind energy, energy storage, and electric vehicles. Without an integrated approach *missing synergies* would reduce the value and viability of solar energy.

Participants encouraged SaskPower to *account for solar's full value* (43%; n=13). Participants stressed that solar energy reduces GHG emissions and wanted SaskPower to recognize that explicitly. Carbon pricing was one option noted for ensuring that the value of zero-emissions energy would be reflected in utility decisions.

Participants emphasized barriers that would require major shifts to the current function and practices of SaskPower. Most directly, 30% (n=9) suggested that SaskPower needed to clarify its role in solar energy generation and felt that the *utility's uncertain role* in the future of solar energy was a barrier to solar adoption in the province. Related to this, participants thought the business model of the utility would have to change to adapt to the new technological environment. They expressed a desire for clarity around whether SaskPower sees itself as a grid operator or electricity generator, going forward.

Participants outlined barriers that were out of scope for SaskPower. More than a third (37%; n=11) indicated that ensuring appropriate *solar access* should be a municipal responsibility. A similar percentage (37%; n=11) said *regulations,* like requiring new homes to be solar-ready, would require new provincial legislation.

Along with this list of barriers to solar, we summarized specific changes to solar self-generation programs requested by stakeholders. These changes are shown below in a page extracted from the final report (Dolter & Boucher, 2017).

Figure 6.1

Program Improvement Suggestions

Program Improvements: Workshop Suggestions

Stakeholders offered a range of suggestions on how SaskPower could improve its current solar program offerings. Suggestions for improvements were offered at every table at every external workshop. Here are the most common suggestions for improvements:

1. The *Net Metering* ***contract length is too short*** and could be *changed from 2 to 20 years* to enhance customers' ability to access financing.
2. There is currently *no incentive to over-produce* in the Net Metering program because there is *no payout for leftover credits at the end of the year*. Solar projects could ***get paid for the excess production*** instead of having *Net Metering credits net to zero after 12 months*.
3. There is currently a *lack of virtual Net Metering process*, which means you *can't share with a neighbour* because you *must have solar physically connected to a meter instead of having solar at one location offsetting a meter at another*. This is a problem for farmers who often have *6 meters for 1 operator*. This could be remedied with **a *Virtual Net Metering*** program that would allow ***transferable credits*** and ***virtual billing*** across meters. This could also provide *easier program access for co-ops* and opportunities *for people who cannot install or afford solar.*
4. Currently, SaskPower keeps carbon credits, but the *value of* ***carbon credits*** could be *factored into the price* paid for solar or the credits could be awarded to solar customers.
5. For both Net Metering and the Small Power Producers (SPP) program, the ***100 kW program limit* is *too small*** *for commercial installations* and the cap could be *changed from 100 kW to 1 MW* or removed altogether.
6. As well, SaskPower could ***increase SPP rates at the same rate as retail rate increases*** rather than the current 2% which may be *less than inflation*.
7. In general, investors would benefit from *transparency for the future of solar programs* and a higher degree of ***program certainty and stability***.
8. Municipalities could use ***clarity around timing of new programs*** *to prepare for the new programs; e.g. secure sites, bylaws, community notification, grants*.
9. Lastly, SaskPower would be wise to ***fix programs before promotion***.

37

6.4.2. Summary Report and Changes to SaskPower's Solar Programs

We submitted our report to SaskPower on April 28th, 2017. In the months that followed, several changes were made within SaskPower's organization structure that impacted the response to the report. Our contacts in the utility were a special team of experts from SaskPower tasked with studying the future of solar energy. The team was headed by the Director of Customer Service who also oversaw programs related to energy efficiency. Shortly after our report was submitted, the Director of Customer Service left SaskPower. The internal team of experts that had been assembled to study the future of solar energy went back to positions in their home departments. This delayed the utility's public response to our report.

The stakeholders who had participated in the engagement process expressed concerns to us about the delayed response, asking whether the final report would be made public. SaskPower had committed to making the report public, and this was stated at each engagement workshop. Public publication of the report would allow participants to evaluate whether their views were reflected in the final report. The public engagement process had raised stakeholder expectations, and a delay threatened to erode the goodwill and trust that had been developed over the course of the consultation.

Our engagement summary report was eventually released to the public and posted on SaskPower's website when changes to SaskPower's solar programs were announced approximately a year after the engagement activity. SaskPower made the following changes to the *net metering* and *small power producers* programs (see Table 6.3).

Table 6.3

Pre- and Post-Public Engagement Self-Generation Programs

	Pre-public engagement	**Post-public engagement[1,2]**
Net metering	Capacity limit: 100kW Rate: Credit on bill Credit carryover: Month-to-month for one year Contract term: Two years Installation rebate: 20% to a limit of $20,000.	Capacity limit: 100kW Rate: Credit on bill Credit carryover: Month-to-month for three years Contract term: 10 years Installation rebate: 20% to a limit of $20,000.
Small power producers/power generation partner program[3]	Capacity limit: 100kW Rate: 10.83 cents/kWh Annual rate escalation: 2% Contract term: 20 years Installation rebate: None	Capacity limit: 1MW Rate: 10.83 cents/kWh Annual rate escalation: 0.6% Contract term: 20 years Installation rebate: None

Notes:

1. Source: (SaskPower, 2018c, 2018b).
2. The new solar energy programs were updated approximately a year after the public engagement.
3. The small *power producers program* changed names to the *power generation partner program* after the public engagement.

For the *net metering* program, the contract terms were extended from two years to 10 years. Also, the net metered credits were carried over on a month-to-month basis for a period of three years instead of the previous one year. These changes addressed the first and second program improvements requested by participants (see Figure 1).

For the small *power producers* program (renamed the *power generation partner program*), the eligible nameplate capacity of projects increased from 100kW to 1MW. This change partly addressed the fifth improvement to the programs requested by participants (see Figure 1), although the same change was not made for the *net metering* program.

Deviating from stakeholder requests, the annual rate escalation for projects under the *power producers program* decreased from 2% to 0.6%. Stakeholders had asked that this rate escalate at the same percentage as increases to the retail rate (the sixth request in Figure 1). The lower rate of escalation was likely meant to reduce concerns that the solar self-generation programs were not viable over the long-term and to address concerns about the cross-subsidization of solar projects by non-self-generating customers (see Dolter & Boucher, 2018).

Missing from the new programs was a move towards virtual net metering or net billing (the third program improvement request in Figure 1). Although virtual net metering was discussed throughout the engagement process, this model for net metering was not made available to self-generation customers.

6.5. Discussion

Having gathered feedback on the future of solar energy in Saskatchewan, and with the benefit of now seeing the resulting program changes, we can ask 1) did these program changes respond to stakeholder input? And 2) did the program changes help to overcome the barriers to solar energy identified by stakeholders?

6.5.1. Barriers Addressed by SaskPower

First, we address to what extent the barriers addressed in the stakeholder workshops were addressed by the program changes (see Table 6.4). We found that none of the barriers were fully addressed, most were partially addressed, and three were not addressed at all.

Table 6.4

Barriers addressed by SaskPower

Barrier	Fully addressed[1]	Partially addressed[2]	Not addressed[3]	Comments
Economic		x		Credit carryover increased to 3 years and contract terms increased to 10 years.
Education		x		SaskPower released the Let's Talk Solar Report to the public and made upgrades to their website that provided additional information about solar energy.
Grid Integration		x		The selection process for the newly formed power generation program provides contingencies for solar sites that would be preferable for grid integration purposes.
Corporate Culture		x		Leadership at SaskPower is desirous of more acceptance of solar energy internal to their corporation.
Quality Assurance		x		SaskPower encourages solar vendors to become "efficiency partners", which makes them a provider recognized by the utility. A list of these vendors is provided on SaskPower's website. SaskPower, however, limits the level of quality assurance they provide and notes "SaskPower does not expressly or implicitly guarantee or warrant the work of any Energy Efficiency Partner"(SaskPower, 2019).
Application Process		x		Adjustments were made to the application process. It is not clear whether these changes adequately respond to stakeholder concern.

Customer Service	x		The solar programs reside within Customer Programs and Strategy. It is not clear whether the changes have decreased wait times for the review of solar net metering applications.
Negative Perception	x		SaskPower has made attempts to be more open and public about their renewable energy plans. NIMBYism associated with solar has not been addressed.
Missing Synergies	x		There is consideration being made for novel pilot projects that would integrate solar with a portfolio of other DE technologies. The self-generation programs remain in the Customer Service division and do not reside with the Supply Planning group.
Lack of Accounting for Solar's Full Value	x		The federal government's carbon pricing plan impacts the financial cost of coal- and natural-gas-fired generation plants. SaskPower retains the net metering program which rewards solar energy at the retail price of electricity.
Regulation		x	Many of the suggested regulatory changes would be out of scope for SaskPower.
Solar Access		x	Many of the suggested solar access suggestions were out of scope for SaskPower
The Utility's Uncertain Role		x	This would be outside of the scope for SaskPower and would reside under the authority of the provincially electric representatives.

Notes:

1. Fully addressed means approximately more than 90% of the barriers within the barrier category were addressed.
2. Partially addressed means approximately 10-90% of the barriers within the barrier category were addressed.
3. Not addressed means approximately less than 10% of the of the barriers within the barrier category were addressed.

6.5.2. Maintenance and minor adjustments

The changes made by SaskPower responded directly to program improvement requests presented by stakeholders. During the public engagement, there was much consternation over the short terms of carry over times and contract length for the *net-metering* program. Both of these were adjusted in line with stakeholder feedback generated from the public engagement activities. For the *small power producers* program, the program capacity limit was adjusted upwards to address stakeholder requests, but the annual rate escalation was reduced. However, in general, the changes made to SaskPower's programs were those of maintenance and minor adjustment. The two self-generation programs remained relatively intact with minor revisions. These adjustments do not necessarily adapt SaskPower's system to the disruptive potential of solar energy and DE. Solar energy in both of these programs has seen exponential growth. For the success of solar and DE to continue, maintenance and minor adjustments are likely not enough. SaskPower's preference for minor, incremental change is not unusual. The literature on maintenance is clear: incumbent regimes are resistant to change, and the status quo or minor alterations are typically preferred (Geels & Schot, 2007; Frank W. Geels et al., 2017; Köhler et al., 2019; Smith, 2007). These small changes, including tweaks and adjustments to existing programs, tend to be favoured by public institutions because they present less risk than larger changes.

6.5.3. Integrated approaches

Participants in the engagement sessions identified *missing synergies* as a barrier to solar energy adoption. There was a sense that solar energy needed to be treated in an integrated fashion, incorporating synergistic alignments among technologies, institutions, and levels of government. This approach does not yet appear to have been adopted within SaskPower for small-scale solar projects. Solar self-generation programs are under the direction of the Customer Service branch, which also oversees customer-facing programs related to energy efficiency. An integrated approach would see solar self-generation placed under the direction of Supply Planning, the group that plans and decides on the future of electricity generation for SaskPower. Choosing not to make this change and maintaining the status quo by leaving solar programs under the direction of Customer Service is unlikely to facilitate the shift of DE to a prominent role in the future of electricity in Saskatchewan.

The literature on DE emphasizes the importance of integrated approaches. From a technological perspective, Brandoni et al. argue that DE should be an integrated energy system with the use of a portfolio of technologies that work in tandem (Brandoni, Arteconi, Ciriachi, & Polonara, 2014). As Schulz notes, "Distributed generation refers to a wide range of supply sources and not all of them are necessarily based on renewable energy or carbon-neutral fuels. In general, it refers to plants connected to the distribution network rather than the transmission lines" (2010, p. 14). Additionally, Blanchet has emphasized that DE is best approached as an integrated socio-technical system (Blanchet, 2015).

Size matters for the distributed and small-scale potential applicability of DE and solar energy. The Supply Planning group at SaskPower does integrate consideration of utility-scale solar within its planning domain. SaskPower has contracted with Saturn Power to build a 10 MW solar farm near Swift Current (Zammit, 2019). It has also issued a call for proposals for a second 10 MW solar farm to be built in the province. The scale of solar projects may be a determining factor in whether they are integrated within the larger supply planning framework for SaskPower and utilities in general.

6.5.4. System change

Unlike integrated approaches, system change involves a fundamental rethink of the way business is conducted. A system contains interconnections and often interdependencies between various groups, organizations, and entities (Welbourn, Warwick, Carnall, & Fathers, 2012).

SaskPower developed as a vertically-integrated utility tasked with electrifying a large province with a substantial number of rural communities and farmers. To keep electricity costs low, SaskPower took advantage of economies of scale in power production and focused its earliest efforts on generation using the lignite coal resource in the southeast of the province. This centralized model remains intact, even as SaskPower incorporates a greater number of natural gas electricity generation units and large wind farms onto its grid.

A system change would see SaskPower rethinking the centralized model in the face of new developments in DE technologies. Participants noted that SaskPower's future business model is uncertain. Although questions about SaskPower's future direction were raised in the solar consultations, these questions have not been answered publicly.

6.5.5. Is incrementalism good enough?

The changes SaskPower made to its solar programs were incremental. The construction of the two programs remained the same with minor alterations. SaskPower is not unique in using an incremental approach as public institutions tend to favour incrementalism (Hayes, 2002). The purpose of incremental decision-making by public entities has been to protect the public from the risks that can be associated with ambitious decision-making and potential failure. The thinking is that businesses can fail but governments cannot. Utilities, in particular, have been incremental in their approach, and in the past, incremental decision-making for utilities was effective. Given the urgency and pressure to reshape the electrical grid, however, incrementalism in this way is likely not enough to move the electrical system to adapt to new technological advances and pressures. For example, it has been demonstrated in other jurisdictions that using an overage tariff, which was used as a means to manage the growth of DE, would significantly reduce the overall growth of the solar industry (Comello & Reichelstein, 2016). These, among other examples, illustrate that being overly cautious can work against the overall goals.

Under current circumstances, maintaining the status quo and rejecting new systems and processes is a risk to the utility. One way to minimize this risk when instituting incremental changes is to gain institutional experience and learning in the process. Incrementalism as a decision strategy theory, known as "muddling through," recognizes the intellectual shortcomings people face when confronted with complex decisions (Good, 2011; Lindblom, 1959; Simon, 1955). Proponents of this theory have observed that complex decisions are often not made by sensible and comprehensive analysis but instead are driven by irrational factors. Similar to incrementalism, the work of behavioural economics, notably by Kahneman and Tversky, argues that decision-making is highly influenced by irrational human tendencies. Of particular relevance to muddling through is their work on prospect theory. This theory argues that in decision-making contexts people overvalue loss and undervalue reward (Kahneman & Tversky, 1979). Put another way, people are inclined to take more risks to avoid a loss than take risks to realize a gain. The result of this risk aversion at the institutional level is status quo bias (Kahneman & Lovallo, 1993; Zeckhauser & Samuelson, 1988).

For incrementalism to work it must be directed and overcome status quo bias. Muddling through does not entail a passive approach to policy making, as some have criticized it for (Grandori, 1984). It involves strategically moving towards solving a problem and learning from the causes and effects while they are unfolding. A way to minimize the risk of undirected incremental change is to conduct change experiments. As small changes are implemented, the utility could test more ambitious programs by using pilot projects. Piloting projects is a way to test scenarios and to develop understanding of complex problems and potential solutions (Sanderson, 2002). Such an approach would allow the utility to maintain its preferred incrementalism while testing systemic change. When confronted with complex problems, humans learn from experience and trial-and-error (Woodhouse & Collingridge, 1993). Pilot projects are a means to overcome decision biases. For utilities, this could take the form of microgrid communities, virtual net-metering programs, and supports for storage and EV integration. These pilot options may only have marginal impact on the utility and therefore do not pose significant risk—or perceived risk. Pilot projects could instigate a broader systemic change in the utility if they are successful—perhaps even in the short term.

6.5.6. How can utilities learn from public engagement?

The public engagement process used by SaskPower was novel compared to its previous engagement approaches (Martens, 2015; Martens et al., 2015). In our view, there is a clear connection between the public engagement and the changes made to SaskPower's solar self-generation programs. In other words, SaskPower listened to what stakeholders had to say. The changes made by SaskPower were incremental, and it remains unclear how this engagement meaningfully impacted decision-making on larger issues such as integrating DE technologies into the supply planning process and system change with regards to SaskPower's business model.

Public engagement is an opportunity for policy learning (Holmes, 2011), but a caveat with policy learning is that institutional learning involves adaptation—and a willingness to change. Public institutions, which many utilities are, risk losing decision-making legitimacy if their engagement processes are disconnected from public expectations and stated goals (Bryson et al., 2012). The delay in the release of the engagement report led to skepticism by participating stakeholders and threatened to undermine the legitimacy of the process. The connection between the stakeholder input and the resulting program changes may have alleviated this skepticism to a certain extent.

If SaskPower is to move beyond maintenance and minor adjustments to programs and tackle larger existential questions related to its centralized business model, continued public engagement will be of value. In the extant literature, strong collaboration between actors and stakeholders were noted to be an important part of a transition to DE (Miron, 2014). Complexity issues arise as the system is moved from centralized to decentralized configurations. Local actors, such as municipalities, business, and community partners, are needed to partake in energy systems and planning (Blanchet, 2015; Hawkey, Webb, & Winskel, 2013; Sperling, Hvelplund, & Mathiesen, 2011).

As DE requires new actors to facilitate managing complexity, it may also require new actors to overcome decision biases. Recall our previous discussion on incrementalism and behavioural economics. The tendency toward risk aversion creates status quo bias. This bias can be overcome when decision points and accountability are diffuse amongst actors—risk aversion bias is magnified when there are high levels of accountability placed on one or a few actors (Lerner & Tetlock, 1999; Tetlock & Boettger, 1994). Atkinson pointedly argues that, "abandoning the status quo may look relatively unattractive if the results can be clearly traced to a specific decision-maker" (2011, p. 16). This shouldn't be surprising given that in such a circumstance the perceived risk of loss would be high. Public engagement can provide a logic for change that shifts the burden of accountability away from a single actor.

A practical strategy to manage complexity and status quo bias is co-design, which in a co-production process of policy or programs with stakeholders and institutions. This approach has shown promise at moving forward 'wicked problems' in the public sphere (Bovaird, 2007; Bradwell & Marr, 2008; Voorberg, Bekkers, & Tummers, 2015). A co-design approach built into public engagement may yield some outcomes. Co-design would mean that stakeholders are the agents of change—not the target of change. It may be that our engagement process helped to begin conversations of system change within SaskPower, but for this change to be long-lasting and effective, these conversations may need to carry on publicly throughout the transition period.

6.6. Conclusion

Electric utilities around the world are facing similar challenges to SaskPower. In this regard, Saskatchewan is not unique. Novel public engagement approaches such as that used in this study have promise as the transition to increased DE unfolds. However, more meaningful connections between public engagement and decision-making are needed to overcome barriers and create a representative vision for DE. It is understandable that utilities resist the disruptions DE can cause to their business practices and to the overall functioning of the electrical grid.

Solar energy can be highly disruptive to the functioning of utilities. The energy system is becoming increasingly decentralized, and the expectations are that utilities will find novel ways to think about these problems. Public engagement on DE can begin a conversation on these issues. In this study, public engagement on solar programs evolved into a broader discussion of the role of the utility and the transition to DE. Utilities can respond to public engagement in three ways: (1) maintenance and tweaks, (2) integrated approaches, and (3) system change. We showed that although incrementalism is the favoured approach, both of SaskPower and of other public institutions, alternative approaches can provide a mechanism to move towards the required integrated approaches and system change. We suggest practical approaches such as piloting ambitious programs and co-designing programs.

There are limitations and caveats with the research design used in this study. This was a single case study, and it is difficult to make general claims based on one case. We point out, however, that case study research, although limited, can provide in-depth insights and an opportunity for co-learning. We hope that this research helps to clarify how public engagement can be used to improve decision-making at utilities and also demonstrates the shortcomings of one-time public engagement. While our work helped to improve existing programs, it is not clear that the larger questions we raised made a lasting impact on the utility. Time will tell whether the engagement process can act as the beginning of an on-going conversation on the energy transition in Saskatchewan.

Chapter Seven: Conclusion

Chapter Seven: Conclusion

This dissertation began by asking two research questions related to sustainable innovation, one broadly focused on technology and society, the other more narrowly addressing the need to accelerate change. The dissertation has argued that socially and technologically driven pressures are creating opportunities to observe accelerated social-technical change in action. By observing on-going accelerated transitions, the goal of this dissertation was to further the understanding of the mechanisms of these transitions. To explore the research questions, this dissertation focused on a case study of a particular accelerated transition that is currently unfolding: decentralized energy (DE). To operationalize answering the research questions, comparative research alongside an in-depth case study analysis was conducted. *Chapter Two* discussed the concept of DE and served as an exploratory analysis that was woven throughout the remaining chapters. This exploratory chapter helped inform the comparative work featured in *Chapters Three* and *Four*. For the comparative work, interviews were conducted with experts and stakeholders (n=60) in three countries: Sweden, Canada, and the United States. The in-depth case study analysis of DE focused on public engagement and policy development of solar energy in Saskatchewan, which are featured in *Chapters Five* and *Six*. Because these chapters serve the dual role of dissertation chapters and manuscripts for individualized publication, the five manuscript chapters minimally reference each other. These papers, however, are the result of careful triangulation around the themes of energy justice, acceleration, governance, the MLP, and public engagement. In sum, this work spanned three countries and five cities, involved 60 interviews with experts, included workshops and surveys involving more than 1000 stakeholders, and resulted in five papers (each organized as separate chapters). To bring the dissertation together, this concluding chapter revisits the research questions using the new insights gained from the aggregated contribution of these chapters.

7.1. Research Questions Revisited

Question One: In the context of accelerated social and technical change, is society or technology the driver?

At the beginning of this dissertation, it was argued that social and technical interactions are accelerating change within the energy system. However, some have argued that we are not in a state of accelerated change and that the current transition is not unlike those of the past (Smil, 2016b). I disagree—in part. Although the whole energy system *is* transitioning slowly, one segment of the system is experiencing rapid change and acceleration—(DE), the focus of this dissertation. Pressures to respond to climate change, the public's conviction that "local is better," and a dramatic shift in technological advancement have created an opportunity for social and technical innovation. This socio-technical transition has drivers and barriers that are both socially and technologically oriented. The literature on social-technical sustainability transitions, through frameworks like the Multi-level Perspective (MLP), has established a strong case that there is a co-mingling of dynamics between technology and society (Geels & Schot, 2007; Köhler et al., 2019).

To answer the second part of the question, this section moves from a straightforward response to the more complex issues. In the context of accelerated social and technical change with DE, the observations from this research suggest that it is society that drives this change. Throughout the dissertation, there were examples of DE advanced by social change. What is more, many of the recent examples of DE presented in this dissertation were the result, either wholly or in part, of social innovation. Examples include supportive public policy, collaboration initiatives, business innovations, pilot projects, and more. As a theoretical concept, social innovation is still rather ambiguous, but, in general terms, it refers to creating novel approaches to social change (van der Have & Rubalcaba, 2016). In Anchorage, social innovation was expressed as a need for increased collaboration. In Saskatoon, it was expressed as a strong desire for public policy responses to drive acceleration. In Luleå, the sense was that the recently implemented DE projects were the result of a combination of unique collaboration initiatives and supportive public policy. Of the three cities, Luleå exhibited more examples of acceleration, perhaps due to the entrenched history of cross-sector collaboration. That there are social drivers and impediments to energy transitions is not a novel observation. This understanding has formed the basis of the recent surge of journals, conferences, and research institutes dedicated to advancing an understanding of the social components of energy (D'Agostino et al., 2011; Köhler et al., 2019). Much of this work focuses on the importance of top-down, and often policy-oriented approaches, or the role of social movements and innovation as a mechanism to aggregate momentum. This is best illustrated in the depiction of the MLP as niche and landscape forces placing pressure on the regime.

The work presented in this dissertation suggests that although the locus of acceleration lies with social innovation and collaboration, it also resides within the regime. In fact, the regime can be a potent incubator of acceleration, with regime actors often serving as agents of acceleration. Regime actors possess critical knowledge of obstacles and potential opportunities—such as technical skill, laws and regulations, internal cultural dynamics, and political realities—that can help advance energy transitions forward. Interviews with regime actors suggest that they are motivated to pursue transitions to increased DE. These observations contrast with much of the initial seminal work on sustainability transitions, which depicts a dichotomous and acrimonious relationship between the regime as resistors and the niche as the agents of transition (Geels, 2002). Recent scholarship on regime actors suggests that they can serve an essential role in accelerating transitions (Berggren et al., 2015; Geels, 2019; Geels et al., 2016b). Similarly, the research in this dissertation shows that it is the regime where the dynamics of acceleration reside most prominently. The idea that regime actors can serve as transition accelerators was discussed in *Chapter Four* and analyzed in more detail in *Chapter Five* and *Six*. That there is not necessarily an antagonistic relationship between the regime and the niche is an opportunity to investigate pathways to sustainable transitions that more accurately represent the regime. This dynamic is explored further in answering the second question.

Question Two: How can an understanding of this dynamic be used to further accelerate social and technical change?

Raising the prominence of the regime as a mechanism for accelerated transition has important implications. Based on this conclusion, three insights are highlighted to explain accelerating social and technical change with DE. These insights reflect the perspectives of the author and are based on experiences and observations from the dissertation. They are also an attempt to synthesize the conclusions of the five manuscripts that form this dissertation and draw broader conclusions from these pieces.

Insight One: Unintended Consequences and Energy Justice

There has been a longstanding recognition within the social sciences that there are unanticipated, or unintended, consequences to purposeful action (de Zwart, 2015; Merton, 1936). As a result, non-linear, emergent, and complex adaptive systems—like the unfolding of energy transitions—pose significant challenges to the evaluation of policy (Patton, 2001; Rogers, 2008; Sanderson, 2002). The observations from this dissertation build on this tradition and may serve as a reminder to sustainability transitions scholars of the dynamic feedbacks that exist within energy transitions. This dissertation, for instance, discussed the issue of cross-subsidization and the potentially existential threat it poses to utilities. This issue was explored in detail in *Chapters Five* and *Six*, which showed that in

Saskatchewan embedded fixed costs (e.g., transmission, distribution, and standby power) amount to approximately half of electricity's retail rate. Paying a net-metering program over the marginal cost of electricity created an incremental burden on the utility and, in turn, ratepayers. This creates cross-subsidization.

Unintended consequences can also be positive, which Merton observed by arguing that "undesired effects are not necessarily undesirable" (Merton, 1936). The same financial support for solar energy from SaskPower that created the tension with cross-subsidization also paved the way for opportunities for new actors within the energy system. An industry of solar energy businesses and entrepreneurs is now flourishing, enabling Saskatchewan residents to lower their carbon emissions. This potentially creates feedback within the province, with businesses and residents increasingly motivated to accelerate the energy transition. In *Chapter Five*, in fact, it was shown that stakeholder participants viewed solar energy overwhelmingly positively and saw offshoot benefits previously unknown to the provincial electric utility, SaskPower. The long-term success or failure of DE is contingent on continuously recognizing the unintended consequences of accelerated energy transitions.

The energy justice framework can be a useful tool to interpret, and potentially foresee, unintended consequences. Regime actors, in particular, are often best positioned to be made aware of unintended consequences—both positive and negative. Scholars have observed that in evaluating policy options in adaptive and complex decisions, underlying ethical challenges have unintended consequences (Oliver, Lorenc, & Tinkler, 2019). Building on the exploratory work done in *Chapter Two* on DE and justice, *Chapter Five* used the energy justice approach to analyze a solar energy case study in Saskatchewan. Energy justice is useful as an analytical tool because it can help show the tensions between the different conceptions of justice. In the Saskatchewan case, regime actors within the utility might point out the eventuality of the impacts of cross-subsidization, while regime actors within the municipal public administration might highlight the potentially beneficial unintended consequences of supportive DE policies. The energy justice framework can either show where these tensions lie before they become new roadblocks to sustainability or offer a potential explanation of the tensions causing an unintended consequence. In both cases, the link between energy justice and unintended consequence is an opportunity for further research to advance the understanding of accelerated energy transitions.

Insight Two: A Transformed Role of the State and the Implications to Policy

An implication of this dissertation's overall findings is that revisioning governance and the role of government is essential to accelerate energy transitions. This focus on governance is also supported by an emerging body of research that highlights the significance of governance on urban energy transitions (Hoppe & van Bueren, 2015; Meijer & Bolívar, 2016). Generally understood as the steering activity by government through collective action towards a desired goal or outcome, governance is often stylized as a dichotomy of a hierarchy or market, where actors are seen as part of a top-down or bottom-up orientation (Bevir, 2012). An alternative view, network governance, suggests that a hierarchy-market continuum is too limited, preferring less formalized and reciprocal agreements between actors (Powell, 1990). *Chapter Three* built on this concept, concluding that the interactions of governance dimensions offer a useful interpretation of how energy transitions unfold in the three case studies presented.

The concluding analyses from the later chapters (*Chapters Four, Five, and Six*) suggest that there could be benefits to a transformed role of the state—one that not unlike an interactive form of governance. The literature on interactive governance suggests that there are a variety of ways in which the state and society coordinate to move objectives and outcomes forward (Kooiman, 2016; Torfing, B. Peters, Pierre, & Sørensen, 2012). It emphasizes that although a "steering" role for government still exists, it serves this function as an orchestrator of the bargaining and negotiating between actors, ensuring empowered participation. *Chapter Four* showed that stakeholders with divergent interests can present visions and offer practical suggestions for pathways forward with near-term time horizons (e.g.,10 years). *Chapter Five* suggested approaches to operationalize stakeholder engagement. *Chapter Six* argued that a gap exists between stakeholder engagement and solar energy decision-making in Saskatchewan. This chapter concluded that a more active and accountable role for the state, in this case, the government of Saskatchewan and SaskPower, the publicly owned electric utility, could accelerate the energy transition. This involved role of government is neither "governance without government" or the more traditional conception of state-centred governance. Still the locus of power and authority, the state operates as an involved social change actor that is positioned to respond to complexity (Koppenjan & Klijn, 2004), deal with unintended consequences (as discussed in *Insight One*), and facilitate the acceleration of energy transitions.

In a transformed role of the state, there are direct implications to policy choice and design. Top-down directives for state or market-driven initiatives may not always prove the most useful. *Chapter Three*, for instance, highlighted five governance dimensions with implications for policy choice and design: utility market structure, multi-sector cooperation, decision-making autonomy and capacity, multilevel governance, and public perceptions of climate change. When policies were proposed, in *Chapters Three* and *Four*, they typically played a facilitating role, such as Property Assessed Clean Energy (PACE), carbon taxes, and transmission power pool agreements. The implications of interactive governance go beyond policy choice: the process of policy development and implementation are also impacted. Discussions about how and why actors are involved with the policy process were woven through this dissertation. *Chapters Five* and *Six* analyzed how stakeholders were engaged in a process of solar energy policy development. Both of these chapters concluded that the manner of incorporating public perspectives, emphasizing due process and good governance, impacts the policy process. Specially, *Chapter Five* suggested that stakeholder engagement could be institutionalized through a mechanism similar to the Saskatchewan Rate Review Panel. This process of policy feedback would maintain accountability by the state, enhancing energy justice through advancing due process and good governance. *Chapter Six*, again, argued for a more meaningful link between public engagement activities and decision-making. To address this link, the chapter concluded with practical suggestions for policy development and implementation, such as pilot projects and co-design. Similar examples in the academic literature on interactive policy designs include government-affiliated intermediary organizations (Kivimaa, 2014), state actor-social movement coalitions (Stearns & Almeida, 2004), urban experiments (Bulkeley & Castán Broto, 2013), and citizen-generated local development initiatives (Healey, 2015).

Insight Three: Drawings Lessons from Comparative Research

Drawing international lessons are essential to further the understanding of accelerating energy transitions. Despite the attempt to generalize throughout this dissertation, there is no one-size-fits-all approach to DE. Throughout the chapters, lessons were drawn across jurisdictions based on their observed governance dimensions. The use of governance comparisons as an approach to draw lessons is supported in the literature (Peters, 2014). Peters, for instance, has argued that "[o]ne of the virtues of using governance as an approach to comparative politics is that it is applicable in a wide range of cases"(Peters, 2014, p. 302). The two comparative chapters (*Chapters Three* and *Four*) provided insights on governance and regime dynamics that demonstrate the uniqueness of DE transitions and opportunities for considered generalizations. There remains an opportunity for comparative research on cases for energy transitions. Much of this comparative work falls under two ends of a spectrum: as broad comparisons of political systems or as highly specific comparisons of projects.

Missing are comparisons that lie in the middle—at the level of policy sectors, jurisdiction types, governments, and systems. The challenge of mid-range approaches to comparative work is the boundaries required to facilitate this kind of analysis. Governance dimensions—employed in *Chapter Three*, and in particular their interactions—are worth considering for further comparative work. A focus on governance interactions can lead to further questions. For instance, to what extent does the interaction between public perceptions of climate change and multi-sector collaboration facilitate DE transitions? Are policy communities more effective at facilitating DE transitions in regulated or deregulated utility markets? How much does city level autonomy and capacity impact DE transitions when there is strong support from higher-level governments? These questions, among others, that focus on the interactions of governance dimensions can be explored to offer further insights into the conditions that facilitate DE transitions. The MLP, as a meta-theory of sustainable transitions, provides a potential framework: by comparing each MLP level (niche, regime, and landscape) or between levels.

7.2. Limitations of Contributions

Research limitations have been previously discussed in each manuscript chapter. This section discusses more general limitations concerning the conclusions of this dissertation. In general, the strength of the interdisciplinary approach undertaken in this dissertation is also a source of weakness. It was necessary to generalize to operationalize the arguments throughout this dissertation. Terms like the MLP, energy justice, governance, acceleration, and decentralized energy were also useful to present arguments but, at times, at the expense of precision.

For the comparative chapters (*Chapters Three* and *Four*), the research involved only three cases, and therefore, it is challenging to make generalizable claims. Ragin has presented a caveat for such instances, arguing that "case-oriented researchers are always open to the charge that their findings are specific to the few cases they examine, and when they do make broad comparisons and attempt to generalize, they often are accused of letting their favorite cases shape or at least color their generalizations"(Ragin, 2014, p. *ix*). Although I was cautious not to fall victim to Ragin's caveat of favouritism bias, there were a limited number of cases, and, therefore, the major claims in this analysis leave it open to understandable scrutiny. The claims presented in this analysis should be considered a starting place for further inquiry on the question of comparative research on urban energy transitions and governance. For the two chapters on the solar case study (*Chapters Five* and *Six*), there are limitations and caveats with the research design used in this study. This was a single case study, and, again, it is difficult to make general claims based on one case. Electrical utilities vary greatly from country to country, and careful attention must be paid when drawing lessons from case study research.

7.3. Postscript to My Sons

As I conclude this dissertation with final remarks to my sons, I consider the practical implications of what I have learned on this journey. I will end with a personal reflection of my general sense of the future direction of the energy system, unencumbered of the boundaries of academic theories, the constraints of research methods, and the high standards of evidence required in academic writing.

To start, I don't know what the future holds. In the relatively short period of this dissertation, I have seen solar generation costs drop by 60% and wind costs by 30%. In 2014, when I began my dissertation, solar and wind were heralded as "too expensive," and the sense at that time was that we would have to wait a long time for prices to drop—perhaps even decades. The forecasters were wrong. Now, the problem seems to be that these technologies are too cheap and will impose a painful economic impact on utility companies. Since I submitted the papers in this dissertation, SaskPower has announced a dramatic rollback of its solar net-metering program, emphasizing concern over the exponential uptake of solar installations in the province and the burden to its bottom line and cost to consumers. In five years, solar has moved from an expensive marginal technology to a potential disruptor to the electrical utilities. Solar is not alone. Innovative energy technologies are surging as businesses pursue cost reductions and seek new ways to solve old problems within the energy system. Frankly, I can hardly keep up with the pace of technological change, and I am more than a little skeptical of anyone who claims otherwise. There are many examples of technological innovation: solar thermal has made significant efficiency gains; battery technology costs are on the decline; experiments with blockchain have shown some potential; Small Modular Reactors are attracting increasing investment; net-zero housing is becoming normalized so that some municipalities have adopted building codes to achieve this standard; microgrid deployments are on the rise across the world; and transnational grids are proliferating.

There are more energy options and ways of deploying energy solutions than at any time in history. Given the potential of this technology, why do we persist with the same thinking about our energy system? In the past, for instance, the most popular energy option was more often than not the cheapest, safest, most reliable, and most convenient. We now have a portfolio of technologies that can meet this mix of requirements and serve our needs. Knowing there are fewer technological limitations, I would tell my sons that they have an opportunity to engage in the energy future in a more meaningful way than at any time in history. No longer bystanders to the whims of innovation, people will drive this energy transition. New and exciting technologies will come and go, but what will persist is a core of values in how energy decisions are made and which innovations are pursued. I will tell my sons that they should not pursue innovation for its own sake. Although pursuing innovation in this way can be constructive, it is perhaps time to focus on the higher pursuits of justice and values.

We live in a time of stark contrasts: we have abundance, yet we are dissatisfied; we have the opportunity to live long lives, yet we are unhealthy; we have technology that can afford us great convenience, yet we feel overwhelmed and overworked. These contrasts point to a more significant issue embedded in society: the need for direction. The energy system is no different. It will be incumbent on my sons' generation to forge a world out of their sense of values. Within the current constraints and opportunities, what will be the purpose of the energy system? Whom will it serve? How will it move the world forward? I will tell my sons that the future energy system is unknown—because they have yet to create it.

Appendix: Summary of Public Engagement Activities

Online Surveys

The purpose of the online surveys was to obtain broad information on the public sentiment towards solar energy and potential perspectives on solar energy programs in Saskatchewan. The online surveys were prepared and administered by SaskPower. We were provided the data for the analysis. A limitation of this approach was that the participants were not necessarily representative of the general public and participants would likely self-select themselves for the survey. On this basis, we make no claims to the statistical representation of the analysis. Summary data from the surveys can instead be used to provide a course analysis of the perspectives of the public. There were two components of the online surveys: public and internal.

1. **Public Survey**: A public survey was administered via the SaskPower website and members of the public were permitted to comment and provide feedback through the online portal. There was a total of 625 responses for the public survey.
2. **Internal Survey**: An internal survey was administered, and SaskPower staff were to voluntarily complete the survey. The content of this survey was similar to that of the public survey. There was a total of 261 responses for the internal survey.

Focus Groups

Focus groups were used to garner public opinion on the barriers, principals, and details on the existing solar program. There was a total of six focus groups, each consisting of 7-8 invited representatives of the public and business community who indicated some degree of interest in solar generation. The purpose was to establish more an in-depth perspective than that of the online surveys and have a less partial perspective than that of the deliberative dialogues. Focus group participants were representative of the general population by demographic indicators such as age, gender, and income. There were two sections of focus groups: general public and businesses. The focus groups were conducted by Insightrix Research where we observed the focus groups themselves and reviewed the results from Insightrix Research.

Deliberative Dialogue Workshops

In this paper, we examined whether a deliberative dialogue process impacts decision-making. This work on deliberative dialogues in energy policy builds on previous research conducted (Hindmarsh & Matthews, 2008; van de Kerkhof, 2006). In a previous paper published in Applied Energy we outlined the details of the workshop methods. For more details about the methods used for the deliberative dialogue we refer you to our previous publication (Dolter & Boucher, 2018).

References

Abdmouleh, Z., Gastli, A., & Ben-Brahim, L. (2018). Survey about public perception regarding smart grid, energy efficiency & renewable energies applications in Qatar. *Renewable and Sustainable Energy Reviews*, *82*(1), 168–175.

Adil, A. M., & Ko, Y. (2016). Socio-technical evolution of Decentralized Energy Systems: A critical review and implications for urban planning and policy. *Renewable and Sustainable Energy Reviews*, *57*, 1025–1037. https://doi.org/10.1016/j.rser.2015.12.079

Aiken, G. (2012). Community Transitions to Low Carbon Futures in the Transition Towns Network (TTN). *Geography Compass*, *6*(2), 89–99. https://doi.org/10.1111/j.1749-8198.2011.00475.x

Akorede, M. F., Hizam, H., & Pouresmaeil, E. (2010). Distributed energy resources and benefits to the environment. *Renewable and Sustainable Energy Reviews*, *14*(2), 724–734. https://doi.org/10.1016/j.rser.2009.10.025

Alanne, K., & Saari, A. (2006a). Distributed energy generation and sustainable development. *Renewable and Sustainable Energy Reviews*, *10*(6), 539–558. https://doi.org/10.1016/j.rser.2004.11.004

Alanne, K., & Saari, A. (2006b). Distributed energy generation and sustainable development. *Renewable and Sustainable Energy Reviews*, *10*(6), 539–558. https://doi.org/10.1016/j.rser.2004.11.004

Alanne, K., & Saari, A. (2006c). Distributed energy generation and sustainable development. *Renewable and Sustainable Energy Reviews*, *10*(6), 539–558. https://doi.org/10.1016/j.rser.2004.11.004

Alaska Department of Revenue. (2017). *Production History and Forecast by Production Area from Fall 2017 RSB*.

Alaska Housing Finance Corporation. (2018). *Goal Program: Rating and Award Criteria Plan*.

Alaska Public Utilities Commission. (1998). *Power Pooling/ Central dispatch Planning Study* (Vol. U-97-140). Retrieved from http://rca.alaska.gov/RCAWeb/Documents/Electric/PowerPooling.pdf

Aldiabat, K. M., & Le Navenec, C.-L. (2018). Data Saturation: The Mysterious Step in Grounded Theory Methodology. *The Qualitative Report*, *23*(1), 245–261.

Ambec, S., & Crampes, C. (2012). Electricity provision with intermittent sources of energy. *Resource and Energy Economics*, *34*(3), 319–336. https://doi.org/10.1016/j.reseneeco.2012.01.001

Amended and Restated Alaska Intertie Agreement. (2011). Retrieved from https://www.sec.gov/Archives/edgar/data/878004/000119312512123010/d317480dex10151.htm

Anchorage Climate Action Plan. (2019). *Municipality of Anchorage*. https://doi.org/10.5860/choice.46-0890

Andrews, R., Boyne, G. A., & Andrews, R. (2016). Capacity, Leadership, and Organizational Performance: Testing the Black Box Model of Public Management Published. *Public Administration Review 70(3) 443-454*, *70*(3), 443–454.

Annink, A. (2016). Using the Research Journal Qualitative Data Collection in a Cross-Cultural Context. *Entrepreneurship Research Journal*, *7*(1). https://doi.org/10.1515/erj-2015-0063

Arendt, H. (1958). *The Human Condition* (Second Edi). University of Chicago Press.

Arruda, G. (Ed.). (2018). *Renewable Energy in the Arctic: New Perspectives* (1st ed.). Routledge.

Atkinson, M. M. (2011). Lindblom's lament: Incrementalism and the persistent pull of the status quo. *Policy and Society*, *30*(1), 9–18. https://doi.org/10.1016/j.polsoc.2010.12.002

Atzeni, I., Ordóñez, L. G., Scutari, G., Member, S., Palomar, D. P., & Fonollosa, J. R. (2013). Demand-Side Management via Distributed Energy Generation and Storage Optimization. *IEEE Transactions on Smart Grid*, *4*(2), 866–876.

Aunphattanasilp, C. (2018). From decentralization to re-nationalization: Energy policy networks and energy agenda setting in Thailand (1987–2017). *Energy Policy*. https://doi.org/10.1016/j.enpol.2018.06.006

Baker, S., Waterfield, J., & Bartlam, B. (2018). Saturation in qualitative research: exploring its conceptualization and operationalization. *Quality and Quantity*, *52*(4), 1893–1907.

Bakke, G. (2016). *The Grid: The Fraying Wires Between Americans and Our Energy Future*. New York: Bloomsbury Publishing.

Bardose, G., & Darghouth, N. (2017). *Tracking the Sun 10: The Installed Price of Residential and Non-Residential Photovoltaic Systems in the United States*. Retrieved from https://emp.lbl.gov/sites/default/files/tracking_the_sun_10_report.pdf

Bayulgen, O. (2020). Localizing the energy transition: Town-level political and socio-economic drivers of clean energy in the United States. *Energy Research and Social Science*, *62*(January 2019). https://doi.org/10.1016/j.erss.2019.101376

Bazmi, A. A., Zahedi, G., & Hashim, H. (2011). Progress and challenges in utilization of palm oil biomass as fuel for decentralized electricity generation. *Renewable and Sustainable Energy Reviews*, *15*, 574–583. https://doi.org/10.1016/j.rser.2010.09.031

Beierle, T. C., & Konisky, D. M. (2001). What are we gaining from stakeholder involvement? Observations from environmental planning in the Great Lakes. *Environment and Planning C: Government and Policy*, *19*(4), 515–527. https://doi.org/10.1068/c5s

Beierle, T., & Cayford, J. (2002). *Democracy in Practice: Public Particpation in Environmental Decisions*.

Washington: Resouces for the Future.

Bell, S., & Feng, H. (2014). How proximate and “meta-institutional” contexts shape institutional change: Explaining the rise of the People’s Bank of China. *Political Studies*, *62*(1), 197–215. https://doi.org/10.1111/1467-9248.12005

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., & Rickne, A. (2008). Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. *Research Policy*, *37*(3), 407–429. https://doi.org/10.1016/j.respol.2007.12.003

Berggren, C., Magnusson, T., & Sushandoyo, D. (2015). Transition pathways revisited: Established firms as multi-level actors in the heavy vehicle industry. *Research Policy*, *44*(5), 1017–1028. https://doi.org/10.1016/j.respol.2014.11.009

Berman, M., & Orttung, R. W. (2020). Measuring Progress toward Urban Sustainability: Do Global Measures Work for Arctic Cities? *Sustainability*, *12*(9), 3708. https://doi.org/10.3390/su12093708

Betsill, M., & Bulkeley, H. (2004). Transnational Networks and Global Environmental Governance : The Cities for Climate Protection Program. *International Studies Quarterly*, *48*(2), 471–493.

Betsill, M., & Bulkeley, H. (2007). Looking Back and Thinking Ahead: A Decade of Cities and Climate Change Research. *Local Environment*, *12*(5), 447–456. https://doi.org/10.1080/13549830701659683

Bevir, M. (2012). *Governance: A Very Short Introduction*. Oxford: Oxford University Press.

Blanchet, T. (2015). Struggle over energy transition in Berlin: How do grassroots initiatives affect local energy policy-making? *Energy Policy*, *78*, 246–254. https://doi.org/10.1016/j.enpol.2014.11.001

Block, E. S., & Erskine, L. (2012). Interviewing by Telephone: Specific Considerations, Opportunities, and Challenges. *International Journal of Qualitative Methods*, *11*(4), 428–445.

Blomgren, L., Nabatchi, T., & Leary, R. O. (2005). The New Governance - Practices and Processes for Stakeholder and Citizen Participation in the Work of Government. *Public Administration Review*, *65*(5), 547–558.

Bomberg, E., & McEwen, N. (2012). Mobilizing community energy. *Energy Policy*, *51*, 435–444. https://doi.org/10.1016/j.enpol.2012.08.045

Bosman, R., Loorbach, D., Frantzeskaki, N., & Pistorius, T. (2014). Discursive regime dynamics in the Dutch energy transition. *Environmental Innovation and Societal Transitions*, 1–15. https://doi.org/10.1016/j.eist.2014.07.003

Boucher, M. (2016). Decentralized Energy: Prospects, Justice, and Transition. *Energy Research & Social Science*, *11*, 288–293.

Boucher, M. (2020). Governance and decentralized energy transitions: a comparative case study of three medium sized cities in Sweden, Canada, and the United States. *Central European Review of Economics and Management*, *4*(1).

Bouffard, F., & Kirschen, D. S. (2008). Centralised and distributed electricity systems. *Energy Policy*, *36*(12), 4504–4508. https://doi.org/10.1016/j.enpol.2008.09.060

Bovaird, T. (2007). Beyond Engagement and Participation: User and Community Coproduction of Public Services. *Public Administration Review*, (October).

BP. (2019). *Statistical Review of World Energy*.

Bradwell, P., & Marr, S. (2008). *Making the most of collaboration: an international survey of public service co-design*. *Demos Report 23*. London: Price Waterhouse Coopers.

Brandoni, C., Arteconi, A., Ciriachi, G., & Polonara, F. (2014). Assessing the impact of micro-generation technologies on local sustainability. *Energy Conversion and Management*, *87*, 1281–1290. https://doi.org/10.1016/j.enconman.2014.04.070

Breyer, C., Bogdanov, D., Aghahosseini, A., Gulagi, A., Child, M., Oyewo, A. S., … Vainikka, P. (2018). Solar photovoltaics demand for the global energy transition in the power sector. *Progress in Photovoltaics: Research and Applications*, *26*(8), 505–523. https://doi.org/10.1002/pip.2950

Brikland, T. A. (1998). Focusing Events, Mobilization, and Agenda Setting. *Journal of Public Policy*, *18*(1), 53–74. https://doi.org/10.1017/S0143814X98000038

Bryson, J. M., Quick, K. S., & Crosby, B. C. (2012). Designing Public Participation Processes. *Public Administration Review*, *73*(1), 23–34. https://doi.org/10.111/j.1540-6210.2012.02678.x.Designing

Bulkeley, H., & Castán Broto, V. (2013). Government by experiment? Global cities and the governing of climate change. *Transactions of the Institute of British Geographers*, *38*(3), 361–375. https://doi.org/10.1111/j.1475-5661.2012.00535.x

Bulkeley, H., & Metsill, M. M. (2003). *Cities and Climate Change: Urban Sustainability and Global Environmental Governance*. New York: Routledge.

Burger, C., & Weinmann, J. (2013). *The Decentralized Energy Revolution: Business Strategies for a New Paradigm*. New York: Palgrave Macmillan.

Burke, M. J., & Stephens, J. C. (2018). Political power and renewable energy futures: A critical review. *Energy Research and Social Science*. https://doi.org/10.1016/j.erss.2017.10.018

Byrne, D. (2005). Complexity, configurations and cases. *Theory, Culture and Society*, *22*(5), 95–111. https://doi.org/10.1177/0263276405057194

Carl, A. F., & Silverstein, L. B. (2003). *Qualitative data: An introduction to Coding and Analysis*. New York:

New York University Press.

Carl, J. (2013). *Distributed Power in the United States: Prospects and Policies*. Stanford: Hoover Institution Press.

Carley, S. (2009). State renewable energy electricity policies: An empirical evaluation of effectiveness. *Energy Policy*, *37*(8), 3071–3081. https://doi.org/10.1016/j.enpol.2009.03.062

Casey, J. (2018). Peer-to-peer energy trading in prospect, *298*(7894), p.14. Retrieved from http://web.a.ebscohost.com.ezproxy.hwr-berlin.de:2048/ehost/resultsadvanced?vid=23&sid=61d89687-f6a7-4d42-a8a9-e07f21170e0d%40sessionmgr4007&bquery=(blockchain+applications)+AND+(AU+Casey)&bdata=JmRiPWJzdSZ0eXBlPTEmc2l0ZT1laG9zdC1saXZlJnNjb3BlPXNpdGU%3D

Chabrol, M. (2016). Re-examining historical energy transitions and urban systems in Europe. *Energy Research and Social Science*, *13*, 194–201. https://doi.org/10.1016/j.erss.2015.12.017

Chen, H., Ooka, R., Iwamura, K., Huang, H., Yoshizawa, N., Miisho, K., … Tanaka, S. (2008). Study on sustainable redevelopment of a densely built-up area in Tokyo by introducing a distributed local energy supply system. *Energy and Buildings*, *40*(5), 782–792. https://doi.org/10.1016/j.enbuild.2007.05.012

Chilvers, J., Pallett, H., & Hargreaves, T. (2018). Ecologies of participation in socio-technical change: The case of energy system transitions. *Energy Research and Social Science*, *42*, 199–210. https://doi.org/10.1016/j.erss.2018.03.020

Chittum, A., & Østergaard, P. A. (2014). How Danish communal heat planning empowers municipalities and benefits individual consumers. *Energy Policy*, *74*(C), 465–474. https://doi.org/10.1016/j.enpol.2014.08.001

Christopoulos, D. (2015). Exceptional or just well connected ? Political entrepreneurs and brokers in policy making, (December 2014), 475–498. https://doi.org/10.1017/S1755773914000277

City of Saskatoon. (2014). *2014 Saskatoon Greenhouse Gas Emissions Inventory*. Retrieved from https://www.saskatoon.ca/sites/default/files/documents/corporate-performance/environmental-corporate-initiatives/2014_saskatoon_greenhouse_gas_emissions_inventory.pdf

City of Saskatoon. (2017). *Facilitating Solar Energy Opportunities in Saskatoon*.

Clark, W., & Isherwood, W. (2004). Distributed generation: Remote power systems with advanced storage technologies. *Energy Policy*, *32*, 1573–1589. https://doi.org/10.1016/S0301-4215(03)00017-X

Coaffee, J. (2008). Risk, resilience, and environmentally sustainable cities. *Energy Policy*, *36*(12), 4633–

4638. https://doi.org/10.1016/j.enpol.2008.09.048

Comello, S., & Reichelstein, S. (2016). Cost Competitiveness of Residential Solar PV. *Renewable and Sustainable Energy Reviews*, *75*(May 2016), 46–57.

Compact of Mayors. (2015). Compact of Mayors. https://doi.org/10.1017/CBO9781107415324.004

Company, A. T. (2019). Railbely utilities seek regulatory approval to form transmission utility. https://doi.org/10.1002/pfi.4180070909

Corner, A., Markowitz, E., & Pidgeon, N. (2014). Public engagement with climate change: The role of human values. *Wiley Interdisciplinary Reviews: Climate Change*, *5*(3), 411–422. https://doi.org/10.1002/wcc.269

Crutzen, P., & Stoermer, E. (2000). The Anthropocene. *Global Change Newsletter*, *May*(41), 17–18.

Curtin, J., Mcinerney, C., Gallachóir, B. Ó., & Salm, S. (2019). Energy Research & Social Science Energizing local communities — What motivates Irish citizens to invest in distributed renewables ? ☆. *Energy Research & Social Science*, *48*, 177–188.

D'Agostino, A. L., Sovacool, B. K., Trott, K., Ramos, C. R., Saleem, S., & Ong, Y. (2011). What's the state of energy studies research?: A content analysis of three leading journals from 1999 to 2008. *Energy*, *36*(1), 508–519. https://doi.org/10.1016/j.energy.2010.10.013

Daschuk, J. (2013). *Clearing the Plains: Disease, Politics of Starvation, and the Loss of Aboriginal Life.* Regina, SK: University of Regina Press.

de Zwart, F. (2015). Unintended but not unanticipated consequences. *Theory and Society*, *44*(3), 283–297. https://doi.org/10.1007/s11186-015-9247-6

Deerstone Consulting; Crimp Energy Consulting. (2016). *Anchorage Energy Landscape and Opportunities*.

Delina, L. L. (2018). Energy democracy in a continuum: Remaking public engagement on energy transitions in Thailand. *Energy Research and Social Science*, *42*(October 2017), 53–60. https://doi.org/10.1016/j.erss.2018.03.008

Delmas, M., Russo, M. V., & Montes-Sancho, M. J. (2007). Deregulation and environmental differentiation in the electric utility industry. *Strategic Management Journal*, *28*(2), 189–209. https://doi.org/10.1002/smj.578

Devine-Wright, P. (2011). Public engagement with large-scale renewable energy technologies: Breaking the cycle of NIMBYism. *Wiley Interdisciplinary Reviews: Climate Change*, *2*(1), 19–26. https://doi.org/10.1002/wcc.89

Dolter, B., & Boucher, M. J. (2017). *"Let's Talk Solar" Final Report*. Retrieved from file:///Users/martinboucher/Downloads/Report-SolarTaskForce (3).pdf

Dolter, Brett D., & Boucher, M. (2018). Solar energy justice: A case-study analysis of Saskatchewan, Canada. *Applied Energy*, *225*(October 2017), 221–232. https://doi.org/10.1016/j.apenergy.2018.04.088

Dolter, Brett David. (2015). *Greening the Saskatchewan Grid*.

Dooley, J. J. (1998). Unintended consequences: energy R&D in a deregulated energy market. *Energy Policy*, *26*(7), 547–555.

Droege, P. (2002). Renewable Energy and the City: Urban Life in an Age of Fossil Fuel Depletion and Climate Change. *Bulletin of Science, Technology & Society*, *22*(2), 87–99. https://doi.org/10.1177/0270467602022002003

Dryzek, J. S. (2002). Deliberative Democracy and Beyond. *Oxford Scholarship Online*, (March 2015), 1–12. https://doi.org/10.1093/019925043X.001.0001

Dryzek, J. S. (2010). *Foundation and Frontiers of Deliberative Governance*. *Oxford University Press*. https://doi.org/10.1093/acprof

Dubey, S., Sarvaiya, J. N., & Seshadri, B. (2013). Temperature dependent photovoltaic (PV) efficiency and its effect on PV production in the world - A review. *Energy Procedia*, *33*, 311–321. https://doi.org/10.1016/j.egypro.2013.05.072

Ediger, V. Ş., Kirkil, G., Çelebi, E., Ucal, M., & Kentmen-Çin, Ç. (2018). Turkish public preferences for energy. *Energy Policy*, *120*(September), 492–502.

Edwards, P. B., Hindmarsh, R., Mercer, H., Bond, M., & Rowland, A. (2008). A three-stage evaluation of a deliberative event on climate change and transforming energy. *Journal of Public Deliberation*, *4*(1), 6. Retrieved from http://www.publicdeliberation.net/jpd/vol4/iss1/art6/

Ehnert, F., Kern, F., Borgström, S., Gorissen, L., Maschmeyer, S., & Egermann, M. (2018). Urban sustainability transitions in a context of multi-level governance: A comparison of four European states. *Environmental Innovation and Societal Transitions*, *26*(March), 101–116. https://doi.org/10.1016/j.eist.2017.05.002

Emerson, R. M. (1962). Power-Dependence Relations. *American Sociological Association*, *27*(1), 31–41.

Environment and Climate Change Canada. (2019). *National Inventory Report 1990-2017: Greenhouse Gas Sources and Sinks in Canada*. Ottawa, ON. Retrieved from https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/inventory.html

Environment Canada. (2014). National Inventory Report 1990-2012: Greenhouse Gas Sources and Sinks in Canada. Ottawa, ON: The Canadian Government's Submission to the UN Framework Convention on Climate Change.

Ercan, S. A., & Dryzek, J. S. (2015). The reach of deliberative democracy. *Policy Studies*, *36*(3), 241–248. https://doi.org/10.1080/01442872.2015.1065969

European Environmental Agency. (2015). *Euroheat and Power (2015). District Heating and Cooling country by country Survey 2015.* Retrieved from http://www.euroheat.org/wp-content/uploads/2016/03/2015-Country-by-country-Statistics-Overview.pdf%0A

Faber, I., Lane, W., Pak, W., Prakel, M., Rocha, C., & Farr, J. V. (2014). Micro-energy markets: The role of a consumer preference pricing strategy on microgrid energy investment. *Energy*, *74*, 567–575. https://doi.org/10.1016/j.energy.2014.07.022

Feldman, L., & Hart, P. S. (2018). Climate change as a polarizing cue: Framing effects on public support for low-carbon energy policies. *Global Environmental Change*, *51*(April), 54–66. https://doi.org/10.1016/j.gloenvcha.2018.05.004

Florini, A., & Sovacool, B. K. (2009). Who governs energy? The challenges facing global energy governance. *Energy Policy*, *37*(12), 5239–5248. https://doi.org/10.1016/j.enpol.2009.07.039

Fonseca, J. A., & Schlueter, A. (2013). Novel approach for decentralized energy supply and energy storage of tall buildings in Latin America based on renewable energy sources: Case study - Informal vertical community Torre David, Caracas - Venezuela. *Energy*, *53*, 93–105. https://doi.org/10.1016/j.energy.2013.02.019

Ford, A. (1997). System Dynamics and the Electric Power Industry. *System Dynamics Review*, *13*(1), 57–85. https://doi.org/10.1002/(SICI)1099-1727(199721)13:1<57::AID-SDR117>3.0.CO;2-B

Fossey, E., Harvey, C., Mcdermott, F., & Davidson, L. (2002). Understanding and evaluation qualitative research. *Australian and New Zealand Journal of Psychiatry*, *36*, 717–732.

Fouquet, R. (2010). The slow search for solutions: Lessons from historical energy transitions by sector and service. *Energy Policy*, *38*(11), 6586–6596. https://doi.org/10.1016/j.enpol.2010.06.029

Fouquet, R. (2016). Historical energy transitions: Speed, prices and system transformation. *Energy Research & Social Science*, *22*, 7–12. https://doi.org/10.1016/j.erss.2016.08.014

Fouquet, R., & Pearson, P. J. G. (2012). Past and prospective energy transitions: Insights from history. *Energy Policy*, *50*, 1–7. https://doi.org/10.1016/j.enpol.2012.08.014

Fraune, C., & Knodt, M. (2017). Challenges of Citizen Participation in Infrastructure Policy-Making in Multi-Level Systems—The Case of Onshore Wind Energy Expansion in Germany. *European Policy Analysis*, *3*(2), 256–273. https://doi.org/10.1002/epa2.1022

Gallo, A. B., Simões-Moreira, J. R., Costa, H. K. M., Santos, M. M., & Moutinho dos Santos, E. (2016).

Energy storage in the energy transition context: A technology review. *Renewable and Sustainable Energy Reviews*, *65*, 800–822. https://doi.org/10.1016/j.rser.2016.07.028

Gargan, J. J. (1981). Consideration of Local Government Capacity. *Public Administration Review*, *41*(6), 649–658.

Geels, F. W. (2014). Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective. *Theory, Culture & Society*, *31*(5). https://doi.org/10.1177/0263276414531627

Geels, F W, Kemp, R., & Dudley, G. (2012). Environmental Innovation and Societal Transitions. *Environmental Innovation and Societal Transitions*, *4*, 63–78. https://doi.org/10.1016/j.eist.2012.08.003

Geels, Frank W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy*, *31*(8–9), 1257–1274. https://doi.org/10.1016/S0048-7333(02)00062-8

Geels, Frank W. (2019). Socio-technical transitions to sustainability: a review of criticisms and elaborations of the Multi-Level Perspective. *Current Opinion in Environmental Sustainability*, *39*, 187–201. https://doi.org/10.1016/j.cosust.2019.06.009

Geels, Frank W., Kern, F., Fuchs, G., Hinderer, N., Kungl, G., Mylan, J., … Wassermann, S. (2016a). The enactment of socio-technical transition pathways: A reformulated typology and a comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990-2014). *Research Policy*, *45*(4), 896–913. https://doi.org/10.1016/j.respol.2016.01.015

Geels, Frank W., Kern, F., Fuchs, G., Hinderer, N., Kungl, G., Mylan, J., … Wassermann, S. (2016b). The enactment of socio-technical transition pathways: A reformulated typology and a comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990-2014). *Research Policy*, *45*(4), 896–913. https://doi.org/10.1016/j.respol.2016.01.015

Geels, Frank W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy*, *36*(3), 399–417. https://doi.org/10.1016/j.respol.2007.01.003

Geels, Frank W., Sovacool, B. K., Schwanen, T., & Sorrell, S. (2017). The Socio-Technical Dynamics of Low-Carbon Transitoins. *Joule*, *1*, 463–479. https://doi.org/.1037//0033-2909.I26.1.78

Glaser, B. G., & Strauss, A. L. (1999). *Discovery of Grounded theory*. New York: Routledge. https://doi.org/https://doi.org/10.4324/9780203793206

Good, D. A. (2011). Still budgeting by muddling through: Why disjointed incrementalism lasts. *Policy and Society*, *30*(1), 41–51. https://doi.org/10.1016/j.polsoc.2010.12.005

Government of Saskatchewan. (2010). *First Nation and Métis Consultation Policy Framework*.

Government of Saskatchewan. (2017). *Prairie Resilience: A Made-in-Saskatchewan Climate Change Strategy*. Retrieved from http://publications.gov.sk.ca/documents/66/104890-2017 Climate Change Strategy.pdf

Grandori, A. (1984). A Prescriptive Contingency View of Organizational Decision Making. *Administrative Science Quarterly*, *29*(2), 192–209.

Grönkvist, S., & Sandberg, P. (2006). Driving forces and obstacles with regard to co-operation between municipal energy companies and process industries in Sweden. *Energy Policy*, *34*(13), 1508–1519. https://doi.org/10.1016/j.enpol.2004.11.001

Grubler, A. (2012). Energy transitions research: Insights and cautionary tales. *Energy Policy*, *50*, 8–16. https://doi.org/10.1016/j.enpol.2012.02.070

Grubler, A., Wilson, C., & Nemet, G. (2016). Apples, oranges, and consistent comparisons of the temporal dynamics of energy transitions. *Energy Research & Social Science*, *22*, 18–25. https://doi.org/10.1016/j.erss.2016.08.015

Guest, G., Bunce, A., & Johnson, L. (2006). How Many Interviews Are Enough? An Experiment with Data Saturation and Variability. *Field Methods*, *18*(1), 59–82. https://doi.org/10.1177/1525822X05279903

Gullers Grupp. (2018). *The public 's views on climate change 2018: A quantitative survey of the Swedish public's view on climate solutions*.

Habermas, J. (1976). *Legitimation Crises*. Baston, MA: Beacon Press.

Habermas, J. (1984). *Theory of Communicative Action* (Translated). Boston: Beacon Press.

Hai, M. A., Mekhilef, S., & Hossain, K. M. (2019). Public Readiness to Adopt Solar Energy – Responses of Some Finnish Citizens. *Journal of Clean Energy Technologies*, *6*(4), 268–277. https://doi.org/10.18178/jocet.2018.6.4.473

Hanger, S., Komendantova, N., Schinke, B., Zejli, D., Ihlal, A., & Patt, A. (2016). Community acceptance of large-scale solar energy installations in developing countries : Evidence from Morocco. *Energy Research & Social Science*, *14*, 80–89. https://doi.org/10.1016/j.erss.2016.01.010

Hardin, R. (1971). Collective action as an agreeable n-prisoners. *Behavioral Science*, *11*, 203–481. https://doi.org/10.1002/bs.3830160507

Hawkey, D., Webb, J., & Winskel, M. (2013). Organisation and governance for the transformation of urban energy systems: District heating and cooling in the UK. *Journal of Cleaner Production*, *50*, 22–31.

Hayes, M. (2002). *The Limits of Policy Change: Incrementalism, Worldview, and the Rule of Law*. Georgetown University Press.

He, G., & Kammen, D. M. (2015). Where, when and how much wind is available a provincial-scale wind resource assessment for China. *Renewable Energy*, *85*, 74–84. Retrieved from http://dx.doi.org/10.1016/j.enpol.2014.07.003%0Ahttp://dx.doi.org/10.1016/j.enpol.2014.07.003i

Healey, P. (2015). Citizen-generated local development initiative: recent English experience. *International Journal of Urban Sciences*, *19*(2), 109–118. https://doi.org/10.1080/12265934.2014.989892

Hekkert, M. P., Suurs, R. a. a., Negro, S. O., Kuhlmann, S., & Smits, R. E. H. M. (2007). Functions of innovation systems: A new approach for analysing technological change. *Technological Forecasting and Social Change*, *74*(4), 413–432. https://doi.org/10.1016/j.techfore.2006.03.002

Hennink, M. M., Kaiser, B. N., & Marconi, V. C. (2017). Code Saturation Versus Meaning Saturation: How Many Interviews Are Enough ? *Qualitative Health Research*, *27*(4), 591–608. https://doi.org/10.1177/1049732316665344

Hess, D. J. (2016). The politics of niche-regime conflicts: Distributed solar energy in the United States. *Environmental Innovation and Societal Transitions*, *19*, 42–50. https://doi.org/10.1016/j.eist.2015.09.002

Hindmarsh, R., & Matthews, C. (2008). Deliberative speak at the turbine face: Community engagement, wind farms, and renewable energy transitions in Australia. *Journal of Environmental Policy and Planning*, *10*(3), 217–232. https://doi.org/10.1080/15239080802242662

Hiremath, R. B., Kumar, B., Balachandra, P., & Ravindranath, N. H. (2011). Decentralized sustainable energy planning of Tumkur district, India. *Environmental Progress & Sustainable Energy*, *30*(2), 248–258. https://doi.org/10.1002/ep.10467

Hirsh, R. F., & Jones, C. F. (2014). Energy Research & Social Science History ’ s contributions to energy research and policy. *Energy Research & Social Science*, *1*, 106–111. https://doi.org/10.1016/j.erss.2014.02.010

Hodson, M., & Marvin, S. (2009). “Urban ecological security”: A new urban paradigm? *International Journal of Urban and Regional Research*, *33*(1), 193–215. https://doi.org/10.1111/j.1468-2427.2009.00832.x

Hodson, M., & Marvin, S. (2012). Mediating Low-Carbon Urban Transitions? Forms of Organization, Knowledge and Action. *European Planning Studies*, *20*(3), 421–439. https://doi.org/10.1080/09654313.2012.651804

Hoffmann, W. (2006). PV solar electricity industry: Market growth and perspective. *Solar Energy Materials and Solar Cells*, *90*(18–19), 3285–3311. https://doi.org/10.1016/j.solmat.2005.09.022

Holmes, B. (2011). *Citizens' engagement in policymaking and the design of public services – Parliament of Australia*. *Politics and Public Administration Section*. Retrieved from http://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/rp/rp1112/12rp01

Holt, A. (2010). Using the telephone for narrative interviewing: a research note. *Qualitative Research*, *10*(1), 113–121. https://doi.org/10.1177/1468794109348686

Hommels, A. (2005). Studying Obduracy in the City: Toward a Productive Fusion between Technology Studies and Urban Studies. *Science, Technology & Human Values*, *30*(3), 323–351. https://doi.org/10.1177/0162243904271759

Hoppe, T., & de Vries, G. (2019). Social Innovation and the Energy Transition. *Sustainability*, *11*(1), 141. https://doi.org/10.3390/su11010141

Hoppe, T., & van Bueren, E. (2015). Guest editorial: governing the challenges of climate change and energy transition in cities. *Energy, Sustainability and Society*, *5*(1). https://doi.org/10.1186/s13705-015-0047-7

Hughes, B. R., Chaudhry, H. N., & Ghani, S. A. (2011). A review of sustainable cooling technologies in buildings. *Renewable and Sustainable Energy Reviews*, *15*(6), 3112–3120. https://doi.org/10.1016/j.rser.2011.03.032

Hughes, T. P. (1983). *Networks of Power: Electrification in Western Society, 1880-1930*. Baltimore and London: Johns Hopkins University Press.

Hurlbert, M., McNutt, K., & Rayner, J. (2010). Policy Pathways: Transitioning to Sustainable Power Generation in Saskatchewan. *Renewable Energy L. & Pol'y Rev.*, 87–100. Retrieved from http://heinonlinebackup.com/hol-cgi-bin/get_pdf.cgi?handle=hein.journals/relp2010&section=14

Hurlbert, M., Osazuwa-Peters, M., McNutt, K., & Rayner, J. (2019). Transitioning from coal: Toward a renewables-based socio-technical regime in Saskatchewan. *Environmental Innovation and Societal Transitions*, (January). https://doi.org/10.1016/j.eist.2019.11.005

IEA. (2009). Cities, Towns & Renewable Energy: Yes In My Front Yard, 194. Retrieved from http://www.iea.org/publications/freepublications/publication/Cities2009.pdf

IEA. (2014). *World Energy Outlook 2014*.

IEA. (2016). *World Energy Outlook 2016*.

IEA. (2018). *World Energy Outlook*. https://doi.org/10.1049/ep.1977.0180

IEA. (2019). *Nuclear Power in a Clean Energy System*. Paris.

Imbault, F., Swiatek, M., De Beaufort, R., & Plana, R. (2017). The green blockchain: Managing decentralized energy production and consumption. *Conference Proceedings - 2017 17th IEEE International Conference on Environment and Electrical Engineering and 2017 1st IEEE Industrial and Commercial Power Systems Europe, EEEIC / I and CPS Europe 2017*. https://doi.org/10.1109/EEEIC.2017.7977613

International Energy Agency. (2016). *Snapshot of Global Photovoltaic Markets*. https://doi.org/ISBN 978-3-906042-42-8

International Energy Agency. (2019). *World Energy Outlook*. https://doi.org/10.1093/ijlct/1.1.92

IPCC. (2007). *Summary for Policymakers*. *Climate Change 2014, Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom and New York, USA: Cambridge University Press. https://doi.org/10.1017/CBO9781107415324

IPCC. (2018a). *Global warming of 1.5°C: Summary for Policymakers*.

IPCC. (2018b). Global Warming of 1.5 ^{o}C. *IPCC Special Report*. Retrieved from https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf

Jacobsson, S., & Johnson, A. (2000). The diffusion of renewable energy technology: an analytical framework and key issues for research. *Energy Policy*, *28*, 625–640.

Jan, R., Kemp, R., & van Asselt, M. (2001). More evolution than revolution: transition management in public policy. *The Journal of Futures Studies*, *3*(1), 15–31.

Janesick, V. J. (1999). A Journal About Journal Writing as a Qualitative Research Technique: History, Issues, and Reflections. *Qualitative Inquiry*, *5*(4), 505–524.

Jenkins, K. (2018). Setting energy justice apart from the crowd: Lessons from environmental and climate justice. *Energy Research & Social Science*, *39*(September 2017), 117–121. https://doi.org/10.1016/j.erss.2017.11.015

Jenkins, K., Mccauley, D., Heffron, R., Stephan, H., & Rehner, R. (2016). Energy justice : A conceptual review. *Energy Research & Social Science*, *11*, 174–182. https://doi.org/dx.doi.org/10.1016/j.erss.2015.10.004

Jiang, L., & O'Neill, B. C. (2017). Global urbanization projections for the Shared Socioeconomic Pathways. *Global Environmental Change*, *42*, 193–199. https://doi.org/10.1016/j.gloenvcha.2015.03.008

Joly, T. L., & Westman, C. N. (2017). *Taking Research Off the Shelf : Impacts, Benefits, and Participatory Processes around the Oil Sands Industry in Northern Alberta*.

Jones, C., Hine, D. W., & Marks, A. D. G. (2017). The Future is Now: Reducing Psychological Distance to Increase Public Engagement with Climate Change. *Risk Analysis*, *37*(2), 331–341. https://doi.org/10.1111/risa.12601

Kahneman, D., & Lovallo, D. (1993). Timid Choices and Bold Forecasts: A Cognitive Perspective on Risk Taking. *Management Science*, *39*(1), 17–31. https://doi.org/10.1287/mnsc.39.1.17

Kahneman, D., & Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica: Journal of the Econometric Society*, *47*(2), 263–292.

Kallio, H., Pietil, A., Johnson, M., & Kangasniemi, M. (2016). Systematic methodological review : developing a framework for a qualitative semi-structured interview guide. https://doi.org/10.1111/jan.13031

Kannan, N., & Vakeesan, D. (2016). Solar energy for future world : A review. *Renewable and Sustainable Energy Reviews*, *62*, 1092–1105.

Karavas, C. S., Arvanitis, K., & Papadakis, G. (2017). A game theory approach to multi-agent decentralized energy management of autonomous polygeneration microgrids. *Energies*, *10*(11). https://doi.org/10.3390/en10111756

Karavas, C. S., Kyriakarakos, G., Arvanitis, K. G., & Papadakis, G. (2015). A multi-agent decentralized energy management system based on distributed intelligence for the design and control of autonomous polygeneration microgrids. *Energy Conversion and Management*, *103*, 166–179. https://doi.org/10.1016/j.enconman.2015.06.021

Kardooni, R., Yusoff, S. B., Kari, F. B., & Moeenizadeh, L. (2018). Public opinion on renewable energy technologies and climate change in Peninsular Malaysia. *Renewable Energy*, *116*, 659–668. https://doi.org/10.1016/j.renene.2017.09.073

Karger, C. R., & Hennings, W. (2009). Sustainability evaluation of decentralized electricity generation. *Renewable and Sustainable Energy Reviews*, *13*(3), 583–593. https://doi.org/10.1016/j.rser.2007.11.003

Keirstead, J. (2008a). What changes, if any, would increased levels of low-carbon decentralised energy have on the built environment? *Energy Policy*, *36*(12), 4518–4521. https://doi.org/10.1016/j.enpol.2008.09.019

Keirstead, J. (2008b). What changes, if any, would increased levels of low-carbon decentralised energy have on the built environment? *Energy Policy*, *36*(12), 4518–4521. https://doi.org/10.1016/j.enpol.2008.09.019

Keirstead, J., Jennings, M., & Sivakumar, A. (2012). A review of urban energy system models:

Approaches, challenges and opportunities. *Renewable and Sustainable Energy Reviews*, *16*(6), 3847–3866. https://doi.org/10.1016/j.rser.2012.02.047

Kemp, R., Schot, J., & Hoogma, R. (1998). Regime Shifts to Sustainability through Processes of Niche Formation: The Approach of Strategic Niche Management. *Technology Analysis & Strategic Management*, *10*(2), 175–198. https://doi.org/10.1080/09537329808524310

Kern, F., & Rogge, K. S. (2018). Harnessing theories of the policy process for analysing the politics of sustainability transitions: A critical survey. *Environmental Innovation and Societal Transitions*, *27*(October 2017), 102–117. https://doi.org/10.1016/j.eist.2017.11.001

Kern, F., & Smith, A. (2008). Restructuring energy systems for sustainability? Energy transition policy in the Netherlands. *Energy Policy*, *36*(11), 4093–4103. https://doi.org/10.1016/j.enpol.2008.06.018

Kingdon, J. (1984). *Angenda, Alternatives, and Public Policies*. Addison-Wesley Educational Publishers.

Kittner, N., Lill, F., & Kammen, D. M. (2017). Energy storage deployment and innovation for the clean energy transition. *Nature Energy*, *2*(July), 1–6. https://doi.org/10.1038/nenergy.2017.125

Kivimaa, P. (2014). Government-affiliated intermediary organisations as actors in system-level transitions. *Research Policy*, *43*(8), 1370–1380. https://doi.org/10.1016/j.respol.2014.02.007

Kivimaa, P., & Kern, F. (2016). Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions. *Research Policy*, *45*(1), 205–217. https://doi.org/10.1016/j.respol.2015.09.008

Kleinman, D. L., Delborne, J. A., & Anderson, A. A. (2011). Engaging citizens: The high cost of citizen participation in high technology. *Public Understanding of Science*, *20*(2), 221–240. https://doi.org/10.1177/0963662509347137

Klijn, E. H., & Teisman, G. R. (2003). Institutional and strategic barriers to PPP: an analysis of dutch case. *Public Money & Management*, *0962*, 137.

Kofinas, P., Dounis, A. I., & Vouros, G. A. (2018). Fuzzy Q-Learning for multi-agent decentralized energy management in microgrids. *Applied Energy*, *219*(December 2017), 53–67. https://doi.org/10.1016/j.apenergy.2018.03.017

Köhler, J., Geels, F. W., Kern, F., Markard, J., Wieczorek, A., Alkemade, F., … Wells, P. (2019). An agenda for sustainability transitions research: State of the art and future directions. *Transitionsnetwork.Org*, 1–66.

Kooiman, J. (2016). Interactive governance and governability. *Critical Reflections on Interactive Governance: Self-Organization and Participation in Public Governance*, 29–50. https://doi.org/10.4337/9781783479078

Koppenjan, J., & Klijn, E.-H. (2004). *Managing Uncertainties in Networks* (1st ed.). London: Routledge.

Laird, F. N. (2001). *Solar Energy, Technology Policy, and Institutional Values*. New York: Cambridge University Press. https://doi.org/10.2307/3985732

Lammers, I., & Diestelmeier, L. (2017). Experimenting with law and governance for decentralized electricity systems: Adjusting regulation to reality? *Sustainability (Switzerland)*, *9*(2). https://doi.org/10.3390/su9020212

Lancaster, K. (2017). Confidentiality, anonymity and power relations in elite interviewing: conducting qualitative policy research in a politicised domain politicised domain. *International Journal of Social Research Methodology*, *20*(1), 93–103. https://doi.org/10.1080/13645579.2015.1123555

Lerner, J. S., & Tetlock, P. (1999). Accounting for the Effect of Accountability. *Psychological Bulletin*, *125*(2), 255–275.

Lesage, D., Van de Graaf, T., & Westphal, K. (2010). *Global Energy Governance in a Multipolar World*. London and New York: Ashgate Publishing.

Lin, B., & Ouyang, X. (2014). Energy demand in China:comparison of characteristics between the US and China in rapid urbanization stage. *Energy Convers*, *79*, 128–139.

Lindblom, C. E. (1959). The Science of " Muddling " Through. *Public Administration Review*, *19*(2), 79–88.

Liu, Y., Zuo, K., Liu, X. (Amy), Liu, J., & Kennedy, J. M. (2018). Dynamic pricing for decentralized energy trading in micro-grids. *Applied Energy*, *228*(July), 689–699. https://doi.org/10.1016/j.apenergy.2018.06.124

Lo Prete, C., Hobbs, B. F., Norman, C. S., Cano-Andrade, S., Fuentes, A., von Spakovsky, M. R., & Mili, L. (2012). Sustainability and reliability assessment of microgrids in a regional electricity market. *Energy*, *41*(1), 192–202. https://doi.org/10.1016/j.energy.2011.08.028

Loorbach, D. (2010). Transition Management for Sustainable Development: A Prescriptive, Complexity-Based Governance Framework. *Governance*, *23*(1), 161–183. https://doi.org/10.1111/j.1468-0491.2009.01471.x

Luleå Kommun. (2020). Luleå Kommun. Retrieved January 31, 2020, from https://www.lulea.se/

Macdougall, H., Tomosk, S., & Wright, D. (2018). Geographic maps of the impact of government incentives on the economic viability of solar power. *Renewable Energy*, *122*, 497–506.

Macnaghten, P., & Chilvers, J. (2014). The future of science governance: Publics, policies, practices. *Environment and Planning C: Government and Policy*, *32*(3), 530–548. https://doi.org/10.1068/c1245j

Maibach, E. W., Nisbet, M., Baldwin, P., Akerlof, K., & Diao, G. (2010). Climate Change As a Public Health

Issue. *BMC Public Health*, *10*(299).

Malterud, K., Siersma, V. D., & Guassora, A. D. (2016). Sample Size in Qualitative Interview Studies : Guided by Information Power. *Qualitative Health Research*, *26*(13), 1753–1760. https://doi.org/10.1177/1049732315617444

Manfren, M., Caputo, P., & Costa, G. (2011). Paradigm shift in urban energy systems through distributed generation: Methods and models. *Applied Energy*, *88*(4), 1032–1048. https://doi.org/10.1016/j.apenergy.2010.10.018

Markard, J. (2018). The next phase of the energy transition and its implications for research and policy. *Nature Energy*, *3*(August), 151–163. https://doi.org/10.1057/9781137533982_8

Markard, J., Raven, R., & Truffer, B. (2012). Sustainability transitions: An emerging field of research and its prospects. *Research Policy*, *41*(6), 955–967. https://doi.org/10.1016/j.respol.2012.02.013

Markard, J., & Truffer, B. (2006). Innovation processes in large technical systems: Market liberalization as a driver for radical change? *Research Policy*, *35*(5), 609–625. https://doi.org/10.1016/j.respol.2006.02.008

Martens, L. (2015). *Power Shifts: The Politics of Sustainability Transitions in Electricity Systems and the Possibilities for First Nations Participation (PhD Thesis)*. *University of Saskatchewan*. https://doi.org/10.1017/CBO9781107415324.004

Martens, L., McNutt, K., & Rayner, J. (2015). Power to the people? The impacts and outcomes of energy consultations in Saskatchewan and Nova Scotia [Canada]. *Canadian Journal of Political Science*, *48*(1), 1–27. https://doi.org/10.1017/S0008423915000190

McCauley, D., Heffron, R. J., Stephan, H., & Jenkins, K. (2013). Advancing Energy Justice: the Triumvirate of Tenets. *International Energy Law Review*.

Mccright, A. M., & Dunlap, R. E. (2011). The Politicization of Climate Change and Polarization in the American's Views of Global Warming, 2001-2010. *The Sociological Quarterly*, *52*(2), 155–194.

Mccright, A. M., Marquart-pyatt, S. T., Shwom, R. L., Brechin, S. R., & Allen, S. (2016). Ideology , capitalism , and climate: Explaining public views about climate change in the United States. *Energy Research & Social Science*, *21*, 180–189. https://doi.org/10.1016/j.erss.2016.08.003

Meadowcroft, J. (2009). What about the politics? Sustainable development, transition management, and long term energy transitions. *Policy Science*, *42*, 323–340.

Meerow, S. a., & Baud, I. (2012). Generating resilience: exploring the contribution of the small power producer and very small power producer programs to the resilience of Thailand's power sector. *International Journal of Urban Sustainable Development*, *4*(March 2015), 20–38.

https://doi.org/10.1080/19463138.2012.667414

Meijer, A., & Bolívar, M. P. R. (2016). Governing the smart city: a review of the literature on smart urban governance. *International Review of Administrative Sciences*, *82*(2), 392–408. https://doi.org/10.1177/0020852314564308

Merton, R. K. (1936). The Unanticipated Consequences of Purposive Social Action. *American Sociological Review*, *1*(6), 894–904. https://doi.org/10.2307/2084615

Meyer, N. I. (2003). Distributed generation and the problematic deregulation of energy markets in Europe. *International Journal of Sustainable Energy*, *23*(March 2015), 217–221. https://doi.org/10.1080/01425910412331290724

Mildenberger, M., Howe, P., Lachapelle, E., Stokes, L., Marlon, J., & Gravelle, T. (2016). The distribution of climate change public opinion in Canada. *PLoS ONE*, *11*(8). https://doi.org/10.1371/journal.pone.0159774

Mill, J. S. (1843). *A System of Logic, Ratiocinative and Inductive*.

Mill, J. S. (1856). *On Liberty* (2nd Editio). London: John W. Parker and Son, West Strand.

Miller, C. A., Iles, A., & Jones, C. F. (2013). The Social Dimensions of Energy Transitions. *Science as Culture*, *22*(2), 135–148. https://doi.org/10.1080/09505431.2013.786989

Miller, C. A., O'Leary, J., Graffy, E., Stechel, E. B., & Dirks, G. (2015). Narrative futures and the governance of energy transitions. *Futures*, *70*, 65–74. https://doi.org/10.1016/j.futures.2014.12.001

Minkkinen, M., Auffermann, B., & Ahokas, I. (2019). Six foresight frames: Classifying policy foresight processes in foresight systems according to perceived unpredictability and pursued change. *Technological Forecasting and Social Change*, *149*(September). https://doi.org/10.1016/j.techfore.2019.119753

Mintrom, M. (1997). Policy entrepreneurs and the diffusion of innovation. *American Journal of Political Science*, *41*(3).

Mintrom, M., & Vergari, S. (1996). Advocacy Coalitions, Policy Entrepreneurs , and Policy Change. *Policy Studies Journal*, *24*(3), 420–435.

Miron, R. (2014). The Socioeconomic Impacts of Local Energy Programmes: A Case Study of Avrig, Romania. *Management of Environmental Quality: An International Journal*, *25*, 9. https://doi.org/10.1108/MEQ-01-2014-0007

Moe, T. M. (2005). Power and Political Institutions. *Perspectives on Politics*, *3*(2), 215–233. Retrieved from http://journals.cambridge.org/download.php?file=%2FPPS%2FPPS3_02%2FS1537592705050176a.pdf&code=2ffe3bf159d21d14f111c69b82140018

Mohammed, Y. S., Mustafa, M. W., Bashir, N., Ogundola, M. a., & Umar, U. (2014). Sustainable potential of bioenergy resources for distributed power generation development in Nigeria. *Renewable and Sustainable Energy Reviews*, *34*, 361–370. https://doi.org/10.1016/j.rser.2014.03.018

Morse, J. M. (1995). Editorial: The Significance of Saturation. *Qualitative Health Research*, *5*(2), 147–149.

Mulugetta, Y., Jackson, T., & van der Horst, D. (2010). Carbon reduction at community scale. *Energy Policy*, *38*(12), 7541–7545. https://doi.org/10.1016/j.enpol.2010.05.050

Muratori, M., Schuelke-Leech, B. A., & Rizzoni, G. (2014). Role of residential demand response in modern electricity markets. *Renewable and Sustainable Energy Reviews*, *33*, 546–553. https://doi.org/10.1016/j.rser.2014.02.027

Murray, P., Orehounig, K., Grosspietsch, D., & Carmeliet, J. (2018). A comparison of storage systems in neighbourhood decentralized energy system applications from 2015 to 2050. *Applied Energy*, *231*(July), 1285–1306. https://doi.org/10.1016/j.apenergy.2018.08.106

Mussard, M. (2017). Solar energy under cold climatic conditions: A review. *Renewable and Sustainable Energy Reviews*, *74*(January), 733–745. https://doi.org/10.1016/j.rser.2017.03.009

Mutz, D. C. (2008). Is Deliberative Democracy a Falsifiable Theory? *Annual Review of Political Science*, *11*(1), 521–538. https://doi.org/10.1146/annurev.polisci.11.081306.070308

New Zealand Government. (2019). *Discussion Document Accelerating renewable energy and energy efficiency*.

Nisbet, M. (2009a). Communicating Climate Change: Why Frames Matter for Public Engagement. *Environmental Magazine*, *51*(2).

Nisbet, M. (2009b). Communicating Climate Change: Why Frames Matter for Public Engagement. *Environment*, *51*(2), 12–24.

Norgaard, R. B. (2007). Deliberative economics. Kenneth E. Boulding Lecture delivered at the 9th Biennial Meeting of ISEE, December 2006, Delhi India. *Ecological Economics*, *63*(2–3), 375–382. https://doi.org/10.1016/j.ecolecon.2007.04.002

NRCAN. (2017). *Photovoltaic potential and insolation dataset*. Retrieved from http://www.nrcan.gc.ca/18366

Ntanos, S., Kyriakopoulos, G., Chalikias, M., Arabatzis, G., & Skordoulis, M. (2018). Public perceptions and willingness to pay for renewable energy: A case study from Greece. *Sustainability*, *10*(687). https://doi.org/10.3390/su10030687

Nykvist, B., & Nilsson, M. (2015). Rapidly falling costs of battery packs for electric vehicles. *Nature Cl*, *5*(April), 329–332. https://doi.org/10.1038/NCLIMATE2564

Nyquist, S. (2015). Peering into energy's crystal ball. *McKinsey Quarterly*, (July), 1–7.

O'Neill, S. J., & Nicholson-Cole, S. (2009). " Fear Won ' t Do It " Visual and Iconic Representations. *Science Communication*, *30*(3), 355–379. https://doi.org/10.1177/1075547008329201

Obama, B. (2017). The irreversible momentum of clean energy. *Science*, *355*(6321), 126–129. https://doi.org/10.1126/science.aam6284

Oliver, K., Lorenc, T., & Tinkler, J. (2019). Evaluating unintended consequences: New insights into solving practical, ethical and political challenges of evaluation. *Evaluation*, 15–17. https://doi.org/10.1177/1356389019850847

Ong, S., Campbell, C., Denholm, P., Margolis, R., & Heath, G. (2013). Land-Use Requirements for Solar Power Plants in the United States, (June). https://doi.org/10.2172/1086349

Orehounig, K., Evins, R., & Dorer, V. (2015). Integration of decentralized energy systems in neighbourhoods using the energy hub approach. *Applied Energy*, *154*, 277–289. https://doi.org/10.1016/j.apenergy.2015.04.114

Ortlipp, M. (2008). Keeping and Using Reflective Journals in the Qualitative Research Process. *The Qualitative Report*, *13*(4), 695–705.

Orttung, R., & Zhang, E. (2019). *Energy in the Arctic*.

Ostrom, E. (2000). Collective Action and the Evolution of Social Norms. *The Journal of Economic Perspectives*, *14*(3), 137–158. Retrieved from http://www.jstor.org/stable/2646923%5Cnhttp://about.jstor.org/terms

Pacala, S., & Socolow, R. (2004). Stabilization wedges: solving the climate problem for the next 50 years with current technologies. *Science (New York, N.Y.)*, *305*(5686), 968–972. https://doi.org/10.1126/science.1100103

Paliwal, P., Patidar, N. P., & Nema, R. K. (2014). Planning of grid integrated distributed generators: A review of technology, objectives and techniques. *Renewable and Sustainable Energy Reviews*, *40*, 557–570. https://doi.org/10.1016/j.rser.2014.07.200

Pateman, C. (2012). Participatory democracy revisited. *Perspectives on Politics*, *10*(1), 7–19. https://doi.org/10.1017/S1537592711004877

Patton, M. Q. (2001). Evaluation, Knowledge Management, Best Practices, and High Quality Lessons Learned. *American Journal of Evaluation*, *22*(3), 329–336.

Pellizzone, A., Allansdottir, A., De Franco, R., Muttoni, G., & Manzella, A. (2017). Geothermal energy and the public: A case study on deliberative citizens' engagement in central Italy. *Energy Policy*, *101*(May), 561–570. https://doi.org/10.1016/j.enpol.2016.11.013

Pepermans, G., Driesen, J., Haeseldonckx, D., Belmans, R., & D'haeseleer, W. (2005). Distributed generation: Definition, benefits and issues. *Energy Policy*, *33*(6), 787–798. https://doi.org/10.1016/j.enpol.2003.10.004

Perex-Arriaga, I., & Knittel, C. (2016). Utility of the Future. Retrieved from http://energy.mit.edu/research/utility-future-study/

Peters, B. G. (2014). Is governance for everybody? *Policy and Society*, *33*(4), 301–306. https://doi.org/10.1016/j.polsoc.2014.10.005

Petrini, H., Sandstrom, E., Lundkvist, G., Grip, C.-E., & Boden, A. (2004). Energy Network SSAB - LuleKraft - City of Lulea: Two Decades' Experience of Co-Productin of Steel, Electric Power and District Heating. *Scanmet II: 2nd International Conference on Process Development in Iron and Steelmaking, 6-8 June 2004*.

Pierre, J. (2014). Can Urban Regimes Travel in Time and Space? Urban Regime Theory, Urban Governance Theory, and Comparative Urban Politics. *Urban Affairs Review*, *50*(6), 864–889. https://doi.org/10.1177/1078087413518175

Pinker, A. (2018). Tinkering with Turbines : Ethics and Energy Decentralization in Scotland, *91*(2), 709–748. https://doi.org/10.1353/anq.2018.0031

Poli, R. (2017). *Introduction to anticipation studies* (Anticipati). Cham: Springer.

Powell, W. W. (1990). Neither Market Nor Hierarchy: Network Forms of Organization. *Research in Organizational Behavior*, *12*, 295–336.

Proudlove, A., Lips, B., Sarkisian, D., & Shrestha, A. (2017). *50 State of Solar: Q4 2016 Quarterly Report & Annual Review*. *NC Clear Energy Technology Center*. Retrieved from https://nccleantech.ncsu.edu/the-50-states-of-solar-report-2016-annual-review-and-q4-update/

Quiggin, D., Cornell, S., Tierney, M., & Buswell, R. (2012). A simulation and optimisation study: Towards a decentralised microgrid, using real world fluctuation data. *Energy*, *41*(1), 549–559. https://doi.org/10.1016/j.energy.2012.02.007

Ragin, C. C. (2014). *The Comparative Method: Moving Beyong Qualitative and Quantitative Strategies* (2nd ed.). University of California Press.

Ramachandra, T. V. (2009). RIEP: Regional integrated energy plan. *Renewable and Sustainable Energy Reviews*, *13*, 285–317. https://doi.org/10.1016/j.rser.2007.10.004

Raven, R., Kern, F., Smith, A., Jacobsson, S., & Verhees, B. (2016). The politics of innovation spaces for low-carbon energy: Introduction to the special issue. *Environmental Innovation and Societal Transitions*, *18*, 101–110. https://doi.org/10.1016/j.eist.2015.06.008

Raven, R. P. J. M., & Geels, F. W. (2010). Socio-cognitive evolution in niche development: Comparative analysis of biogas development in Denmark and the Netherlands (1973–2004). *Technovation*, *30*(2), 87–99. https://doi.org/10.1016/j.technovation.2009.08.006

Rhodes, E., Axsen, J., & Jaccard, M. (2017). Exploring Citizen Support for Different Types of Climate Policy. *Ecological Economics*, *137*, 56–69. https://doi.org/10.1016/j.ecolecon.2017.02.027

Ribeiro, F., Ferreira, P., Araújo, M., & Cristina Braga, A. (2018). CreateModelling perception and attitudes towards renewable energy technologies. *Renewable Energy*, *122*(July), 688–697.

Riess, C., Walter, M. S. J., Weiherer, S., & Groper, M. (2018). Evaluation and Quantification of the Range Extension of Battery Powered Electric Vehicles in Winter by Using a Separate Powered Heating Unit. *EPE 2018 - Proceedings of the 2018 10th International Conference and Expositions on Electrical And Power Engineering*, 75–80. https://doi.org/10.1109/ICEPE.2018.8559871

Rifkin, J. (2011). *The Third Industrial Revolution: How Lateral Power is Tranforming Energy, the Economy, and the World*. New York: Palgrave Macmillan.

Rihoux, B., Alamos, P., Bol, D., Marx, A., & Rezsohazy, I. (2013). From Niche to Mainstream Method? A comprehensive mapping of QCA applications in journal articles from 1984 to 2011. *Political Research Quarterly*, *66*(1), 175–184. https://doi.org/10.1177/1065912912468269c

Roberts, C., & Geels, F. W. (2018). Political acceleration of sociotechnical transitions - Lessons from four historical case studies. In K. Jenkins & D. Hopkins (Eds.), *Transitions in Energy Efficiency and Demand: The Emergence, Diffusion, and Impact of Low-Carbon Innovation*.

Roberts, N. C., & King, P. J. (1991). Policy Entrepreneurs: Their Activity Structure and Function in the Policy Process. *Journal of Public Administration Research and Theory*, *1*(2), 147–175.

Robinson, O. C. (2014). Qualitative Research in Psychology Sampling in Interview-Based Qualitative Research: A Theoretical and Practical Guide. *Qualitative Research in Psychology*, *11*, 25–41. https://doi.org/10.1080/14780887.2013.801543

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., III, E. L., … Foley., J. (2014). Planetary Boundaries : Exploring the Safe Operating Space for Humanity. *Ecology and Society*, *14*(2), 1–28.

Rogers, P. J. (2008). Using programme theory to evaluate complicated and complex aspects of interventions. *Evaluation*, *14*(1), 29–48. https://doi.org/10.1177/1356389007084674

Rojas-Zerpa, J. C., & Yusta, J. M. (2014). Methodologies, technologies and applications for electric supply planning in rural remote areas. *Energy for Sustainable Development*, *20*, 66–76.

https://doi.org/10.1016/j.esd.2014.03.003

Rosenbloom, D., Haley, B., & Meadowcroft, J. (2018). Critical choices and the politics of decarbonization pathways: Exploring branching points surrounding low-carbon transitions in Canadian electricity systems. *Energy Research & Social Science*, *37*, 22–36.

Rowe, G., & Frewer, L. (2005). A Typology of Public Engagement Mechanisms. *Science, Technology & Human Values*, *30*(2), 251–290. https://doi.org/10.1177/0162243904271724

Ruggiero, S., Varho, V., & Rikkonen, P. (2015). Transition to distributed energy generation in Finland: Prospects and barriers. *Energy Policy*, *86*, 433–443.

Safaei, H., & Keith, D. W. (2015). How much bulk energy storage is needed to decarbonize electricity? *Energy and Environmental Science*, *8*, 3409–3417. https://doi.org/10.1039/c5ee01452b

Samet, R. H. (2013). Complexity, the science of cities and long-range futures. *Futures*, *47*, 49–58. https://doi.org/10.1016/j.futures.2013.01.006

Sanderson, I. (2002). Evaluation, Policy Learning and Evidence-Based Policy Making. *Public Administration*, *80*(1), 1–22.

SaskPower. (n.d.). *SaskPower Various Annual Reports (1949-2016)*. Regina, SK.

SaskPower. (2017a). *Let's Talk Solar (Presentation)*.

SaskPower. (2017b). Power Rates. Retrieved September 22, 2017, from http://www.saskpower.com/accounts-and-services/power-rates/

SaskPower. (2017c). *SaskPower 2016-17 Annual Report*. Regina, SK.

SaskPower. (2017d). Solar. Retrieved September 22, 2017, from http://www.saskpower.com/our-power-future/our-electricity/supply-options/solar/

SaskPower. (2018a). *2017-18 Annual Report*.

SaskPower. (2018b). Net Metering Program Guidelines.

SaskPower. (2018c). *Power Generation Partner Program Guidelines*. https://doi.org/10.1109/T-AIEE.1926.5061281

SaskPower. (2018d). *Rate Application*. Retrieved from http://www.saskpower.com/wp-content/uploads/Rate_Application2016_2017.pdf

SaskPower. (2019). *Solar PV Suppliers*. Retrieved from https://www.saskpower.com/Efficiency-Programs-and-Tips/Business-Savings-Programs/Efficiency-Programs/-/media/205C4A5D4B434D61A16B5C015B09A57B.ashx

Saunders, B., & Kitzinger, J. (2015). Anonymising interview data: challenges and compromise in practice. *Qualitative Research*, *15*(5), 616–632. https://doi.org/10.1177/1468794114550439

Saunders, R. W., Gross, R. J. K., & Wade, J. (2012). Can premium tariffs for micro-generation and small scale renewable heat help the fuel poor, and if so, how? Case studies of innovative finance for community energy schemes in the UK. *Energy Policy*, *42*, 78–88. https://doi.org/10.1016/j.enpol.2011.11.045

Schmitt, P. (2013). Resilience Thinking in Urban Planning. In T. Tasan-Kok & A. Eraydin (Eds.), *GeoJournal Library* (pp. 109–130). New York: Springer. Retrieved from http://dx.doi.org/10.1007/978-94-007-5476-8

Schober, M. (2018). The future of face-to-face interviewing. *Quality Assurance in Education*, *26*(2). https://doi.org/10.1108/QAE-06-2017-0033

Schot, J., & Kanger, L. (2018). Deep transitions: Emergence, acceleration, stabilization and directionality. *Research Policy*, *47*(6), 1045–1059. https://doi.org/10.1016/j.respol.2018.03.009

Schulz, N. (2010). Lessons from the London Climate Change Strategy: Focusing on Combined Heat and Power and Distributed Generation. *Journal of Urban Technology*, *17*(3), 3–23. https://doi.org/10.1080/10630732.2010.553038

Sekhon, J. (2004). Quality Meets Quantity: Case Studies, Conditional Probability, and Counterfactuals. *Perspectives and Politics*, *2*(2), 4–15.

Seyfang, G., Park, J. J., & Smith, A. (2013). A thousand flowers blooming? An examination of community energy in the UK. *Energy Policy*, *61*, 977–989. https://doi.org/10.1016/j.enpol.2013.06.030

Shwom, R., Bidwell, D., Dan, A., & Dietz, T. (2010). Understanding U.S. public support for domestic climate change policies. *Global Environmental Change*, *20*(3), 472–482. https://doi.org/10.1016/j.gloenvcha.2010.02.003

Simon, H. (1955). A Behavioral Model of Rational Choice. *The Quarterly Journal of Economics*, *69*(1), 99–118.

Skjølsvold, T. M., Throndsen, W., Ryghaug, M., Fjellså, I. F., & Koksvik, G. H. (2018). Orchestrating households as collectives of participation in the distributed energy transition: New empirical and conceptual insights. *Energy Research and Social Science*, *46*(December 2017), 252–261. https://doi.org/10.1016/j.erss.2018.07.035

Smil, V. (2016a). *Energy Transitions: Global and National Perspectives, 2nd Edition*. Santa Barbara, USA: Praeger.

Smil, V. (2016b). Examining energy transitions: A dozen insights based on performance. *Energy Research & Social Science*, *22*, 194–197. https://doi.org/10.1016/j.erss.2016.08.017

Smink, M., Negro, S. O., Niesten, E., & Hekkert, M. P. (2015). How mismatching institutional logics hinder niche-regime interaction and how boundary spanners intervene. *Technological Forecasting and Social Change*, *100*, 225–237. https://doi.org/10.1016/j.techfore.2015.07.004

Smith, A. (2007). Translating Sustainabilities between Green Niches and Socio-Technical Regimes. *Technology Analysis & Strategic Management*, *19*(4), 427–450. https://doi.org/10.1080/09537320701403334

Smith, A., Stirling, A., & Berkhout, F. (2005). The governance of sustainable socio-technical transitions. *Research Policy*, *34*(10), 1491–1510. https://doi.org/10.1016/j.respol.2005.07.005

Smith, A., Voß, J.-P., & Grin, J. (2010). Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research Policy*, *39*(4), 435–448. https://doi.org/10.1016/j.respol.2010.01.023

Söderholm, K. (2018). Pioneering industry/ municipal district heating collaboration in Sweden in the 1970s. *Energy Policy*, *112*, 328–333.

Sonnenschein, M., Lünsdorf, O., Bremer, J., & Tröschel, M. (2014). Decentralized control of units in smart grids for the support of renewable energy supply. *Environmental Impact Assessment Review*. https://doi.org/10.1016/j.eiar.2014.08.004

Sørensen, B. (1991). A history of renewable energy technology. *Energy Policy*. https://doi.org/10.1016/0301-4215(91)90072-V

Soshinskaya, M., Crijns-Graus, W. H. J., Guerrero, J. M., & Vasquez, J. C. (2014). Microgrids: Experiences, barriers and success factors. *Renewable and Sustainable Energy Reviews*, *40*, 659–672. https://doi.org/10.1016/j.rser.2014.07.198

Sovacool, B. K. (2014a). Energy Studies Need Social Science. *Nature*, *511*(7511), 529–530. https://doi.org/10.1038/511529a

Sovacool, B. K. (2014b). What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda. *Energy Research & Social Science*, *1*, 1–29. https://doi.org/10.1016/j.erss.2014.02.003

Sovacool, B. K. (2016). How long will it take? Conceptualizing the temporal dynamics of energy transitions. *Energy Research & Social Science*, *13*, 202–215. https://doi.org/10.1016/j.erss.2015.12.020

Sovacool, B. K., & Brown, M. a. (2010). Twelve metropolitan carbon footprints: A preliminary comparative global assessment. *Energy Policy*, *38*(9), 4856–4869. https://doi.org/10.1016/j.enpol.2009.10.001

Sovacool, B. K., Burke, M., Baker, L., Kumar Kotikalapudi, C., & Wlokas, H. (2017). New Frontiers and

Conceptual Frameworks for Energy Justice. *Energy Policy*, *105*(March), 677–691.

Sovacool, B. K., & Dworkin, M. H. (2014). *Global Energy Justice: Problem, Principles, and Practices*. Cambridge: Cambridge University Press.

Sovacool, B. K., & Dworkin, M. H. (2015). Energy justice: Conceptual insights and practical applications. *Applied Energy*, *142*, 435–444. https://doi.org/10.1016/j.apenergy.2015.01.002

Sovacool, B. K., & Geels, F. W. (2016). Further reflections on the temporality of energy transitions: A response to critics. *Energy Research & Social Science*, *22*, 232–237. https://doi.org/10.1016/j.erss.2016.08.013

Sovacool, B. K., Heffron, R. J., McCauley, D., & Goldthau, A. (2016a). Energy decisions reframed as justice and ethical concerns. *Nature Energy*, *1*(5), 16024. https://doi.org/10.1038/nenergy.2016.24

Sovacool, B. K., Heffron, R. J., McCauley, D., & Goldthau, A. (2016b). Energy decisions reframed as justice and ethical concerns. *Nature Energy*, *1*(May). https://doi.org/10.1038/nenergy.2016.24

Sperling, K., Hvelplund, F., & Mathiesen, B. V. (2011). Centralisation and decentralisation in strategic municipal energy planning in Denmark. *Energy Policy*, *39*(3), 1338–1351. https://doi.org/10.1016/j.enpol.2010.12.006

Stadler, I., & Bukvić-Schäfer, A. S. (2003). Demand side management as a solution for the balancing problem of distributed generation with high penetration of renewable energy sources. *International Journal of Sustainable Energy*, *23*(March 2015), 157–167. https://doi.org/10.1080/01425910412331290788

Statistics Canada. (2016). Population and Dwelling Count Highlight Tables, 2016 Census.

Statistics Canada. (2019). Population estimates on July 1st, by age and sex. Retrieved from https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=1710000501#timeframe

Stearns, L. B., & Almeida, P. D. (2004). The Formation of State Actor-Social Movement Coalitions and Favorable Policy Outcomes. *Social Problems*, *51*(4), 478–504. https://doi.org/10.1525/sp.2004.51.4.478

Stecula, D. A., & Merkley, E. (2019). Framing Climate Change: Economics, Ideology, and Uncertainty in American News Media Content From 1988 to 2014. *Frontiers in Communication*, *4*(February), 1–15. https://doi.org/10.3389/fcomm.2019.00006

Stilgoe, J., Lock, S. J., & Wilsdon, J. (2014). Why should we promote public engagement with science? *Public Understanding of Science*, *23*(1), 4–15. https://doi.org/10.1177/0963662513518154

Stoyanov, A. (2019). Energy Complex of a Municipality on the Example of Lulea (Sweden). *E3S Web of Conferences*, *140*(03005), 4–8. https://doi.org/10.1051/e3sconf/201914003005

Stuart, E. K. (2006). Energizing the island community: a review of policy standpoints for energy in small island states and territories. *Sustainable Development*, *14*(2), 139–147. https://doi.org/10.1002/sd.299

Sütterlin, B., & Siegrist, M. (2017). Public acceptance of renewable energy technologies from an abstract versus concrete perspective and the positive imagery of solar power. *Energy Policy*, *106*, 356–366. https://doi.org/10.1016/j.enpol.2017.03.061

Suurs, R. A. A. (2009). *Motors of sustainable innovation: Towards a theory on the dynamics of technological innovation systems (PhD thesis)*. *Innovation Study Group, Utrecht University, Utrecht*. Retrieved from http://igitur-archive.library.uu.nl/dissertations/2009-0318

Swim, J. K., Stern, P. C., Doherty, T. J., Clayton, S., Reser, J. P., Weber, E. U., … Howard, G. S. (2011). Psychology's Contributions to Understanding and Addressing Global Climate Change. *American Psychologist*, *66*(4), 241–250. https://doi.org/10.1037/a0023220

Tetlock, P., & Boettger, R. (1994). Accountability Amplifies the Status Quo Effect When Change Creates Victims. *Journal of Behavioral Decision Making*, *7*, 1–23.

Thakur, J., & Chakraborty, B. (2015). Intelli-grid: Moving towards automation of electric grid in India. *Renewable and Sustainable Energy Reviews*, *42*(2015), 16–25.

The Intertie Management: Committees' Railbelt Operating and Reliability Standards (2017).

The Truth and Reconciliation Commission of Canada. (2015). *Honouring the Truth, Reconciling for the Future: Summary of the Final Report on the Truth and Reconcilation Commission of Canada*. Winnipeg. https://doi.org/9780660019857, 066001985X

Thomsen, J. (2018). *Enhancing operation of decentralized energy systems by a regional economic optimization model DISTRICT*. *Energy Systems* (Vol. 9). https://doi.org/10.1007/s12667-017-0261-9

Thorpe, C., & Gregory, J. (2010). Producing the post-fordist public: The political economy of public engagement with science. *Science as Culture*, *19*(3), 273–301. https://doi.org/10.1080/09505430903194504

Tilley, L., & Woodthorpe, K. (2011). Is it the end of anonymity as we know it? A critical examination of the ethical principle of anonymity in the context of 21st centruy demands on the qualitative reseacher. *Qualitative Research*, *11*(2), 197–212. https://doi.org/10.1177/1468794110394073

Tilly, C. (1984). *Big Structures, Large Processes, Huge Comparisons*. New York: Russel Stage Foundation.

Torfing, J., B. Peters, G., Pierre, J., & Sørensen, E. (2012). *Interactive Governance: Advancing the Paradigm*. Oxford University Press. https://doi.org/10.1093/acprof

Trutnevyte, E. (2014). The allure of energy visions: Are some visions better than others. *Energy Strategy*

Reviews, *2*. https://doi.org/10.1016/j.esr.2013.10.001

Turkson, J., & Wohlgemuth, N. (2000). Power sector reform and distributed generation in sub-Saharan Africa. *Energy Policy*, *29*(2001), 135–145. https://doi.org/10.1016/S0301-4215(00)00112-9

Turnheim, B., Pel, B., Avelino, F., Jenkins, K., Kern, F., Alkemade, F., … Schot, J. (2019). An agenda for sustainability transitions research: State of the art and future directions. *Environmental Innovation and Societal Transitions*, *31*(January), 1–32. https://doi.org/10.1016/j.eist.2019.01.004

United Nations. (2010). *World Urbanization Prospects: The 2009 Revision*. *Population and Development Review* (Vol. ESA/P/WP/2). New York. https://doi.org/10.2307/2808041

United Nations. (2018). 68% of the world population projected to live in urban areas by 2050, says UN. *Department of Economic and Social Affairs*, 1–5. Retrieved from https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

United States Census Bureau. (2018). Population and Housing Unit Estimates. Retrieved January 31, 2020, from https://www.census.gov/programs-surveys/popest/data/tables.2018.html

Van Boven, L., Ehret, P. J., & Sherman, D. K. (2018). Psychological Barriers to Bipartisan Public Support for Climate Policy. *Perspectives on Psychological Science*, *13*(4), 492–507. https://doi.org/10.1177/1745691617748966

van de Kerkhof, M. (2006). Making a difference: On the constraints of consensus building and the relevance of deliberation in stakeholder dialogues. *Policy Sciences*, *39*(3), 279–299. https://doi.org/10.1007/s11077-006-9024-5

van den Belt, M. (2004). *Mediated Modeling: A System Dynamics Approach to Environmental Consensus Building*. Washington: Island Press.

van den Hove, S. (2006). Between consensus and compromise: Acknowledging the negotiation dimension in participatory approaches. *Land Use Policy*, *23*(1), 10–17. https://doi.org/10.1016/j.landusepol.2004.09.001

van der Have, R. P., & Rubalcaba, L. (2016). Social innovation research: An emerging area of innovation studies? *Research Policy*, *45*(9), 1923–1935. https://doi.org/10.1016/j.respol.2016.06.010

van der Klauw, T., Gerards, M. E. T., & Hurink, J. L. (2017). Resource allocation problems in decentralized energy management. *OR Spectrum*, *39*(3), 749–773. https://doi.org/10.1007/s00291-017-0474-2

van Oudheusden, M. (2011). Questioning “Participation”: A Critical Appraisal of its Conceptualization in a Flemish Participatory Technology Assessment. *Science and Engineering Ethics*, *17*(4), 673–690. https://doi.org/10.1007/s11948-011-9313-z van Veelen, B., & van der Horst, D. (2018). What is energy democracy? Connecting social science energy research and political theory. *Energy Research and Social Science*, *46*(February), 19–28. https://doi.org/10.1016/j.erss.2018.06.010

Vimpari, J., & Junnila, S. (2017). Evaluating decentralized energy investments: Spatial value of on-site PV electricity. *Renewable and Sustainable Energy Reviews*, *70*(December 2016), 1217–1222. https://doi.org/10.1016/j.rser.2016.12.023

Voorberg, W. H., Bekkers, V. J. J. M., & Tummers, L. G. (2015). A Systematic Review of Co-Creation and Co-Production: Embarking on the social innovation journey. *Public Management Review*, *17*(9), 1333–1357. https://doi.org/10.1080/14719037.2014.930505

Walker, G. (2008). Decentralised systems and fuel poverty: Are there any links or risks? *Energy Policy*, *36*(12), 4514–4517. https://doi.org/10.1016/j.enpol.2008.09.020

Walker, G., Hunter, S., Devine-wright, P., Evans, B., & Fay, H. (2007). Harnessing Community Energies: Explaining and Evaluating Community- Based Localism in Renewable Energy Policy in the UK. *Global Environmental Politics*, *7*(2), 64–82.

Watt, D. (2007). On Becoming a Qualitative Researcher: The Value of Reflexivity. *The Qualitative Report*, *12*(1), 82–101.

Weber, M., Hoogma, R., Lane, B., & Schot, J. W. (1999). *Experimenting with sustainable transport innovations: A workbook for strategic niche management*.

Weidlich, A., Vogt, H., Krauss, W., Spiess, P., Jawurek, M., Johns, M., & Karnouskos, S. (2012). Decentralized Intelligence in Energy Efficient Power Systems. In *Energy Systems 2012: Handbook of Networks in Power Systems* (pp. 467–486).

Welbourn, D., Warwick, R., Carnall, C., & Fathers, D. (2012). Leadership of whole systems. King's Fund Report.

Whetten, D., & Rogers, D. (1982). *Interorganizational Coordination: Theory, Research, and Implementation*. Iowa State University Press.

White, C. O. (1976). *Power for a Province: A History of Saskatchewan Power*. Regina: Canadian Plains Reserach Centre, University of Regina.

Whitmarsh, L., O'Neill, S., & Lorenzoni, I. (2013). Public engagement with climate change: What do we know and where do we go from here? *International Journal of Media & Cultural Politics*, *9*(1), 7–25. https://doi.org/10.1386/macp.9.1.7_1

Whitmarsh, L., Seyfang, G., & O'Neill, S. (2011). Public engagement with carbon and climate change: To what extent is the public "carbon capable"? *Global Environmental Change*, *21*(1), 56–65.

https://doi.org/10.1016/j.gloenvcha.2010.07.011

Wibeck, V. (2014a). Enhancing learning, communication and public engagement about climate change - some lessons from recent literature. *Environmental Education Research*, *20*(3), 387–411. https://doi.org/10.1080/13504622.2013.812720

Wibeck, V. (2014b). Social representations of climate change in Swedish lay focus groups: Local or distant, gradual or catastrophic? *Public Understanding of Science*, *23*(2), 204–219. https://doi.org/10.1177/0963662512462787

Wiederholm, J., Castegren, G., Ulaner, M., & Persson, M.-L. (2017). *Fastigheten Nils Holgerssons underbara resa genom Sverige - en avgiftssudie för 2017*. Stockholm. Retrieved from http://nilsholgersson.nu/wp-content/uploads/2017/10/AvgiftsrapportNH2017mBilagor.pdf

Williams, J. (2010). The deployment of decentralised energy systems as part of the housing growth programme in the UK. *Energy Policy*, *38*(12), 7604–7613. https://doi.org/10.1016/j.enpol.2009.08.039

Wolf, J., & Moser, S. C. (2011). Individual understandings, perceptions, and engagement with climate change: Insights from in-depth studies across the world. *Wiley Interdisciplinary Reviews: Climate Change*, *2*(4), 547–569. https://doi.org/10.1002/wcc.120

Wolfe, P. (2008a). The implications of an increasingly decentralised energy system. *Energy Policy*, *36*, 4509–4513. https://doi.org/10.1016/j.enpol.2008.09.021

Wolfe, P. (2008b). The implications of an increasingly decentralised energy system. *Energy Policy*, *36*(12), 4509–4513. https://doi.org/10.1016/j.enpol.2008.09.021

Woodhouse, E. J., & Collingridge, D. (1993). Incrementalism, intelligent trial-and-error, and the future of political decision theory. In I. H. Redner (Ed.), *An heretical heir ofthe enlightenment: Politics, policy, and science in the work of Charles E. Lindblom* (pp. 131–154). Boulder: Westview.

Wurzel, R. K. W., Moulton, J. F. G., Osthorst, W., Mederake, L., Deutz, P., & Jonas, A. E. G. (2019). Climate pioneership and leadership in structurally disadvantaged maritime port cities. *Environmental Politics*, *28*(1), 146–166. https://doi.org/10.1080/09644016.2019.1522039

Wynne, B. (2006). Public engagement as a means of restoring public trust in science - Hitting the notes, but missing the music? *Community Genetics*, *9*(3), 211–220. https://doi.org/10.1159/000092659

Yang, L., Entchev, E., Ghorab, M., Lee, E. J., & Kang, E. C. (2014). Energy and cost analyses of a hybrid renewable microgeneration system serving multiple residential and small office buildings. *Applied Thermal Engineering*, *65*(1–2), 477–486. https://doi.org/10.1016/j.applthermaleng.2014.01.049

Yoshikawa, K., Kawasaki, H., Yoshida, W., Irie, T., Konishi, K., Nakano, K., … Yamamoto, K. (2017). Silicon heterojunction solar cell with interdigitated back contacts for a photoconversion efficiency over 26%. *Nature Energy*, *2*(5), 17032. https://doi.org/10.1038/nenergy.2017.32

Zahedi, A. (2011). A review of drivers, benefits, and challenges in integrating renewable energy sources into electricity grid. *Renewable and Sustainable Energy Reviews*, *15*(9), 4775–4779. https://doi.org/10.1016/j.rser.2011.07.074

Zammit, D. (2019, January 11). SaskPower Continues Solar Power Push. *SwiftCurrent Online*, pp. 1–5. Retrieved from https://www.swiftcurrentonline.com/local/saskpower-continues-solar-power-push

Zeckhauser, W., & Samuelson, R. (1988). Status Quo Bias in Decision Making. *Journal of Risk and Uncertainty*, *59*, 4. https://doi.org/10.1007/BF00055564

Zhumabekuly Aitzhan, N., Svetinovic, D., & Zhumabekuly Aitzhan Nurzhan; Svetinovic, D. (2016). Security and Privacy in Decentralized Energy Trading through Multi-signatures, Blockchain and Anonymous Messaging Streams. *IEEE Transactions on Dependable and Secure Computing*, *5971*(c), 1–1. https://doi.org/10.1109/TDSC.2016.2616861