CONNECTING TECHNOLOGY WITH COMMUNITIES:

THE CASE OF SMALL MODULAR REACTORS

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ABSTRACT

Indigenous people in northern and remote communities around the world share similar experience with energy systems. The history of energy development in those areas is based on the policy of ‘extractivism’ imposed by the ‘western’ world. This has led to the current situation where remote Indigenous communities often suffer from energy insecurity and energy poverty. Indigenous communities in Canada have been through transitions, not just in energy but other socio-economic sectors. Today these communities play an important role in the development of the energy profile for the country. Partnering with them to develop local clean energy production seems an obvious benefit to all parties. However, the record of these partnerships is poor, with some failing to produce the expected benefits and others failing to get off the ground at all. Recent policies push for accelerated energy transitions which create additional pressure where thorough and meaningful work with Indigenous partners is needed.

In this dissertation, I research clean energy development from northern, remote, and Indigenous perspectives within the context of sustainability transitions literature. I focus on the social context of clean energy innovation development in potential application to small modular reactors (SMRs). SMRs currently have momentum as a potential technology for decarbonizing power production with recent discussions of the use of microreactors in remote communities. Since SMRs have yet to be deployed, I first review the literature on clean energy projects in northern and remote communities and outline the common features of successful projects. Next, I focus on one of these features, the role of intermediary actors and organizations, and show how intermediaries have developed distinct storylines about SMRs within the larger narrative of SMR development and deployment in Canada. Finally, I study four case studies of renewable energy projects in Indigenous communities. Using interviews with community leaders, I describe their perspectives and interests in energy projects and compare them with government and industry partners’ perspectives. The results reveal a fundamental misalignment of expectations between Indigenous communities and their partners.

One of the central arguments of this dissertation is the importance of the role of Indigenous intermediaries, i.e., actors and platforms that sustain the momentum of transitions by linking actors, activities, and resources that can move easily between the communities and the larger energy production context. The work of Indigenous intermediaries reveals the need for the construction of a safe space where communities can frame the discussion within Indigenous worldviews and lived experience. I offer policy recommendations for how this
space can be constructed and protected. Meeting this need can help in formulating policy around the successful deployment of small modular reactors (SMRs) or any other clean energy technology.

Innovative features of the dissertation include reflections on the challenges of applying the Euro-centric approaches in the sustainability transitions literature in non-European environments, including remote, northern and Indigenous communities; a systematic review of the lessons from renewable energy case studies from sustainability transitions literature, their practical application in the context of SMR development, and community-based case studies of clean energy projects in application to SMRs.
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I thank my ‘support system’: Bianca, for being a trailblazer and a wonderful cheerleader; Trish, for always listening and encouraging; Glenna, for bringing comfort and connecting us.

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<tr>
<td>3NE</td>
<td>Three Nations Energy</td>
</tr>
<tr>
<td>AB</td>
<td>Alberta</td>
</tr>
<tr>
<td>ACFN</td>
<td>Athabasca Chipewyan First Nation</td>
</tr>
<tr>
<td>AECL</td>
<td>Atomic Energy of Canada Limited</td>
</tr>
<tr>
<td>AESO</td>
<td>Alberta Electric System Operator</td>
</tr>
<tr>
<td>ANT</td>
<td>Actor-Network Theory</td>
</tr>
<tr>
<td>ARC</td>
<td>Advanced Reactor Concepts</td>
</tr>
<tr>
<td>BWRX</td>
<td>Boiling Water Reactor (10th generation)</td>
</tr>
<tr>
<td>CANDU</td>
<td>Canada Deuterium Uranium</td>
</tr>
<tr>
<td>CNL</td>
<td>Canadian Nuclear Laboratories</td>
</tr>
<tr>
<td>EBR</td>
<td>Experimental Breeder Reactor</td>
</tr>
<tr>
<td>EDC</td>
<td>Economic Development Corporation</td>
</tr>
<tr>
<td>ESBWR</td>
<td>Economically Simplified Boiling Water Reactor</td>
</tr>
<tr>
<td>FN</td>
<td>First Nation</td>
</tr>
<tr>
<td>FNPA</td>
<td>First Nations Power Authority</td>
</tr>
<tr>
<td>GEH</td>
<td>General Electric and Hitachi alliance company</td>
</tr>
<tr>
<td>GHG</td>
<td>Greenhouse Gas</td>
</tr>
<tr>
<td>HGTR</td>
<td>High Temperature Gas-cooled Reactor</td>
</tr>
<tr>
<td>HTR-PM</td>
<td>High Temperature Reactor Pebble-bed Module</td>
</tr>
<tr>
<td>IAEA</td>
<td>International Atomic Energy Agency</td>
</tr>
<tr>
<td>IEA</td>
<td>International Energy Agency</td>
</tr>
<tr>
<td>II</td>
<td>Industrial Investments</td>
</tr>
<tr>
<td>IMSR</td>
<td>Integral Molten Salt Reactor</td>
</tr>
<tr>
<td>IPCC</td>
<td>International Panel on Climate Change</td>
</tr>
<tr>
<td>iPWR</td>
<td>Integrated Pressurized Water Reactor</td>
</tr>
<tr>
<td>kW</td>
<td>Kilowatt</td>
</tr>
<tr>
<td>LCOE</td>
<td>Levelized Cost of Electricity/Energy</td>
</tr>
<tr>
<td>MEDA</td>
<td>Muskoday Economic Development Authority</td>
</tr>
<tr>
<td>MLP</td>
<td>Multi-Level Perspective</td>
</tr>
<tr>
<td>MLTC</td>
<td>Meadow Lake Tribal Council</td>
</tr>
<tr>
<td>MMR</td>
<td>Micro Modular Reactor</td>
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</table>
MoU  Memorandum of Understanding
MW   Megawatt
MWe  Megawatt electric
NAEBD National Aboriginal Economic Development Board
NPP  Nuclear Power Plant
NRCan Natural Resources Canada
OPG  Ontario Power Generation
PADC Prince Albert Development Corporation
PPA  Power Purchase Agreement
PV   Photovoltaics
PWR  Pressurized Water Reactor
R&D  Research and Development
RDI  Resource Development Inc.
SaskPower Saskatchewan Power Corporation
SK   Saskatchewan
SMR  Small Modular Reactor
SNM  Strategic Niche Management
SSGR Small Scale Generation Regulation
SSR-W Stable Salt Reactor-Wasteburner
ST   Sustainability Transitions
TIS  Technological Innovation Systems
TRISO TRi-structural ISOtrropic (particle nuclear fuel)
VRE  Variable Renewable Energy
CHAPTER 1. INTRODUCTION

Northern, remote, Indigenous communities are among the most vulnerable to the impacts of climate change (Furgal & Seguin, 2006; NCCIH, 2022; Peace & Myers, 2012; Prowse, Furgal, Wrona, & Reist, 2009; UNDESA, 2008). This risk drives the need for both enhanced energy security and an energy transition for those communities (Grubert & Hastings-Simon, 2022; Kvern, Fitzpatrick, & Fishback, 2022; Rogge, Kern, & Howlett, 2017). However, historically, transitions in the Indigenous context do not have necessarily positive or even neutral connotations. Indigenous people from the time they were colonized went through many transitions with their governance system, economy, and society. They were forced to adapt to the transformation and “transitions” set by the non-Indigenous people settled on their land. Even now, while a sustainable energy transition is fundamental for northern, remote, and Indigenous communities, most of the sustainability transitions (ST) literature is about mitigation whereas for Indigenous peoples the immediate need is for adaptation (Asquith, 2016; Denton et al., 2022; Kivimaa, Brisbois, Jayaram, Hakala, & Siddi, 2022). An energy transition for Indigenous communities today means adapting by addressing two main priorities, energy security and energy affordability (Hossain, Loring, & Marsik, 2016; Kvern et al., 2022). However, there is no unified consensus on an appropriate framework for what the unique sustainability transition and engagement process for Indigenous communities could look like.

This research is inspired by the generation of my grandparents, who lived in the era of early move from traditional lifestyles with no use of electricity to the introduction and widespread of electricity and consequent development of modern technology. The first power plant in my home region of Yakutia was commissioned in 1914 and was set in motion by a locomotive. By the beginning of 1920, its capacity was too small, so a larger, combined heat power plant was planned to be built (RAO ESV, n.d.). Yakutia is rich in natural resources, particularly minerals, such as gold, diamond, and copper, and it is fair to say that the overall reason for the development of electricity in Yakutia was natural resources, in particular, gold.
mining activities. As a result, the electricity system of Yakutia is rather disparate and decentralized. Only a decade ago, parts of the decentralized islanded microgrids had been connected to a larger electricity network. This example shows how a transition happened for the generation of my grandparents. This was new and unknown territory and people were not sure how it was going to affect their lives. The approach to energy development was top-down, imposed from outside, and still today follows that trajectory. Thousands of people were affected by consequences connected to the poor handling and development of energy technologies such as the building of the Viluy large hydro plant in the south, underground nuclear experiments in the far north, and others. New energy projects built for mining sites did not provide any revenue sharing or benefits except for the bare minimum needed to keep infrastructure like schools and hospitals in the area, which mostly served the miners.

This story prompted the realization that, today, we face another energy transition where Indigenous communities are significantly rushed by the global actors’ agenda of addressing climate change, and that we all, as a collective, need to find a different approach to developing a new technology, and especially so in northern, remote, and Indigenous areas. Indigenous peoples around the world sadly share a similar history, driven by the policies of ‘extractivism’ (Greer, 2020; Preston, 2017) which is a part of the narrative for a continuing industrial revolution and accelerated energy development. The energy transitions that accompanied successive waves of the industrial revolution have had an impact on every aspect of peoples’ lives. Today, the focus is on what a sustainable energy transition can look like. In this dissertation, I will push this question one step further and ask, “sustainable for whom?”. Using the example of a technology whose adoption is promoted as part of a transition to clean energy production – small nuclear reactors – I will investigate how this transition is being carried out in northern, remote, and Indigenous contexts.

To do so I will employ two theoretical frameworks: sustainability transitions theories and the Indigenous economic development literature. Sustainability transitions theories provide the tools to understand both the conditions for the success and failure of particular clean energy technologies, including SMRs, and the impact that the successful adoption of a technology could have on the larger social technological systems, in this case, energy systems, of which they are a part. The question of the broader impact of changing energy systems in Indigenous communities is a central one in helping communities decide whether proposed changes are, on balance, desirable or not beyond the narrow discussions of
economic costs and benefits. The Indigenous economic development literature, though hampered by an overly simple distinction between “north” and “south”, raises critical questions of governance. Who decides on the meaning of development and the technological investments that could promote or hinder it? With existing governance structures deeply affected by the history of colonial exploitation and extractivism, what prospect is there that Indigenous communities might be able to decide for themselves what they want to transition towards and whether SMRs might have some value for the direction that they have chosen? While Chapters 2 and 3 contain their own literature reviews that form the basis for the analysis of the case studies of clean energy adoption in Chapter 4, I will briefly review both these bodies of work and provide a brief overview of the current state of SMR technology.

1.1. SUSTAINABILITY TRANSITIONS FRAMEWORKS OVERVIEW

The sustainability transitions research aims to conceptualize and explain how sustainable change can occur in the way societal functions are fulfilled. The unit of analysis is socio-technical systems. Kohler et al. distinguish four founding theoretical frameworks in the field of sustainability transitions studies: the Multi-Level Perspective (MLP), the Technological Innovation System (TIS), Strategic Niche Management (SNM), and Transition Management (TM). (Köhler et al., 2019a) In this research, I focus on two of these frameworks, particularly the Technological Innovation System (TIS) and Strategic Niche Management (SNM), however, I will at some points refer to all four of the existing sustainability transitions frameworks.

**Transition Management (TM)** is a multilevel model of governance which shapes processes of co-evolution using visioning, transition experiments and cycles of learning and adaptation. Transition management helps societies to transform themselves in a gradual, reflexive way through guided processes of variation and selection, the outcomes of which are stepping stones for further change. It shows that societies can break free from existing practices and technologies, by engaging in co-evolutionary steering (Kemp, Loorbach, & Rotmans, 2009). Transition management can also be defined as a deliberative process to influence governance activities in such a way that they lead to accelerated change directed towards sustainability ambitions (Loorbach & Rotmans, 2010). Coops et al. (2022) emphasize the need for radical design approaches in societal systems’ transitions and transformations taking into consideration that transitions and transformations can be defined and used in many
different ways depending on people’s backgrounds (Coops et al., 2022). This approach seems problematic in application to the context of our research since the focus of our work is on Indigenous communities and their projects.

**Technological Innovation Systems (TIS)** approach focuses more on the emergence of novel innovations than on the stability of existing systems. Bergek et al. (2008) argue that an innovation system is primarily an analytical construct, i.e. a tool we use to better illustrate and understand system dynamics and performance (Bergek, Jacobsson, Carlsson, Lindmark, & Rickne, 2008). Musiolik, Markard, & Hekkert (2012) argue that the TIS perspective highlights the dynamic interplay of actors and broader institutional structures in technological fields (Musiolik, Markard, & Hekkert, 2012). The development of new technology is understood to result from the positive fulfilment of seven functions which have a direct and immediate impact on the development, diffusion and use of new technologies: knowledge development and diffusion; guidance of the search/ influence on the direction of search; entrepreneurial experimentation/ entrepreneurial activities; market formation; creation of legitimacy/ counteract resistance to change; resource mobilization; development of positive externalities (Bergek et al., 2008; Köhler et al., 2019b). Criticism of TIS includes the claim that it is “inward oriented and does not pay much attention to the system’s environment” (Markard & Truffer, 2008, p. 610) or that “…the actual success of innovation is mainly regarded as a consequence of the performance of the innovation system itself.” (Smith & Raven, 2012, p. 1029).

**Strategic Niche Management (SNM)**, similarly to TIS, focuses on understanding the early adoption of new technologies with high potential to contribute to sustainable transitions. (Schot & Geels, 2008). In SNM, the emergence of radical sustainable innovations is facilitated by the development of technological niches that are “protected spaces that allow nurturing and experimentation with the co-evolution of technology, user practices, and regulatory structures” (Schot & Geels, 2008). The (technological) niches are the spaces where radical novelties are tried out and developed further while being sheltered from mainstream competition (Schot & Rip, 1997). Essentially, SNM is a governance approach to nurturing niches as seedbeds of sustainable innovations and identifies conditions and processes for niches to become robust and influential (Seyfang, Hielscher, Hargreaves, Martiskainen, & Smith, 2014). Three areas of activity which constitute effective niche-building are expectations, networks, and learning. Kemp, Schot, & Hoogma (1998) argue that niches
cannot be controlled, the government can only contribute to the niche formation processes by setting up a set of successive experiments with new technologies (Kemp, Schot, & Hoogma, 1998). Schot and Geels (2008) recognize that niche development could often be related to minimal involvement of outsiders and lack of second-order learning, or to minimal involvement of regime actors which results in a lack of resources and institutional embedding (Schot & Geels, 2008).

The Multi-Level Perspective (MLP) posits that transitions come about through interaction processes within and among three analytical levels: niches, socio-technical regimes, and a socio-technical landscape (El Bilali, 2019). This approach claims to be able to analyze the broader problem framing of innovating entire systems of production and consumption (Smith, Voß, & Grin, 2010). The most important claim of the multi-level perspective, which distinguishes it from TIS and SNM, is that the further success of new technology is not only governed by processes within the niche but also by developments at the level of the existing regime and the sociotechnical landscape (Geels, 2002). The MLP goes beyond studies of single technologies (such as wind turbines, biofuels, fuel cells, and electric vehicles), which dominate the literature on environmental innovation. Geels (2011) argues that although the innovation system approach is multi-dimensional, the cultural and demand side aspects are underdeveloped and it does not address structural change, how emerging innovations struggle against existing systems (Geels, 2011). However, in the interest of this research, I take SNM, TIS and MLP as sustainability transitions frameworks that we apply to the development of renewable energy and SMRs in northern, remote, and Indigenous context.

Sustainability transitions theories have proposed a number of transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption (Geels, 2011; Kivimaa & Virkamäki, 2014; Köhler et al., 2019a; Markard, Geels, & Raven, 2020; Smith et al., 2010). However, they are based on European-centric approaches, where Indigenous communities are largely absent. The “energy trilemma” used to describe the goals of energy policy has a similar issue with its interpretations of its constituents: security, efficiency, and sustainability (Khan, Hou, Irfan, Zakari, & Le, 2021; Marti & Puertas, 2022; World Energy Council, 2019). Historically Indigenous communities have a unique perspective on sustainability that is different from the European-centric approaches (Kouril, 2015; Sheridan & Longboat, 2006; Throsby & Petetskaya, 2016; Tom,
With the accelerated development of technology and innovation, Indigenous nations see value in getting on board with the global prospects of energy transition but want to do it on their terms.

1.2. INDIGENOUS ECONOMIC DEVELOPMENT

There is an existing literature on economic development opportunities for the North, however, most of it is based on the argument that the North and South are different. The claim is that the North, including the provincial North, i.e., Saskatchewan North, is oftentimes ‘forgotten’. Unlocking the potential of the North requires comprehensive economic development and governance strategies (Coates & Crowley, 2013; Coates & Landrie-Parker, 2016; Zhang & Swanson, 2014).

Indigenous communities face a number of economic challenges. They include the risk that communities might not reach economic prosperity and self-sufficiency even with revenues flowing to the communities, and agreements with different levels of government. The National Aboriginal Economic Development Board (NAEDB) argues “… There are many reasons for this, including resource opportunities creating dependence on a single, and often volatile, revenue stream; management systems being overwhelmed by a large influx of revenues; and chronic underfunding of many services and programs placing pressure on Aboriginal governments and their decision-making processes” (Vining & Richards, 2016).

Sustainable economic development with productive enterprises is a critical tool that is required for effective self-governance (Anderson, Dana, & Dana, 2006; Cornell & Kalt, 1998) that an Indigenous community can use to break free of dependency on outside governments (Boyd & Trosper, 2009; Cornell, 2006).

The absence of a strategic plan or an economic development plan that outlines the vision, mission, and role of the economic development corporations (EDCs) can undermine the strategic goals of the community (“Strategic Plan — Haida Enterprise Corporation,” 2011; Westbank First Nation, 2010). Therefore, first, it is important to have strategic plans that identify goals that align with the visions and objectives developed at the community level for economic development. Regarding economic development in the energy sector that can
include plans such as the Community Energy Plan as in the 3 Nations Energy case (“Goals & Philosophy - Three Nations Energy | Solar Farm In Fort Chipewyan,” n.d.).

Economic development corporations play an important role in Indigenous communities. They hold an interesting position by combining public and private elements. Vining & Richards (2016) argue that “Indigenous economic development corporations are not typical private corporations maximizing income on behalf of owners” (Vining & Richards, 2016). They have a focus on collective ownership. The Canadian Council for Aboriginal Business (CCAB) defines Indigenous EDCs as “a major economic driver for Indigenous communities. These community-owned businesses invest in, own and/or manage subsidiary businesses with the goal of providing financial support to advance community interests” (Canadian Council for Aboriginal Business, 2021). Swanson and Bruni-Bossio (2018) define EDCs as “community-owned ventures that are owned and operated businesses across the region or invested in a portfolio of businesses operating in other places” (Swanson & Bruni-Bossio, 2019). However, there are challenges that are associated with economic development in specifically Indigenous communities.

One of the main challenges around Indigenous EDCs is their affiliation with both politics and business. While some argue that they are adopted to separate politics from business (Dion & Hathaway, 1997; Martin, 2016; Poelzer & Coates, 2015; Soonias & Exner-Pirot, 2016), the overarching goal of EDCs is to return profit or other benefits to the community (Canadian Council for Aboriginal Business, 2021; Tulk, 2013; Wilson & Alcantara, 2012). However, although EDCs are owned by the community they are intended to operate independently of political decision-making (Atkinson, 2008; Ratcliff & Company LLP, 2014). “While having some degree of separation between business and politics is highly correlated with success of Indigenous community-owned businesses (Jorgensen & Taylor, 2005; Nikolakis & Nelson, 2015), complete separation can result in lack of communication and generate misunderstandings that can equally harm economic prospects (Booth & Skelton, 2011; Trosper, Nelson, Hoberg, Smith, & Nikolakis, 2008)” (Hotte, Nelson, Hawkins, Wyatt, & Kozak, 2018a). Therefore, they represent a unique form of institution that is specific to Indigenous communities and their worldview and values.
Value conflict is especially relevant in natural resource development, e.g., forestry, “Indigenous communities often have distinct values and paradigms regarding land and forest resources that may come in conflict with paradigms prevalent among non-Indigenous state or provincial forest managers and industry” (Wyatt, 2008). If key partners in the Indigenous community-owned business diverge from the vision, values and goals of the community, the business may lose the trust and support of community members (Hotte, Nelson, Hawkins, Wyatt, & Kozak, 2018b), even if it is able to deliver economic or other benefits (Grant & Taylor, 2007; Jorgensen & Taylor, 2005). For example, in 1992, members of the Meadow Lake community in Saskatchewan blockaded forestry operations of the forest management company in which they were equal owners (Chambers, 1999). One of the reasons was the effect that clear-cut logging with mechanical harvesters was having on their land and their ability to continue traditional practices. Meadow Lake Tribal Council (MLTC) in itself is an interesting and exemplary case of economic development success. Today, they are building a bioenergy plant, a first-of-its-kind green energy biomass project for Saskatchewan. MLTC’s economic development arm has a governance structure with a clear vision, strategy, and plan that benefits its people. Despite the exemplary cases, communities can have internal divisions in views on the development of the projects.

1.3. SMR DEVELOPMENT IN CANADA

In Canada, the energy transition is for the most part driven by the federal government and the energy industry, with provincial utilities supporting the development of innovative technologies. Discussion of the appropriate development of innovative technology with a focus on community energy needs is limited (Hargreaves, Hielscher, Seyfang, & Smith, 2013; Seyfang et al., 2014; Smith, Hargreaves, Hielscher, Martiskainen, & Seyfang, 2016). The rapid and fairly recent development of small nuclear reactors for power generation in Canada, in the shape of small modular reactors (SMRs), provides a good example of this disconnect between what government and industry and communities see as the trajectory to follow. In the policy documents of the government and industry, microreactors (producing less than 5 MWe) are proposed for remote application, which includes northern, remote, and Indigenous communities and resource extraction sites. Larger SMRs (up to 300 MWe) are generally of direct interest to provincially owned utility companies that plan to connect to existing grids, and these sites are going to be in close proximity to Indigenous communities and on their traditional lands.
1.3.1. SMR technology

SMRs can be defined either as ‘small, modular reactors’ or as ‘small and medium-sized reactors’ according to the International Atomic Energy Agency (IAEA) (International Atomic Energy Agency (IAEA), 2020). The power output for a ‘small’ reactor is considered to be up to 300 MWe, and for a ‘medium’ reactor it is between 300 and 700 MWe respectively. ‘Modular’ means that the reactors are assembled from different modules, where each module is a part of a finished plant, not constructed on site (Ingersoll, 2015; Sovacool & Ramana, 2015). Small nuclear reactors have been around for several decades. Ingersoll (2015) argues that “they are neither new to the nuclear industry nor represent a whole new technology” (Ingersoll, 2015). However, their design features intend to offer an energy option to those customers for whom large nuclear plants are not a viable choice.

SMRs can be organized into the following four categories (IAEA, 2013):

(i) Advanced SMRs, including modular reactors and integrated pressurized water reactors (PWRs);
(ii) Innovative SMRs, including small-sized Generation-IV reactors with a non-water coolant/moderator;
(iii) Converted or modified SMRs, including barge-mounted floating nuclear power plants (NPP) and seabed-moored submarine-like reactors;
(iv) Conventional SMRs, those of Generation-II technologies and still being deployed.

The Nuclear Energy Agency (NEA) SMR Dashboards use these categories to propose a timeline for deployment based on technology and regulatory readiness levels. Conventional designs and advanced designs with fewer innovative features are expected to be demonstrated and commercialized before 2030 while more unusual and innovative SMRs may not be commercialized until later in the 2030s. Thus, they identify Phase 1 and Phase 2 for SMR deployment accordingly (NEA, 2023).

The common SMR designs under review include the following:

1. Integral/Compact Pressurized Water Reactors
This design is in the category of advanced reactors. The attractive feature of this design is there is an integration of the main components of the primary coolant system, such as the steam generator, pressurizer, and pumps, with the reactor’s pressure vessel, the so-called Integrated PWR (iPWR). That makes it compact and eliminates large-size piping. E.g., Westinghouse SMR.

2. High-Temperature Gas Cooled Reactors

The high temperature offered by gas (CO2 or helium)-cooled reactors enables higher plant thermal efficiency while operating at low pressure. These advanced SMRs can be used in high-temperature industrial processes, such as electricity cogeneration and hydrogen production. TRISO (TRi-structural ISOtropic particle) fuel is typically utilized in these reactors, whose configuration retains the fission products within the fuel, providing an effective barrier to their release. E.g., U-Battery (U-Battery SMR), Xe-100 (X-Energy SMR).

3. Molten Salt Reactors

In these reactors, the fuel is either incorporated within the coolant in the form of molten salt (e.g., actinide fluorides), or molten salt is used as a coolant of solid fuel. Either concept enables high-temperature operation at near-atmospheric pressure. The use of liquid fuel allows continual fuel makeup and provides the possibility of removing some fission products online. This design is in an innovative SMR category. e.g., IMSR (Integral Molten Salt Reactor).

4. Liquid-Metal Cooled Fast Reactors

Cooling a reactor with a molten liquid (sodium or lead) offers the advantage of high heat removal capacity and a relatively high temperature at low pressure. Using metal as a coolant is necessary for fast reactors that tend to be small in size due to the elimination of the moderator. This reactor is also in an innovative SMR category. E.g., ARC-100 (Advanced Reactor Concepts, LLC. Reactor), Gen-IV (Generation-IV Reactor) (Hussein, 2021).
The GE-Hitachi BWRX-300 currently selected for development in Ontario and Saskatchewan, is a 300 MWe water-cooled, natural circulation Small Modular Reactor (SMR) with passive safety systems that leverages the design and licensing basis of GEH’s existing reactor (“BWRX-300,” n.d.) This reactor is a smaller-scale version of the Economically Simplified Boiling Water Reactor (ESBWR) that is among the least innovative of advanced reactors. As such, it falls under Phase 1 of the NEA’s SMR timeline, along with other so-called more mature reactors. Phase 2 with less mature designs, including advanced and innovative categories of SMRs, is described as based on innovation that will bring about transformative rather than purely incremental change. However, since there is no commercial product yet, the arguments about timelines and transformation are all speculative.

1.3.2. Pros and cons of SMRs

The main advantage of SMRs is their potential contribution to overcome the cost overruns and construction delays in the nuclear industry, caused in part by the trend towards ever-larger nuclear power reactors designed to capture economies of scale. With SMRs, the ‘economy of multiples’ replaces the ‘economy of scale’ (Locatelli, Bingham, & Mancini, 2014). This also means less commitment and risk of large capital outlays upfront. Modern designs offer passive safety features, therefore reducing the risk of severe accidents. More “far-reaching” benefits include water desalination, hydrogen production and a nuclear waste disposal problem with SMRs burning spent fuel and nuclear waste. However, the context for SMR deployment remains the claim that SMRs are low carbon-emission sources of base-load electricity which can contribute to the fight against climate change. It is argued that SMRs can support the economic, environmental, and social pillars of sustainable development (United Nations, 1987).

Another of the SMR “selling points” that is especially relevant to this research is that they may increase electric system reliability in micro-grids in the case of a small off-grid community or an industrial facility (Islam & Gabbar, 2015; Kulynych & Malloy, 1984). Some argue that this feature can also play a role in social justice by supplying isolated and underserved communities with electricity and heat, addressing problems of energy justice and energy insecurity.
Although the main argument for SMR development is based on the contrast of the costs and deployment time of SMRs versus large reactors, proponents argue that SMR designs should also be able to be licensed quite quickly because of experience with operating older reactors that are essentially larger versions of the same design. They claim that past experience can contribute to the licensing of new SMRs, by showing that some safety concepts were already proven, and their viability was demonstrated, which is why the GE-Hitachi SMR design was selected as one of the first reactors to be developed by the provinces of Ontario and Saskatchewan (NEA, 2023).

However, despite all the pros, there are also arguments against SMRs. One of the main cons is that there is no actual detailed operating, maintenance, and decommissioning information for SMRs that can support proper cost-benefit analysis (Mignacca, Alawneh, & Locatelli, 2019). Therefore, SMRs require different metrics because traditional metrics for evaluating the viability of nuclear power plants do not work for them. In particular, a ‘levelized cost of electricity’ (LCOE) normally applies to large-capacity plants since LCOE is “the total cycle cost of the plant normalized by the total energy production of the plant and is usually expressed as cents per kilowatt-hour (or dollars per megawatt-hour)” (Ingersoll, 2015, p. 93). Due to the economies of scale, LCOE is lowest for large plants. Opponents of SMRs have seized on the argument and concluded that SMR sales will need to amount to hundreds or even thousands to make SMRs competitive. However, Nian & Hari (2017) argue, based on LCOE, that a change in investment costs could influence the competitive landscape of power generation technologies (Nian & Hari, 2017). Overall, the total repayment over the lifetime of the SMR is approximately the same as the upfront financial support for a 500 MWe nuclear power plant. Capital and operation and maintenance costs (O&M) are among the most important factors for SMRs competitiveness. In fact, there is a higher level of uncertainty, particularly in O&M costs, because of the lack of operational experience with SMRs.

The broad range of designs and the consequent need to choose between reactors that are difficult to compare present one of the biggest challenges for the SMR technology (Hussein, 2020). Now with different paths and designs chosen, the challenge is that only the most ‘common’ designs will be developed leaving advanced and innovative designs that potentially have applications in remote locations left over on the side. The difference in the stages of approval for SMR designs’ licensing already reveals the disparity in which different SMR designs have different chances of being implemented in the near future. As such, like
NEA Dashboard and SMR Feasibility Study argue the first one to go “on grid” is GE-Hitachi, the design that is most familiar and overall, a smaller version of the larger (pressurized water) reactor (NEA, 2023; OPG, 2021). The pathway for the first order of SMRs is planned to be on a faster pace with lower financial risk. However, other advanced reactor designs including MMRs are also under review for licensing but presumably will take longer time than the selected GE-Hitachi reactor. Therefore, there is a risk that the licensing of advanced and innovative reactors will require extensive time, if developed at all, where building initial SMRs with on-grid application will be already expensive, thus potentially hindering the building of novel reactors and leaving remote communities with no energy option and its benefits.

The challenges of waste and proliferation remain highly debatable issues of broader technical and institutional challenges. In particular, management and disposal of the nuclear waste streams remains actual with current design choices. Krall, Macfarlane, & Ewing (2022) argue that water-, molten salt–, and sodium-cooled SMR designs will increase the volume of nuclear waste in need of management and disposal by factors of 2 to 30. This is attributed to the use of neutron reflectors and/or chemically reactive fuels and coolants in SMR designs (Krall et al., 2022).

As a result, SMR development and deployment on a schedule that could make a serious contribution to further reducing emissions from power generation and energy-intensive industrial processes will require flexibility and adaptation on the part of policymakers. With utilities and industries “leading the way” there is a tendency towards faster decision-making, concurrently substantiated by the “supportive” role of the government and the discourse of climate change urgency. Currently, Ontario Power Generation (OPG) plans to explore the development of four SMR reactors on their sites. Saskatchewan Power Corporation’s (SaskPower) main goal remains SMR and MMRs, taking into consideration their grid capacity and population (OPG, 2021). However, while OPG has plans built upon an existing infrastructure, policies such as of SaskPower’s create a discourse of planning and siting based on a generic vision of the possibility of developing SMRs. The discourse is based on working with stakeholders with no guarantee that the technology will be built. Since public acceptance remains one of the main challenges for nuclear energy in any form, SMRs will require substantial support for education and communication.
In application to remote communities, micro-modular reactors (MMRs) are considered the best fit as they are designed to be self-contained, low-maintenance, ‘plug-and-play’, units that are easily transportable (DOE Office of Nuclear Energy, 2021). Such reactors are proposed for decentralized energy production in remote communities and industrial sites. Some of the designs can provide heat as well as power and most can also be integrated with renewable energy technology to create hybrid and resilient power grids.

Northern and Indigenous communities and heavy industry stakeholders were identified as potential end-users. The claim is that remote mines and communities could provide a viable market for small modular reactors (Moore, 2016; Wojtaszek, 2019). However, with SMRs in northern, remote, and Indigenous areas there is an issue of appropriateness versus need. The literature on SMRs for remote application is limited and vulnerable to the counter-argument that even MMRs will be both too large and too expensive for the needs of small and isolated communities. (Froese, Kunz, & Ramana, 2020). Because of the diseconomy of scale, the expenses associated with constructing and operating a reactor in remote locations do not increase in direct proportion to the power generated (Froese et al., 2020). The results of the LCOE calculations show that solar energy is the lowest-cost option, followed by wind, and then diesel, while power from SMRs is calculated to be ten times more expensive than that from diesel and renewables (Froese et al., 2020). From the financial perspective, the viable option for SMRs might be in niche markets, for example, off-grid remote mines and communities that use diesel plants with very high fuel costs. Therefore, depending on whether the community is on- or off-grid, the ‘appropriateness’ of the nuclear option can vary.

From a technical standpoint, SMRs, wind, solar, and diesel all play different roles in power system operation. However, from the ‘need’ perspective, SMRs can potentially become a technology that can provide economic development and reduction of dependency for Indigenous communities. Many northern, and in particular, Indigenous communities, have an interest in autonomy as well as maintaining a good relationship with the land. Therefore, rather than SMRs, they see renewable as the technology that can bring economic benefits and that aligns with community values and connection to the land (Cherniak, Dufresne, Keyte, Mallett, & Schott, 2015; Keyte, 2015).
This research will study the development of clean energy from a socio-technical perspective whether their experience of becoming increasingly feasible technology will provide insights for SMRs and whether SMRs can become the technology that put forward economic independence and abundance for Indigenous communities. Despite unpromising LCOE metrics, SMRs are still on their way to being deployed as per utilities’ plans by 2030. Policymakers have done substantial work in creating discourses, raising credibility for people on the feasibility of SMRs using different metrics and tools. For northern, remote, Indigenous communities, the nuclear question becomes a matter of the right size and what people need and want. Energy issues for northern, remote, and Indigenous communities include affordability, efficiency, and security. There are problems to which SMRs could be solutions.

While SMR plans will all need to include the regulatory requirements of the ‘duty to consult’, Indigenous perspectives have not been properly researched and developed through direct engagement with the communities. The dominant narrative remains that of contributing to broader societal clean energy goals by transitioning and accelerating innovative technology with unclear processes for community engagement and community visions of the energy future (Doyon, Boron, & Williams, 2021; Henderson, 2013).

1.4. RESEARCH GOALS

This dissertation strives to push these arguments further by understanding Indigenous approaches to problem definition and problem framing. It will investigate whether traditional sustainability transitions theories can do justice to the ways in which Indigenous peoples frame their own energy transition and understand how to engage with Indigenous peoples, not objectifying them but including them as full partners.

The case chosen is whether industry and government can understand and engage with Indigenous communities and their perspectives of energy sustainability with respect to clean energy technologies, in particular SMRs. I argue that there will be a key role for intermediaries here, but, once again, the concept of “transition intermediaries” developed in the sustainability transitions literature needs to be substantially revised and extended to accommodate the Indigenous context. Using interviews with community leaders and government and energy industry workers, I will show that there is a disconnect between Indigenous community and government and industry perspectives on sustainability transition
and a fundamental misalignment of expectations between Indigenous communities and their partners. Intermediaries will be essential to bridge that gap and bring about a realignment of perspectives that does justice to Indigenous expectations for a clean energy transition in their communities.

Traditionally, sustainability transitions theories have been centred around technological development, where social factors have been used mainly to explain the success or failure of particular innovations. However, there is recent research that shifts focus towards a combination of the technical and social where factors like institutions, culture and behavioural patterns play more prominent roles as drivers of change (Concilio, Bianchi, & Tosoni, 2023). In some technology, the role of institutions and actors is emphasized more. I acknowledge these developments as helpful in understanding how Indigenous communities can take part in and even initiate transitions. Indigenous governance becomes part of the broader socio-technical regime that confronts an innovation like an SMR and helps determine its prospects, but the dissertation will stress that we should not lose sight of the possibility that Indigenous communities can also be places for niche innovation.

Governance encompasses the steering processes within these complex systems, in particular coordination of actors by formal and informal institutions to achieve common goals. The community case studies reveal communities aligned with their goals, perceptions, knowledge and values, technological possibilities, institutional settings, and infrastructure, all of which contribute to a different vision of energy technology and its role in the community. The challenge for the intermediaries is to be true to this vision and to connect it to the very different ways that government and industry understand a sustainable energy transition.

Thus, this dissertation has two goals: the first is to demonstrate how sustainability transitions theories can be modified to respect the Indigenous vision of an energy transition that respects Indigenous worldviews. The second goal is to provide policy support for the role of intermediaries in the sustainable energy transition, especially in translating the Indigenous vision to government and industry, focusing on the potential of SMRs. In other words, how is a sustainable energy transition possible in northern, remote, and Indigenous communities, in particular transition to implementation of clean energy such as SMRs, taking into consideration not only broad policy, socio-economic, and environmental concerns but Indigenous worldviews and experience?
Since SMRs only exist at the moment as demonstration projects, much of the argument is based on the lessons from the deployment of other clean energy technologies. Here, the dominant narrative of adopting new technologies for an accelerated transition to clean sources of energy to address the climate crisis is not aligned with what Indigenous nations are experiencing. That experience is not so much about the capacity building of Indigenous nations - that has been a statement for decades and not much has changed - but about the linking of the skills and tools, that now exist or can be potentially accumulated within the communities and nations, with the ‘mainstream’ government and industry requirements. Transition for communities involves getting into something far more technical and difficult where you need an intermediary that can provide guidance and support in every stage of the project development process. From the sustainability transitions theory perspective, Indigenous intermediaries can modify the socio-technical regime where a different vision of governance takes place. This research uncovers that Indigenous-based intermediaries have a vision that is different from non-Indigenous-based intermediaries. Both are driven by a common goal of a sustainable future but have a different understanding of the process and outcomes.

Finally, a note on terminology. There is a difference between the terms renewable, clean, and sustainable, although they are sometimes used interchangeably. There is an overlap, however, “renewable energy is defined by the time it takes to replenish the primary energy resource, compared to the rate at which energy is used. Sustainable energy is derived from resources that can maintain current operations without jeopardizing the energy needs or climate of future generations. The most popular sources of sustainable energy, including wind, solar and hydropower, are also renewable” (JHU, 2021). Green energy is a subset of renewable energy. Whereas “clean energy is electricity that does not create any greenhouse gasses during its production – although it is not necessarily renewable. And so, while all forms of green and renewable energy are also “clean energy”, so is nuclear power as it does not create any carbon emissions or pollutants during generation (“Difference Between Green, Renewable, and Clean Energy?,” n.d.).

Therefore, SMRs are not renewable but proponents describe them as clean, although some might disagree with that as well. While both of these are essentially non-Indigenous categories, the term renewable in the context of this research is the closest to the Indigenous
perspective. Renewables are considered a part of the clean energy discourse, so, there’s value in studying those practices and applying them to the potential SMR technology implementation. SMR development is very challenging, but there’s a real opportunity for implementation of the technology if we can bridge the gap between perspectives on sustainability transition from government/industry and communities. Otherwise, there is a chance that the technology even though it might ‘break out of the niche’ would not be able to have accelerated adoption. Thus, I aim to provide community-based and community-informed policy recommendations for accelerated technology implementation that would contribute to the Indigenous community’s clean energy sustainability transition.

1.5. RESEARCH STRUCTURE AND METHODS

This research is a manuscript-style thesis with a three-manuscript structure. The first manuscript is the systematic literature review of sustainability transitions literature that provides an overview of two ST theories: the Technological Innovation Systems approach and Strategic Niche Management and their case studies. The first manuscript became a foundation for this research and provided lessons for further papers. The second manuscript identifies the role of intermediaries and discourses around the development of SMRs in Canada using secondary data analysis and semi-structured interviews with government/industry and community energy projects leaders. The third manuscript is the community-based and community-informed research using case studies of clean energy technology development, in particular, renewable energy technology development in northern, remote, and Indigenous communities.

Literature review

The literature review has been conducted for Manuscript 1 (Chapter 2) and Manuscript 2 (Chapter 3) as methods to help identify and critically appraise relevant research, as well as collect and analyze data (Liberati et al., 2009). The aim of a literature review is to identify all empirical evidence that fits the pre-specified inclusion criteria to answer a particular research question or hypothesis (Moher et al., 2009). A systematic literature review has been conducted for the first manuscript (Chapter 2) and a scoping review for the second manuscript (Chapter 3), and the methods used are described more fully in these chapters.
A systematic literature review was conducted to identify gaps in the current evidence and help inform further research in the area of sustainability transitions. The scoping review (Mak & Thomas, 2022; Munn et al., 2018) included secondary data analysis that determined the scope of a body of literature on SMRs to identify SMR discourses. The scoping review included both peer-reviewed and non-peer-reviewed materials on SMRs. I included non-peer-reviewed literature due to the novelty of research in SMR in academic literature and the importance of applied knowledge and non-academic experience in the field. Data were chosen using a comprehensive Web search with the words ‘SMR’ AND ‘Technology’ AND ‘Canada’. Documents were selected based on the context of whether they included discourses around SMR development in Canada. The documents revealed a set of themes. All documents were analyzed using NVivo software. The coding process used a Thematic Analysis approach. This process helped to create a comprehensive list of themes of government and industry perspective on SMR development and engagement with northern, remote, and Indigenous communities.

**Interviews**

Interviews offer researchers the opportunity to uncover information that is “probably not accessible using techniques such as questionnaires and observations” (Blaxter, Hughes, & Tight, 2006, p. 172). Interviews for the second manuscript (Chapter 3) and the third manuscript (Chapter 4) were conducted via Zoom, were conversational in nature and began with a brief overview of the research topic. Interviews were semi-structured and explored the perspectives of government and industry and Indigenous communities, what they think is important when developing energy projects and how they see engagement with Indigenous communities. Discussions were focused on the interview protocol but followed lines of inquiry to delve more deeply into issues of importance as they emerged.

Several interviewees were initially identified based on the secondary data analysis. Then participants were added with the use of the snowball sampling for both Manuscript 2 (Chapter 3) and Manuscript 3 (Chapter 4), where each interviewed person was asked to provide a recommendation on the next two interviewees. This sampling method might generate biased samples because respondents could provide investigators with a higher proportion of other respondents who have characteristics similar to that initial respondent (Erickson, n.d.). However, the snowball sampling allows participants to make estimates about
the social network connecting the researched sample (Etikan, 2016). For Manuscript 2 (Chapter 3) since SMR is an emerging technology and nuclear is a highly regulated and relatively closed industry, this sampling technique was necessary. The recruitment of interviewees and interviews for Manuscript 2 (Chapter 3) was done when data from interviews reached saturation, “the point during data analysis at which incoming data points (interviews) produce little or no new useful information relative to the study objectives” (Guest, Nameyid, & Chen, 2020; Saunders et al., 2018). The saturation was reached when 21 interviews of different SMR stakeholders were conducted. For Manuscript 3 (Chapter 4), interviewees were selected using the snowball technique with initial advice from the community advisor. However, the sampling was not aimed to reach saturation. The number of interviewees was two people for each case study, except for the Tazi Twé project with one community representative. The selection and recruitment of participants were limited due to a number of reasons I describe in the Limitations of Research section. The interviewees from each case study were selected to specifically obtain information on the community governance of the case study projects. I chose community projects leaders who are/were directly involved in the project from each of the four cases with extensive expertise and a well-rounded perspective on the cases. The samples are small but it is to support the depth of case-oriented analysis that is fundamental to this mode of inquiry (Patton, 1991; Sandelowski, 1996).

The interviewees were divided into two categories: government and industry involved in energy and SMR development and clean energy community projects. The selection of interviewees was based on the government/industry and community representatives who could provide narratives from the government and industry perspective and from community projects perspective. The government and industry interviewees were not tied to any community projects. The goal for the two categories was to identify alignment and/or disparity between industry and government and communities’ perspectives using triangulation of the information from the literature and interviews (Bowen 2009). All the interviews were transcribed and coded using NVivo software. Given that the detailed methods sections are included in chapters, rather than putting more information here, I provided a description of all steps for methods and the NVivo coding process with the identified themes in Appendix A.

Community interviews were used for case studies. The case studies “attempt to arrive at a comprehensive understanding of the event under study but at the same time to develop
more general theoretical statements about regularities in the observed phenomena” (Fidel, 1984). Case studies “may be epistemologically in harmony with the reader’s experience and thus to that person a natural basis for generalization” (Stake, 1978). There are a number of community energy projects that are currently being developed at a quite rapid scale. However, I chose four case studies of community projects that provide unique contributions to the outcome of this research. First, they include different technologies, such as solar, hydro, and biomass, with different capacities from very small-scale solar (190 kW) to large-scale hydro (50 MW). Then they are on-grid and off-grid projects. The projects also include different Indigenous groups, such as Cree, Dene, and Métis Nations across the provinces of Saskatchewan and Alberta (see Table 1.1 for more detailed information). They also represent both successful and unsuccessful projects.

Table 1.1. Community projects

<table>
<thead>
<tr>
<th>Projects</th>
<th>Meadow Lake</th>
<th>Tazi Twé</th>
<th>Fort Chipewyan</th>
<th>Muskodany</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location (Aboriginal Affairs and Northern Development Canada, 2014)</td>
<td>SK</td>
<td>SK</td>
<td>AB</td>
<td>SK</td>
</tr>
<tr>
<td>Indigenous groups number (from community interviewee data)</td>
<td>9</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Projects (community interviewee data)</td>
<td>Biomass 2 sawmills: 1) In Meadow Lake 2) In Glaslyn for a post plant for wood</td>
<td>Hydro run-of-the-river</td>
<td>Solar farm</td>
<td>Solar 2 projects</td>
</tr>
<tr>
<td>On-/off-grid (community interviewee data)</td>
<td>On-grid</td>
<td>On-grid</td>
<td>Off-grid</td>
<td>On-grid</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>--------</td>
<td>--------</td>
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<td>--------</td>
</tr>
<tr>
<td>Capacity (community interviewee data)</td>
<td>6.6 MW</td>
<td>50 MW</td>
<td>2.35 MW (+600 kW owned by ATCO)</td>
<td>514 KW: 1) 190 kW 2) 324 kW</td>
</tr>
<tr>
<td>Funding (community interviewee data)</td>
<td>$52.5 million from NRCan</td>
<td>Project cost reached under $900 million but was shelved</td>
<td>$7.76 million: $4.5 million from NRCan $3.3 from Government of Alberta</td>
<td>1) $375,000 from NRCan 2) $250,000 from NRCan</td>
</tr>
<tr>
<td>Ownership (community interviewee data)</td>
<td>100% Indigenous owned</td>
<td>Offer included 49% ownership, 50/50 profit share</td>
<td>100% Indigenous owned</td>
<td>100% Indigenous owned</td>
</tr>
<tr>
<td>Main goal (community interviewee data)</td>
<td>Revenue generation for owner nations</td>
<td>Stable power source, revenue generation</td>
<td>Offset diesel generation, support local grid. Self-sufficiency, stake in their own energy system.</td>
<td>1) Community development project with a social component 2) Revenue generation</td>
</tr>
<tr>
<td></td>
<td>1) Community development project with a social component 2) Revenue generation</td>
<td>Both aimed to reduce GHG emissions, decrease the amount of electricity consumed by 40%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Governance (community interviewee data)</td>
<td>Self-managed and developed</td>
<td>Outsourced management</td>
<td>Outsourced to a different company the whole process and outsourced management</td>
<td>Self-managed and developed</td>
</tr>
<tr>
<td>Governance structure (community interviewee data)</td>
<td>MLTC Resource Development Inc. (RDI) (overlooks partnerships) ↓ MLTC Industrial Investments (MLTC II) – economic development arm</td>
<td>PADC (Prince Albert Development Corporation) – business and investment corporation owned by 12 FNs</td>
<td>Three Nations Energy (3NE) – company owned by 3 FNs</td>
<td>MEDA (Muskoday Economic Development Authority)</td>
</tr>
<tr>
<td></td>
<td>MEDA prepared the application, FN applied, got approved, then</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Governance Body (community interviewee data)

<table>
<thead>
<tr>
<th>Governance Body</th>
<th>RDI Board of Directors: 9 Chiefs from FNs Tribal Chief 2 external Board members</th>
<th>PADC Board of Directors: 12 First Nations Chiefs</th>
<th>3 NE Board of Directors: 2 governors from Mikisew Cree FN 1 political and 1 administrative senior executive person from Athabasca Chipewyan FN and Fort Chipewyan Métis Association</th>
<th>MEDA Board of Directors: 4 Muskoday FN members 3 independent members Recently added an executive director and a non-voting chair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiative (community interviewee data)</td>
<td>FN’s request for proposal</td>
<td>ATCO approached first</td>
<td>FN through FNPA</td>
<td></td>
</tr>
<tr>
<td>Contract (community interviewee data)</td>
<td>Supposed to be PPA with SaskPower</td>
<td>Owned, sold back to ATCO</td>
<td>PPA with SaskPower</td>
<td></td>
</tr>
<tr>
<td>Dates (community interviewee data)</td>
<td>Completed and started to operate in 2022</td>
<td>Shelved in 2017</td>
<td>Completed and started to operate in 2020</td>
<td>Completed and started to operate in 2022</td>
</tr>
</tbody>
</table>

My research aims to expand the traditional understanding of the policy framework for innovative technology adoption in northern, remote, and Indigenous communities. It is expected to deliver relevant insights for policymakers and Indigenous leaders about the various dynamics affecting the Indigenous groups’ participation in sustainable innovative technology transitions.

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Chapter 2 of this dissertation has been published. Chapters 3 to 4 of this dissertation consist of manuscripts that are being submitted for publication. For each of the manuscripts, as per the College of Graduate and Postdoctoral Studies guidelines for manuscript-style
theses, the student is the first author and is primarily responsible for the content. The following is a list of all authors for the each of the three manuscripts:

- Chapter 3: Iakovleva, M., & Rayner, J. (2023) (preprint)
- Chapter 4: Iakovleva, M.
LIMITATIONS OF RESEARCH

The connection and engagement with communities and this research in general have been greatly affected by the COVID-19 pandemic. Originally, the research plan included in place community interviews with community members. However, all the interviews were moved to be conducted online via Zoom, which created limitations for this research in depth of the scope and building personal relationships. As an Indigenous person, I understand that building relationships in the community is part of Indigenous culture and practices but, limited by the pandemic, I was restricted to conducting interviews online. Conducting interviews online created a barrier to recruiting participants from the community projects. Indigenous communities prefer interpersonal communication in establishing contacts, therefore, interviewees from communities are limited to two for three of the case studies and to one in the Tazi Twé project. The latter was more difficult to recruit since the project was unsuccessful, hence creating an impediment to finding people directly involved or affiliated with the development of the project. Online interviewing is absolutely not my preferred way of conducting this research; however, in-person, unfortunately, was not deemed to be possible. Even with lighter COVID-19 restrictions, another reason was not to put community members at risk. Therefore, among the limitations, the interviewees’ responses could have less openness and transparency, which in some cases could be even if conducted in person. That might potentially have led to the lack of trust of people in how much they could actually share. This also goes to the government/industry interviewees, who, however, could be bound to that by professional responsibilities and obligations to non-disclosure.
CHAPTER 2. BREAKING OUT OF A NICHE: LESSONS FOR SMRS FROM SUSTAINABILITY TRANSITIONS STUDIES

A version of this chapter has been peer-reviewed and published in the journal *Nuclear Technology* as a co-authored publication with my co-supervisors Dr. Jeremy Rayner and Dr. Ken Coates.


This chapter reviews clean energy technology innovation case studies that apply two popular sustainability transitions frameworks – strategic niche management (SNM) and technological innovation systems (TIS). I focus on those that include policy-relevant recommendations that could be applied to the challenges posed by successfully scaling up SMRs from prototypes to commercial production. An important contribution of this chapter is that it provides reflections on the challenges of applying the Euro-centric approaches in the sustainability transitions literature to non-European environments, including remote, northern, and Indigenous communities. The results reveal five lessons for policy development that reflect the current situation with SMRs and support evidence-informed decision-making in communities currently considering SMRs as part of a future clean energy mix.

2.1. INTRODUCTION

Canadian interest in small modular reactors (SMRs) remains significant. Growing demand for clean power generation to meet climate change mitigation goals, the presence of an existing nuclear engineering capacity, and potential demand at both ends of the small design spectrum, from baseload power in smaller jurisdictions (~300MWe) to reliable power in remote communities (5-30 MWe), are all contributing to this interest. In northern communities, in particular, there is evidence that energy security concerns will be the dominant driver of clean energy technology choices (Coates & Landrie-Parker, 2016). A stakeholder-driven process convened by Natural Resources Canada resulted in the SMR
roadmap released in 2018 (Canadian Small Modular Reactor Roadmap Steering Committee, 2018) and the Province of New Brunswick continues with its efforts to create an energy research cluster that will lead to the production of an advanced SMR in the province. The governments of Ontario, Saskatchewan and New Brunswick signed a memorandum of agreement on December 1, 2019, pledging to work together to develop SMRs in Canada. (Alberta has since joined the provincial effort.) SMR research may play a part in the refurbishment of the Canadian Nuclear Laboratories (CNL) site at Chalk River, Ontario and, more speculatively, in the former Atomic Energy of Canada Limited (AECL) research facility at White Shell, Manitoba (CNL, 2019).

Nonetheless, there is still a very high probability that SMRs in Canada and elsewhere will share the fate of many other promising technologies and fail to scale up from prototypes and experimental designs to commercial production. The scaling challenge for SMRs is particularly acute since large-scale modular production is essential to the business case for smaller reactor designs. Social acceptability, while much more controversial in other countries and among energy policy researchers than in the Canadian policy environment, remains a factor in almost all energy technology choices, and not only where nuclear technologies are concerned. However, it is important not to lose sight of the broader lessons from the innovation literature in considering the kind of policy environment that can support scale-up and successful adoption.

The policy literature on SMRs is currently quite small and necessarily speculative. We review two existing literatures drawn from the broader field of sustainability transitions, namely strategic niche management (SNM) and technological innovation systems (TIS), in which there has been a sustained focus on case studies of clean energy innovation. Almost all are studies of innovation in renewable energy. Drilling down further into case studies involving energy innovation in North America, the Nordic countries and Russia, we isolate cases in which the authors have drawn more broadly applicable lessons to answer our three research questions: (1) what are the factors tending to support the success of clean energy innovation and those which contributed to failure? (2) of these factors, which are likely to be most relevant in the success or failure of SMRs? (3) what is the potential role of public policy in addressing the challenges identified in the case studies?
2.2. CONTEXT

According to the International Atomic Energy Agency (IAEA), the power output for a ‘small’ reactor is considered to be up to 300 MWe. ‘Modular’ means that the reactors are assembled from standard components, where each component is a part of a finished plant, not constructed on site. At present, however, SMR designs for power generation differ “by power output, physical size, fuel type, enrichment level, refuelling frequency, site location, and spent fuel characteristics” (Sovacool & Ramana, 2015, p. 101). They also vary by the level of development, from those few already in operation (e.g., the Russian KLT-40 floating power plant or Chinese HTR-PM reactor) to experimental designs that have not yet commenced regulatory review. The International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency (NEA) consider SMRs to have many potential benefits: opening up additional energy markets, providing a contribution to CO2 reduction, offering a scalable response to slower growth in energy demand, a better fit for small electricity grids, and a replacement for older fossil fuel plants. To varying degrees, all these benefits remain on the table, yet development and, more importantly, deployment of SMRs has been frustratingly slow.

Traditional analyses of the challenges that continue to hamper the development and deployment of SMRs range from the relatively optimistic (Ingersoll, 2015) to the profoundly negative (Mez, 2012; Sovacool & Ramana, 2015). The challenges are usually summarized as technical, social and institutional, including the business case for SMRs.

Technical challenges are not so much an engineering problem as a consequence of the failure of vendors and potential buyers to agree on a small number of potentially promising designs. The result is regulatory uncertainty. Nuclear power generation remains heavily regulated and new design configurations or additional developments in designs will have to be tested and validated. Alternatives to small PWRs will inevitably attract significant regulatory scrutiny. While delays may be reduced by using computational analysis methods to predict the safety of the reactor components and systems, innovative designs will take longer to bring into service in large numbers.

Social challenges are embedded in the controversial history of nuclear power, the legacy of high-profile accidents, and ongoing public concerns with the safe long-term storage of nuclear waste. Implausible though this may seem to some, concerns about the potential for
the deployment of large numbers of widely dispersed small reactors to promote harmful nuclear proliferation have already been expressed.

In addition to the regulatory environment, institutional challenges include a range of legal and business issues. As with the regulatory issue just noted, prevailing models of risk, legal liability, rates of return and project management are strongly influenced by incumbent technologies, in this case, large nuclear power generation facilities. The rapidly changing business landscape for power generation and uncertainty about future power grid configurations offer both challenges and opportunities for SMRs.

The business case for SMRs also remains uncertain. While proponents have argued that shorter construction time, faster time to first revenue, and higher reliability in fabrication costs and scheduling will significantly reduce financial risk compared with larger projects, much of the business case rests on the potential for modular factory or on-site production to reduce unit costs and rapidly recoup the substantial initial outlay in research, development, testing and regulatory approval costs. Parallels have been drawn with commercial aircraft manufacturing to explain the business case for SMRs but the implications of this analogy for medium-sized countries like Canada are not especially reassuring.

2.2.1. A new look at SMRs: nuclear innovation and sustainability transitions

From an innovation perspective, the challenges listed in the previous section amount to a significant handicap for SMRs in comparison with existing power generation technologies. However, the fact that an innovation starts at a disadvantage with respect to incumbent technologies is not in itself at all unusual. In the innovation literature, it is referred to as the problem of “bridging the ‘valley of death’ between R&D and market introduction” (Schot & Geels, 2008, p. 538). As already noted, regulators are suspicious of unfamiliar technologies, investors have difficulty translating financial uncertainty into manageable risk, and end users are often both innately conservative about familiar technologies and unaware of the potential benefits provided by innovative alternatives. The deck almost always seems stacked against the newcomer. What is unusual about SMRs is the length of the list of challenges and the crowded market of alternative technologies promising to navigate the transition to clean power generation targets. In many countries, clean energy goals are
increasingly stringent and, more damaging still, coming increasingly imminent when the large-scale deployment of SMRs is still so far away.

It may seem paradoxical that we turn to the literature on competing technologies, especially renewables, for lessons that could speed up the deployment of SMRs. However, even the now familiar wind turbines and PV panels were once in exactly the same situation as SMRs; many renewable technologies, for example, third-generation biofuels, large-scale battery power storage, and electric heavy goods vehicles, are still there. Their challenges and their successes and failures have been widely studied in the context of a broad transition to more sustainable energy production, distribution and consumption. The case for the adoption of SMRs is now most often placed firmly in the context of this transition. We thus review case studies of renewable energy technologies in the sustainability transitions literature, with a focus on case studies from which policy-relevant lessons are drawn.

A key feature of the sustainability transitions literature is its focus on the broad challenge of modifying entrenched socio-technical systems. Socio-technical systems “encompass production, diffusion and use of technology”, and, in transitions theories, imply co-evolution of the elements of the system forming strong functional relationships that are very difficult to change. In a helpful overview, Köhler et al. (2019) distinguish four founding theoretical frameworks in the field of sustainability transitions studies: the Multi-Level Perspective (MLP), the Technological Innovation System (TIS) approach, Strategic Niche Management (SNM), and Transition Management (TM) (Köhler et al., 2019a). We focus on two of these frameworks, TIS and SNM. For our purposes, they focus more on the emergence and facilitation of a new technology/innovation, rather than system-level questions of transition pathways that occupy the other frameworks. This feature of TIS and SNM has sometimes attracted criticism but makes them especially appropriate for answering our questions about SMRs.

2.2.1.1. Technological innovation system (TIS)

The Technological Innovation System (TIS) is defined as “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). Alternatively, it is a “set of networks of actors and institutions that jointly interact in a specific technological field and
contribute to the generation, diffusion and utilization of variants of a new technology and/or a new product” (Markard & Truffer, 2008, p. 611). The key terms are deliberately broadly defined. Thus, actors include firms, universities and research institutes, financers, consultants, associations, private consumers and public facilities with different competencies, resources, and strategies. Institutions include norms, standards, regulations, values, collective expectations, cognitive frames, culture etc. that facilitate and constrain the decisions and activities of actors. TIS emphasizes the dynamic interplay of actors and institutions in technological fields (Bergek et al., 2008; Carlsson & Stankiewicz, 1991; Edquist, 2006). For any given technology, a TIS may be a sub-system of an existing policy sector, such as energy or transportation, or may cut across several sectors (Bergek et al., 2008).

The main practical relevance of TIS theory is to identify system failures in the emergence of new technologies and to derive recommendations for technology-specific policies to remedy these failures (Bergek et al., 2008; Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007; Jacobsson, Sandén, & Bångens, 2004). To do so, TIS-based analysis usually takes a functional approach, mapping activities that take place in the generation and diffusion of innovations that contribute to technological change. Functions are the activities in an innovation system that contribute to the system’s goals of developing, applying, and diffusing new technological knowledge (Bergek et al., 2008). The idea that successful innovation requires the performance of a number of key functions is clearly based on an evolutionary approach to the social sciences, particularly evolutionary economics.

TIS-based studies usually identify seven key processes, which have a direct and immediate impact on the development, diffusion and use of new technologies (Bergek et al., 2008; Hekkert et al., 2007; Köhler et al., 2019a), which are mapped using a series of indicators:

- Knowledge development and diffusion
- Guidance of the search/ Influence on the direction of search
- Entrepreneurial experimentation/ Entrepreneurial activities
- Market formation
- Creation of legitimacy/ counteract resistance to change
- Resource mobilization
- Development of positive externalities
Combining these functions, Köhler et al. (2019) distinguish a scheme of analysis that consists of six steps leading to explicit policy recommendations:

1. Set the starting point for the analysis, i.e., defining the TIS in focus.
2. Identify the structural components of the TIS (actors, networks and institutions).
3. Move from structure to functions. Come up with a picture of an “achieved” functional pattern, i.e., a description of how each function is currently filled in the system.
4. Assess how well the functions are fulfilled and set goals in terms of a ‘desired’ functional pattern.
5. Identify mechanisms that either induce (drive) or block a development towards the desirable functional pattern.
6. Specify key policy issues related to these inducements and blocking mechanisms.

The policy should specifically aim at remedying poor functionality in relevant TISs by strengthening/adding inducement mechanisms and weakening/removing blocking mechanisms. By analyzing weaknesses in the functional pattern of the TIS we can identify the key blocking mechanisms that, in turn, lead us to a specification of the relevant policy issues (Köhler et al., 2019a).

TIS proponents have argued that this analytical scheme (see Figure 2.1) effectively replaces the rather narrow justification for policy interventions that address market failures in traditional economic approaches to innovation with a broader and more challenging remit to address “system failures” that threaten successful scale-up to commercial success.
2.2.1.2. Strategic Niche Management (SNM)

While TIS has an explicitly functionalist approach to the construction of a “safe space” in which innovative technologies can be protected against the adverse selection pressures coming from an established socio-technical regime, the Strategic Niche Management (SNM) approach is, at first glance, less prescriptive about what is required for successful innovation. However, it, too, employs very similar evolutionary metaphors, including its central idea of niches as “protected spaces that allow nurturing and experimentation with the co-evolution of technology, user practices, and regulatory structures” (Schot & Geels, 2008, p. 538). SNM then focuses on the governance of a small number of key processes that are required to protect niches and, finally, to allow the technology to make the transition from niche to mainstream (Seyfang et al., 2014).

Paralleling the seven TIS functions, SNM-based accounts often focus on ‘three internal niche processes’ (Kemp et al., 1998; R. P. J. M. Raven, 2005; Schot, Hoogma, & Elzen, 1994):

1. **Expectations and visions**
   Articulation of expectations and visions is crucial because it provides direction to the development/learning process, attracts attention and resources as well as new actors, and legitimate (continuing) protection and nurturing.

2. **Social networks**
   A successful niche development requires a new combination of actors, preferably coming from previously unconnected fields and disciplines, creating a constituency behind the new technology, facilitating interactions between relevant stakeholders, and providing the necessary resources).

3. **Learning**
   Appealing to a familiar systems theory distinction, (Hoogma, Kemp, Schot, & Truffer, 2005; Kemp et al., 1998) argue that niche-level learning includes both first- and second-order learning. Thus, learning needs not only to accumulate facts, data, and lessons about how to improve the technology but also to generate alternative cognitive
frames and different ways of supporting the niche. Two-level learning enables adjustment of the technology and/or social embedding to increase the chances of successful diffusion.

Recently there has been a shift in focus in SNM from studying the interactions between the three niche-internal processes towards understanding the larger context of innovation. This latter process includes actors embedded in networks who are willing to invest resources in experiments based on a shared, positive vision of an innovation. Under the influence of this shared vision, niche development progresses at two levels simultaneously: the level of projects in local practices and the global niche level (Schot & Geels, 2008). Thus, the transition experiments by local networks provide space for local activities but also create learning opportunities that may be aggregated into generic lessons and rules. Outcomes are also reflexive as they adjust previous expectations and enrol more actors to expand the social network (see Figure 2.2).

As already noted, SNM lessons tend to focus less on policy and more on governance, in the sense of “steering” the niche towards self-sufficiency. A range of actors are involved in steering, including users, societal groups and state actors. Steering can address many parts of the process, by adding a new actor, a specific learning process or a set of demonstration projects which may redirect evolving dynamics towards a desired path. Niches, it is said, emerge through a process of collective enactment and SNM has been called a form of reflexive governance (Voss, Bauknecht, & Kemp, 2006).
Figure 2.2. The dynamics of niche development trajectories (R. Raven, Bosch, & Weterings (2010))

2.3. METHOD

Using the two main scientific journal database platforms, Scopus and Web of Science (Core Collection), we searched for all publications using the two framework terms: Strategic Niche Management (SNM) and Technological Innovation System (TIS) in the title and/or in abstract, with a date range of 1900-2019. The overall number of articles revealed for SNM in the Scopus database was 566 and in Web of Science 481. The number of articles for TIS in the Scopus database was 15,731 results and in Web of Science 10,070, the latter results reflecting the number of studies of technology and innovation in these databases.

Second, the results were manually screened based on the presence of the combination keywords and a case study. A total of 129 case studies for SNM and 101 for TIS were chosen for the analysis. The peak year for both frameworks in publications is 2018 with a total of 49 papers (17-SNM, 32-TIS). Other peak years for SNM are 2017 and 2019, whereas for TIS they are 2015 and 2019. The total number of papers for those peak years is 59 out of 230. This makes 108 papers in total for all peak years, which comprises about 50% of all chosen publications (see Figures 2.3 and 2.4). The screening revealed 24 papers for both SNM and TIS that included descriptive or comparative analyses of both theoretical frameworks (i.e., without case studies). They are categorized separately as theoretical papers. The articles represent a wide range of subjects and geographical locations.
Third, for the purpose of the paper, case studies were divided into energy and non-energy categories depending on the nature of the case studies. The energy category includes different types of energy production (hydrogen, biofuels, etc.), energy efficiency technology and methods, renewable energy technology (wind, solar, biomass), and transport (electric, hybrid vehicles, and others). The non-energy category encompasses agriculture, infrastructure (eco-industrial parks), the IT sector (eVoting system), and wastewater management. After this
further screening, there were 77 case studies on energy and 24 on non-energy for TIS, and 86 case studies on energy and 43 on non-energy for SNM (see Figure 2.5).

The majority of the papers on energy for SNM are on community initiatives, biofuels, renewable energy technology (including PV solar, biomass, wind), electrical vehicles and agriculture (see Figure 2.6).
The TIS papers on energy are predominately on hydrogen and fuel cell technology and with a small number on other renewables (including PV, biomass, wind) (see Figure 2.7).

Figure 2.6. SNM energy themes.

Figure 2.7. TIS energy themes.
Fourth, the papers are geographically categorized according to the following areas: Europe, North America, South America, Africa, Middle East, South Asia, South East Asia, China, Australia and New Zealand, and Russia. According to the regional analysis, the majority of the case studies are from Europe, 114 for SNM and 86 for TIS. Out of 111 European cases for SNM, the majority have case studies in the Netherlands (n=30) and the UK (n=25) (see Figure 2.8).

Figure 2.8. Geography of SNM case studies.
In comparison, the European TIS case studies are more evenly distributed, the leading countries being Sweden (n=15) and Germany (n=14), the Netherlands (n=13) and the UK (n=13) (see Figure 2.9). Among other regions, South Asia (n=15) and Africa (n=11) are behind Europe for SNM. For TIS, North America (n=8), South Asia (n=7) and China (n=7) come after Europe. It is worth mentioning that some of the cases are interregional and within-region comparative case studies, of which there are 30 for SNM and 14 for TIS.

Figure 2.9. Geography of TIS case studies.
For this paper, we chose a mix of widely cited synthesis articles and a sub-group of cases, including the majority of the studies of energy technologies (broadly conceived) in a northern context, encompassing the Nordic countries, Canada, Alaska and Russia, to include geographic regions with pressing energy needs and strong interest in SMRs.

2.4. RESULTS

2.4.1. Lessons from synthesis articles

In addition to the database of case studies, the literature review also turned up a small number of heavily cited review articles by leading sustainability transitions scholars. These provide an overview of the strengths and weaknesses of the two approaches and sometimes locate them in the broader field of sustainability transitions studies. They include Schot & Geels (2008), which summarizes the lessons of SNM studies up to that point; Smith & Raven (2012), which reflects on the consequences of the idea of “protective space” for an innovation that is found in both frameworks; and a more recent body of work on the problem of accelerating sustainability transitions in an era of “crisis”, of which Roberts & Geels (2019) is taken as a typical example. These review articles both help to situate some of the lessons found in the individual case studies but also contain important suggestions for policy interventions of their own that are relevant to the case of SMRs.

Schot & Geels's (2008) review of SNM literature draws out the implications of the three fundamental processes of strategic niche management to underline the importance of three specific forms of intervention: articulating expectations, helping networks and assisting learning.

(a) expectations contribute to the successful furthering of the novelty when they are robust (shared by many actors), specific, and of high quality (substantiated by ongoing projects); (b) social networks contribute when their membership is broad (plural perspectives) and deep (substantial resource commitments by members); and (c) learning processes are broad, covering issues on a variety of socio-technical dimensions, not only accumulating facts, data and first-order lessons, but also generating second-order learning about alternative ways of valuing and supporting the niche (Schot & Geels, 2008).
Smith and Raven (2012) note how the SNM literature has converged on two kinds of spatially distinct processes – local and global - and problematized the relationship between them:

‘Local’ relates to experimentation in specific places with local contexts, supported by local networks, and generating lessons accordingly. ‘Global’ refers to an emerging institutional field or proto-regime supported by a network of actors that is concerned with knowledge exchange and resource flows transcending local contexts. This field is constituted by actors such as industry platforms, user-groups and other intermediary organisations and operates partly autonomous (sic) from local experiments. (Smith & Raven, 2012, pp. 1028–1029)

The distinction between local and global experimentation in niches sets up the problem of the potential “stickiness” of local innovation that we find in so many of the SNM energy case studies. The more that those who are working on the innovation attempt to locate themselves in the problems and perceptions of local communities of users, the more the lessons that they learn are context-dependent, and the more they cut themselves off from the broader set of intermediary actors who will be critical for the break out from the niche to the general application of the technology. This fundamental paradox of niche management presents an obvious challenge for the smaller SMRs that are intended for use in remote communities.

Smith & Raven (2012) present the problem of sticky learning as a specific instance of a more general drawback of both SNM and TIS frameworks, namely, an excessive focus on the early stages of innovation and on the challenges of protecting new technologies from adverse selection pressures. In keeping with the governance concerns of SNM, they argue instead for greater attention to be paid to the strategic moves that will support the process of breakout and widespread adoption. Here they distinguish between strategies that depend on adapting the innovation to an existing socio-technical context, e.g. by identifying gaps that the incumbent technologies have left open that could be filled by the innovation (“fit and conform”), and the more radical attempts to change the context so that the innovation itself becomes mainstream and the incumbents progressively obsolete (“stretch and transform”) (Smith & Raven, 2012). In the SMR case, we see both strategies at work, the former in the interest in remote locations, hybrid grids and other specialty applications, and the latter in the
battle between so-called “clean” and “renewable” technologies for clean energy baseload applications.

Finally, the new literature on accelerating transitions is generally critical of the focus found in both SNM and TIS on experimentation, learning, “enactment” through participation, and other slow, incremental, and local processes. The real challenge today, it is said, is to respond in time to an increasingly critical situation. Appealing to historical lessons from much earlier transitions, this literature, which is still developing, argues both for having innovations ready to go when crises and other kinds of focusing events open a window of opportunity (a concept derived from the work of John Kingdon on policy agenda setting (Kingdon, 2011) and for a return to a more top-down process of policy intervention to choose promising technologies, even in the face of opposition. Awareness of the ability of incumbents to resist these interventions has in part been tempered by results from some of the case studies reviewed below that have highlighted ways in which incumbents have come to see the potential of innovations and taken them up, using their resources to ensure speedy adoption. Again, this literature is clearly relevant for understanding the relationships between the vendors of large reactors and SMRs and between existing power utilities and SMRs.

2.4.2. Lessons from case studies

2.4.2.1. Roadmaps

Two cases (Andersson, Perez Vico, Hammar, & Sandén, 2017; Bento & Fontes, 2019) emphasize the importance of roadmaps as essential transition tools, in keeping with the core concept of pathways in transitions studies. Some of the earliest work in transitions theory was devoted to isolating and describing a small number of characteristic pathways which have guided transitions research ever since. While having a goal and making some assumptions about the kind of pathway to be followed will help map the key steps from here to there, these are necessary but not sufficient conditions of sustainability transitions. The cases support other studies that have highlighted the politics of transitions (Meadowcroft, 2011). Andersson et al. (2017), in particular, identify a lack of political direction and policy support in the form of concrete strategies to overcome incumbent opposition as reasons for the failure of tidal kite technology (Andersson et al., 2017). It is a useful reminder that the existence of a Canadian SMR roadmap, though an achievement of sorts, will not by itself bring about the widespread
adoption of SMRs unless the political obstacles are systematically addressed, a conclusion supported by larger studies of nuclear energy governance, e.g. Baker & Stoker (2015) (Baker & Stoker, 2015).

2.4.2.2. The symbolic dimension: legitimation, framing and narratives

Studies of SMRs sometimes seem to assume that anything to do with nuclear energy faces unique problems of legitimation. The case studies of sustainable energy innovation provide a helpful corrective, reminding us that many if not most innovations originally encountered similar handicaps and that those technologies currently enjoying a favoured status with stakeholders and the broader public do so largely because of hard work on the part of proponents. This work includes developing plausible narratives about the technology, framing it as the solution to a problem with resonance for the lived experience of stakeholders, and gaining the trust and winning over those initially sceptical about the balance of risks and benefits. This effort must, of course, address the long and complex public response to nuclear power, such as the memory of Hiroshima and Nagasaki, the lingering reminders of Mutually Assured Destruction, Atoms for Peace campaigns, and recollections about the Three Mile Island, Chernobyl, and Fukushima accidents. Solar and wind power, in contrast, labour under few such conceptual burdens and sustained criticism. Overcoming their perceptions will not be achieved overnight nor does it appear automatically as an output of the normal functioning of an innovation system (Heiskanen, Jalas, Rinkinen, & Tainio, 2015; Koistinen, Upham, & Bögel, 2019; Kvellheim, 2017).

2.4.2.3. The role of intermediaries

One of the most common conclusions of the case studies, particularly those influenced by SNM, is the importance of intermediary actors in successful innovation and, conversely, the identification of missing intermediaries in cases of innovation failure. Intermediary actors may be needed to “join up” learning processes within niches, to provide access to investment, to bring about a more supportive regulatory environment and to connect local and global innovation. The challenge in drawing lessons from this literature is the extent to which the precise type and role of successful intermediation is context-dependent. In particular, the Nordic context of so many of these case studies, which stress the role of public agencies as intermediaries e.g. Kivimaa (2014) (Kivimaa, 2014), may not be easily translatable to other
regions, for example, North America. The TIS approach to intermediation organized around supply chains may be more promising here and there is evidence that the Canadian provincial governments most interested in SMR development have already started to work along these lines. It will be interesting to see whether publicly owned utilities (where they still exist) or regional development ministries will play a significant role as intermediaries.

2.4.2.4. The role of incumbents

As already noted, the sustainability transitions literature is currently undergoing something of a revolution in its estimation of the role of incumbents in innovation. Earlier studies tended to see incumbent industries, for example, coal or gas-powered energy producers, as undifferentiated opponents of energy innovation. A host of more nuanced studies have suggested that incumbents, though acutely aware of the dangers posed by innovation, have a variety of potential responses in which they may see innovations as complementary to their existing activities or even as potential replacements whose early adoption may ensure their own survival. Their institutional prominence, existing research programs, and well-established networks make incumbent industries especially effective intermediaries if they can be enlisted in support of innovation. While there are studies that continue to demonstrate the chilling effect that incumbent opposition can have on innovation, e.g. Pihlajamaa et al. (2013) (Pihlajamaa et al., 2013), there are others that illustrate some surprising roles for incumbents in promoting technologies that are apparently incompatible with their existing business models (Andreasen & Sovacool, 2015; Karakaya, Nuur, & Assbring, 2018). Yet others add the now familiar cautionary note that policy intervention may be necessary to tip the balance in favour of support rather than opposition or indifference (Mäkitie, Andersen, Hanson, Normann, & Thune, 2018). TIS studies often present the opportunities as enlisting established industries in the supply chain rather than as potential customers for the innovation, a point with obvious relevance for the “modular” part of SMR development.

2.4.2.5. Spatial path dependency

A final feature of these case studies is also a more nuanced understanding of the relation between local and global contexts for innovation. The early work in this area tended to stress the challenges faced by innovations developed in global centres when they are
confronted by local circumstances and peculiarities. There are certainly very significant advantages to locally embedded innovation, especially in terms of the legitimation function and the relatively small-scale networks of local and regional actors that support and protect the innovation during its early stages of development. However, more recent work (Bento & Fontes, 2015; Lukkarinen et al., 2018) has stressed the extent to which local innovation is in danger of a path-dependent development trajectory in which it is progressively cut off from the larger world in ways that make scaling up to large-scale production and commercialization difficult. This problem of “stickiness” is especially challenging for SMRs because of the apparent need for large-scale production of small reactors that may, individually, have very local applications.

2.5. DISCUSSION

The lessons from the case studies suggest two pathways for Canadian SMR development, by no means mutually exclusive but each with a rather different set of conditions and requirements. These pathways follow those articulated by Smith and Raven (Smith & Raven, 2012). In the first pathway, the strategy is “fit and conform”, finding gaps and opportunities in the existing energy landscape; in the second, SMRs “stretch and transform” how we think about clean energy. Both paths will require significant policy work.

In “fit and conform”, the goal is to position SMRs to fill gaps in the current power generation landscape. In Canada, this means very small reactors for northern and remote applications and larger SMRs for replacing coal-fired baseload generation in smaller provinces where full-size reactors would be infeasible. Very small reactors are a distinct niche, involving innovative designs and are likely further away from commercialization than larger SMRs, not least because of regulatory hurdles. They will require careful and, above all, respectful work with communities that have a legacy of painful experience with outsiders promising transformative innovation. At the same time, however, the literature warns against the problem of “spatial path dependency” in which work in a specialized, geographically distinct niche is increasingly cut off from broader global developments. Even within the niche, there are very distinct applications, such as mining versus remote indigenous communities with little contemporary economic activity and many concerns about impacts on traditional practices. This suggests the importance of international collaboration with
similarly situated communities, sharing information across specialized networks that will require support from a variety of government agencies.

The “utility scale” SMR, on the other hand, looks much more generic and much closer to reality. The challenge here will be to find the appropriate scale on which collaboration will be successful. After some initial hesitation, which has already largely passed, the role of incumbents will likely be positive right across the supply chain, given the problems many of them are experiencing finding new markets. Innovative solutions to production problems, e.g. enlisting shipbuilders as experts in modular production, will be critical to bringing these SMRs online at the speed required to support a plausible narrative that they are essential tools in a rapid transition to decarbonized power production, as the climate change NGOs are demanding. Either way, narrative and framing generally will be key tasks which public policy can support but which it must treat with care lest SMRs become victims of partisan politics.

A more significant challenge in terms of scaling-up is the likelihood that, if utility-scale SMRs really are successful, supply will be dominated by producers with access to large markets, the European Union, the United States and China. Whether a medium-sized economy like Canada’s wants to support domestic production of SMRs or to encourage collaboration with, for example, American producers is very much an open question, but it is, perhaps, already significant thatARC and NuScale are both frontrunners for this type of SMR in Ontario and New Brunswick. Governance that encourages collaboration between provinces will be critical in respect of the bargaining power that Canada will be able to exercise in this situation and the newly signed MoU between the three leading SMR provinces (with Alberta joining the effort) is a most welcome development.

More speculatively, there is a possibility that SMRs will be part of a more dramatic transformation of power production, amounting to “stretch and transform”. The suggestion here is that increasing use of intermittent renewables, combined with the rapidly diminishing availability of land for large-scale deployment of these renewables, is likely to spur the development of distributed and/or decentralized power generation, involving, for example, the design of residences and commercial space as power producers. SMRs, particularly the smaller designs, could provide local baseload power opportunities and much-needed grid stability in “hybrid grids”. The business case will rest on providing other services such as heating to pay for the facility during the inevitable periods of oversupply of intermittents
when electricity prices will become negative. Clearly, major questions remain to be addressed about finances and economics, which require more cautious and comprehensive assessments of the costs and benefits of energy technology. (B Mignacca & Locatelli, 2020; Thomas, Dorfman, Morris, & Ramana, 2019)

Narrative and framing will also be important here since the SMRs will have to be located in the heart of residential and commercial neighbourhoods to provide district heating. As gas heating becomes more problematic from a climate change perspective, this narrative will become more plausible. At the same time, resistance from a well-entrenched gas industry is likely to be intense, especially where natural gas is cheap, secure, and readily available, as in Canada. Here, both the problematic and sometimes puzzling role of intermediaries in the SNM and TIS cases, in particular, and the role of public policy in enabling and supporting intermediaries more generally, will likely be central. In such a case, the lessons from the literature on accelerated transitions, which stresses a more top-down policy engagement, are most relevant.

All emerging technologies struggle to connect financial sustainability, technological capabilities, public acceptance, and an appropriate regulatory environment. The current debate about the over-reach of social media and big data firms demonstrates the interconnection between the core elements in technological acceptability. The implementation of Small Modular Reactors must address all of these challenges, plus the added burden of overcoming the highly emotional criticisms of many aspects of nuclear energy and power. Comparable issues surround many other emerging technologies, from genetically modified organisms to advanced medical technologies, drones and automated vehicles. In each instance, proponents have learned that political and policy issues are crucial to public acceptance and regulatory approvals.

SMR manufacturers have, understandably, focused on the science and the improvement of the technology. But lessons from the SMR experience to date and from the introduction of other technological innovations provide important lessons for nuclear energy practitioners and policymakers generally. Challenges with the scientific literacy of the public, civil service and politicians add to the difficulties, making public debate vulnerable to hyperbole, exaggeration and falsehoods. Scientists and technologists, trained to respond to queries with technical precision, have struggled to address public criticisms and the hard-to-
control attacks on social media. For SMRs to succeed, clearly, requires new approaches to policy-making and outreach. Additional research is required to evaluate the lessons learned from other technological fields and public engagement processes and to assess how best to adapt them to fit with SMR technologies. Some preliminary observations be offered, however.

Experience in other fields of public evaluation of development processes and from the literature on sustainability transitions provides a partial outline. Policy and regulation have to proceed in lockstep with science and should not lag well behind technological change, as recent developments have demonstrated. Development teams are routinely very science-heavy, with little engagement with social scientists and policy specialists. If anything has been learned in recent years, it is that post-development outreach efforts struggle to find public acceptance. Conversely, as the literature on Indigenous engagement with the energy sector demonstrates, the pattern of viewing communities as a barrier to development has been replaced with processes that treat Indigenous peoples as partners or collaborators. Involving future clients and customers early on in the process will likely become de rigueur in the near future; the SMR sector would do well to adopt this approach. This necessitates, in turn, that the industry focus on future applications and practical implementations as well as the technology and expands communications and engagement efforts with potential customers, working with them to address concerns and priorities within the technological development process.

More broadly, policymakers and politicians need to be brought into the processes as early as possible. While the science on SMRs is not fully settled, many of the key issues have been clearly articulated. So, too, have the primary questions or doubts about the technology. The current policy on nuclear power reflected the concerns and priorities of earlier technologies and not necessarily those related to SMRs. Moving on to preliminary legislation and building in scientific and consultative requirements that address public concerns would help regularize public discussion about the technology. This would allow for more public discussion earlier in the process and for the joint establishment of political parameters and program requirements. In the end, the core lesson is that scientists and business leaders have to learn to trust and engage with the public at large and, specifically, with the communities that will be directly involved with the SMRs. Processes that reach out to citizens with accessible and high-quality information and that reflect the potential customers’ use of the
information provide valuable insights to the scientists and the companies, producing better technologies and improved approval regimes.

The 21st century is the age of rapid technological change, urgent concerns about climate change and environmental protection generally, and uneasy relationships between scientists, technology companies and the public. Politicians and civil servants sit in the middle of this contested territory, called to act in the public interest while simultaneously addressing citizens’ concerns, accurate or not. Proponents of SMR technologies must recognize that, in the contemporary environment, community consultations, public education, and co-production of policy have become core elements in both technological production and sustainable transitions. At present, substantial gaps remain between the various solitudes, suggesting that the path toward the successful implementation of SMRs could prove to be rocky and unpredictable. New approaches, based on a strong understanding of the societal aspects of technological innovation, can be built into oversight and approach processes, potentially expediting the movement of the technologies from the laboratory into the field. Technology without social acceptance will struggle mightily to become wide application, necessitating new approaches to engagement between scientists, companies, regulators and policymakers. In the process, Canada and other democratic nations might well create pathways for technological innovation that could smooth the transition to a truly technology-enabled society.

A final observation is in order. The global debate about climate change and the profound sense of urgency found amongst activists has not yet informed the policy environment nor, intriguingly, the scholarly literature. The focus remains on traditional forms of scientific evaluation, project approval and technological assessment. SMRs appear, scientifically, to have the potential to contribute to the reduction of greenhouse gas emissions. The conversations, both at the policy and academic levels, about moving SMRs from concept to implementation appear to be locked in pre-crisis processes and assumptions. The scholarly literature points to a path toward policy acceptance for SMRs but the analysis also makes it clear that the outcome is far from certain.

While this kind of trajectory (a disconnect between societal needs and tolerance and the much slower pace of policy development) is the bane of technological change generally, the connection between SMRs, community energy needs and climate change argues for
different processes, ones that require moving beyond traditional approaches and looking for urgent solutions and evaluation procedures for potential vital technologies. Scholarly literature on technological innovation and sustainable energy traditions outline how and why this is difficult; the public discourse on the need for readily available, safe and reliable energy technologies. Nations need, in sum, evaluation and approval procedures that match environmental needs and societal aspirations.

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CHAPTER 3. ACCELERATING THE DEPLOYMENT OF SMRS IN CANADA: THE IMPORTANCE OF INTERMEDIARIES

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This chapter is focused on the importance of "intermediaries", i.e., actors and platforms that sustain the momentum of transitions by linking actors, activities, and resources. In sustainability transitions their role in the acceleration phase is less well understood and SMRs provide a compelling case study of the challenges. This chapter uses the document, web, and interview data to analyze the role of intermediaries in Canadian SMR deployment, focusing particularly on the intermediaries needed for successful social innovation; identifies gaps, and evaluates the role of public policy in supporting the development of these critical relationships.

3.1. INTRODUCTION

Energy policy is sometimes described as an exercise in managing the trilemma posed by three, partially conflicting, policy goals: security, efficiency, and sustainability (IEA, 2009). Sometimes, policymakers will have the luxury of maintaining a particular balance over a long period of time, untroubled by events or dynamics external to the energy policy sector. In other cases, they will be under pressure to recalibrate their approach by emphasizing one part of the trilemma over the others. The focus on a rather narrow conception of efficiency that dominated energy policy in the 1980s through to the turn of the century – and, incidentally, proved so damaging to the prospects of the available nuclear power generation technologies – is a case in point. But it is also a case where, to the dismay of the ideologues, countries set about the pursuit of efficiency with varying degrees of enthusiasm and over a period of decades rather than months or even years (Capano, Zito, Toth, & Rayner, 2022).

In recent years, however, two developments have injected a new sense of urgency into the project of recasting energy policy in the developed world. First, climate policy concerns
have greatly increased in salience, forcing an urgent reconsideration of the place of sustainability in energy policy and particularly in power generation. The demand for “clean” energy (however defined) is expected to increase dramatically in the very near term if key pledges on GHG mitigation are to be met on schedule. Second, worries about energy security, which had been airily dismissed by efficiency advocates as an automatic co-benefit of properly functioning energy markets, have reappeared with a vengeance. Among other causes, analysts point to the challenge to global supply chains posed by both the pandemic and increasing international tensions after a long period of relative calm. The convergence of these developments is now commonly described in the language of a “crisis” that demands rapid response, including a reorganization of energy policy priorities. Time, it is argued, is not on our side.

Research on the sustainability side of the challenge has identified two priorities for action in response to the crisis (Victor, Geels, Sharpe, & Sharpe, S., 2019). First, accelerating innovation and enabling the rapid diffusion of new technologies that are more sustainable (and, we should now add, less dependent on international energy markets) than those that they replace. And second, strengthening the institutions that will support an equitable sharing of the costs and benefits of policy change on the scale demanded by the crisis. This paper is concerned primarily with the first of these priorities but the second is always a concern and we will return to it in the concluding section. Innovation in civilian nuclear technologies may prove to be an important part of the overall re-orientation of energy policy but both the need for accelerated deployment and the new salience of energy security create their own challenges. Considerations of equity with respect to nuclear innovation are a largely uncharted territory (but see Sovacool, Martiskainen, Hook, & Baker (2019)).

In this paper, we consider the prospects for a particular technology – small modular reactors (SMRs) – whose deployment is proposed as part of the solution to the contemporary challenges outlined above. Four Canadian provinces are current signatories to an MoU on the development of SMRs. What is the role of public policy in furthering their plans? In section 2, we briefly review the broader literature on accelerating innovation and technology diffusion, including our own previous work on the lessons of other clean energy technologies that may be relevant for SMRs (Iakovleva, Rayner, & Coates, 2021). As we shall see, this is a large topic, and we will focus on the role of what has been called “intermediaries” in acceleration. In section 3, we consider the specific SMR technologies currently under development in
Canada and the claims that are being made about them. In section 4, we report on a series of interviews that we have undertaken with the government, industry, and communities in Canada. Section 5 presents a discussion and conclusion.

3.2. BEYOND “WILLPOWER”: ACCELERATING THE ADOPTION OF CLEAN TECHNOLOGIES WITH INTERMEDIARIES

The urgency of the clean energy challenge and especially the rapid adoption and deployment of key technologies poses several problems. The very language in which this phenomenon is usually described in the literature, as a clean energy “transition”, suggests a long-term incremental change. Historical studies of energy transitions – of which there are now many – have indeed concluded that these are lengthy processes that resist simple policy interventions aimed at speeding them up (or slowing them down) and whose implications are generally poorly understood by key actors during much of the time that the transition is underway. These accounts have, in turn, been challenged by contemporary theorists who have argued that the historical studies have been overwhelming of transitions driven by external forces at a time when governments and societies lacked strong mechanisms for collective action. Our current challenge, they claim, is very different. Slow progress in the adoption of clean technologies can only be the result of a lack of political will to overcome self-interested opposition from those who benefit from the status quo (Sovacool & Geels, 2016).

This conclusion is a troubling one on many levels. Posing the challenge as a simple power struggle removes it from the realms of policy design and science altogether. Moreover, the appeal to “willpower” is uncomfortable in countries whose recent history has been marked by the rise of authoritarian politicians claiming to be able to resolve any political problem by the application of their “unshakeable will”. In countries with longer democratic traditions, it sounds like an invitation to blind irrationality, and, indeed, some recent manifestations of climate action seem to have taken this form. In response, there has been a renewed attempt to provide a more nuanced understanding of the role of politics and policy in managing the direction and tempo of energy transitions and we draw on these accounts in our approach to understanding how policy can accelerate the deployment of SMRs.

Space precludes the more detailed description that this literature deserves but its primary conclusions are as follows (Roberts & Geels, 2018; Roberts et al., 2018). First, the
main role of policy and politics will be a negative one, removing some predictable obstacles in the path of technological innovation, or “friction” as these writers like to call it. Friction may come from incumbents who stand to lose from the proposed change (as the exponents of political willpower have argued) but it may also come from broader public concern about the new technologies, including access and utility as well as risk, or from developmental problems with the technology itself – sometimes from all three. Second, where positive action may be required to overcome friction, policy should be focused in the following areas:

- Supporting well-developed technologies (if available) to minimize unforeseen problems with the technology itself during the acceleration phase
- Enabling and supporting coalitions to counter the opposition from incumbents and to mobilize public support
- Favouring policies that have positive feedback effects in the policy system itself, creating a desirable “stickiness” for new technologies
- Developing policies with “situational awareness” of local contexts (a feature which, on this view, explains the absence of general lessons about positive policy interventions that could travel from one transition or one jurisdiction to another in the earlier comparative literature on transitions)

In this paper, we focus on the second of these interventions, coalition building in support of new technologies, in the case of SMRs in Canada. Some SMR designs certainly fit the description of a well-known technology, and other interventions will also be important, but we want to focus squarely on the kind of policy interventions that can address the claim that only “political will” can accelerate a clean energy transition in the face of entrenched incumbents who benefit from the status quo.

In a previous paper (Iakovleva et al., 2021), we arrived at a very similar conclusion by conducting our own search for policy interventions associated with successful clean technology innovation in countries like Canada, notably the Nordic group, that might be relevant for SMRs. While there was some evidence of coalition building by governments during the period we studied, the received wisdom that states should avoid “picking winners” in their innovation policies made this kind of direct intervention unusual. Instead, the policy was directed towards supporting what the transition literature calls “intermediaries” who
perform several different roles under the general umbrella of coalition building. Their presence was associated with success and their absence with failure.

Once again, there is now a large literature on intermediaries but to summarize for our purposes, interest in intermediaries grew out of earlier innovation literature where they were identified as “organization(s) or bod(ies) that act [as] an agent or broker in any aspect of the innovation process between two or more parties” (Howells, 2006, p. 720). Once innovation, especially at a systemic level, began to be understood as a complex process involving shifting roles and relationships within an innovation ecosystem, the importance of intermediaries was clear. They are needed to help technologies reach new audiences, to explain and justify technology adoption, and, most importantly, to facilitate connections in the landscape of actors and organizations that was increasingly described as a “network” in the innovation literature (Fischer & Guy, 2009; Lindkvist et al., 2019; Sovacool, Turnheim, Martiskainen, Brown, & Kivimaa, 2020; Stewart & Hyysalo, 2008).

To perform their brokerage functions, intermediaries have to tread a fine line between advocacy and restraint and, as a result, often face what van Lente et al. (2020) call “legitimation challenges” (van Lente, Boon, & Klerkx, 2020). Kivimaa et al. have developed an influential typology that distinguishes between intermediaries that are identified with a strong mandate to promote change at various levels, which we call advocacy intermediaries, and those with weaker change mandates where the brokerage or even weaker information functions are dominant (Kivimaa, Boon, Hyysalo, & Klerkx, 2019). All three types are found in transitions but where acceleration is concerned, the advocacy intermediaries will obviously play a key role in coalition building and creating counterweights to incumbents. Broker intermediaries connect researchers, vendors and markets, while information intermediaries work in the broader public sphere.

Nuclear energy is assumed to face problems of legitimation more than other areas so intermediaries of the first kind will be especially important in the politics of transition. Legitimation requires the persistent work of proponents in creating plausible narratives and frameworks. Intermediaries are among those proponents. In successful innovation, intermediaries need to be identified, while in cases of innovation failure, it is crucial to identify missing intermediaries. Intermediary actors may be needed to ‘join up’ learning
processes within niches, to provide access to investment, to bring about a more supportive regulatory environment, and to connect local and global innovation.

However, the precise type and role of successful intermediaries are, as the acceleration literature concedes, context-dependent. Canadian provincial government follows the approach to intermediation organized around supply chains so that publicly owned utilities or regional development ministries may play a significant role as intermediaries. Another lesson is that incumbents such as incumbent industries can become effective intermediaries. This is because of their institutional prominence, research programs, and well-established networks (Kivimaa, Laakso, Lonkila, & Kaljonen, 2021; Sovacool et al., 2019). There’s “a stronger degree and perceived need of incumbent-oriented innovation intermediation in cases where shared understanding about the need to act on societal challenges has emerged, or innovative alternative solutions are sufficiently developed to warrant a shift towards their mainstreaming” (Sovacool et al., 2020, p. 14). Intermediaries can also become incumbent actors and adopt more incumbent-oriented strategies over their lifetime. Industries may see innovations as complementary to their existing activities or even as potential replacements whose early adoption may ensure their own survival. Some of the sustainability transitions researchers add that policy intervention may be necessary to tip the balance in favour of support rather than opposition of indifference. Incumbents can drive low-carbon innovations when they are supported by dedicated innovation intermediaries. “Incumbent-oriented intermediaries may facilitate or enable specific kinds of transformative/systemic change and address various aspects of the dual challenge of institutions (fit and conform, stretch and transform)” (Sovacool et al., 2020, p. 15).

3.3. RESEARCH QUESTION AND METHOD

The research results reported here are part of a larger project investigating policy development and governance of SMR innovation in Canada. It uses a qualitative approach using the methods of documentary research and interviews.

The steps for research were as follows:

1. Preparing and organizing data, including public documents, such as the SMR Roadmap, the Action Plan and the Feasibility Study, websites of relevant government agencies and SMR vendors, and the transcripts of 14 interviews with policymakers,
vendors, and community leaders concerned with energy futures. Interview subjects are not identified by name but according to a classification of their organization. 6 interview subjects came from industry (4 utilities, 1 vendor and 1 other); 4 came from intermediary organizations (3 advocacy organizations and 1 broker); 3 from community economic development organizations and 1 academic.

2. Reviewing and exploring data. Examining the data for patterns or repeated ideas that emerge.

3. Developing a data coding system. Based on the initial ideas, establishing a set of codes that can be applied to categorize data.

4. Conducting and transcribing interviews.

5. Assigning codes to the data.


For this paper, we wanted to identify the main storylines about SMRs in Canada currently in circulation; to identify the position of actors identified as belonging to intermediary organizations with respect to these storylines; and to assess the contribution of intermediaries to the development of policy in directions indicated in the storylines.

No documents addressed these questions directly and none of the questions were asked directly of the interview subjects themselves. What we present here emerges from the coding of the data, using the approach of van Lente et al. (2020) (van Lente et al., 2020). That is, we look for the storylines or collective narratives about SMRs provided by the main actors; how the actors position themselves within those storylines; and, most importantly, whether there is evidence of efforts to align themselves with others in the classic role of an intermediary whether they represent an intermediary organization or not.

3.4. SMR STORYLINES

In this section, we present the evolution of the narratives or storylines that SMR advocates have produced over the years since the Roadmap was released. We argue that the early work to enrol support and get the project off the ground was achieved under an overarching narrative of cooperation and mutually beneficial division of labour between participants. This is a narrative that is still in play today. However, thanks in part to the work
of intermediaries seeking to promote accelerated development and deployment of SMRs, the original narrative fractured into two, second-level, storylines that we call the accelerated deployment storyline and the accelerated innovation storyline. To some extent, these narratives map onto developments in Ontario and New Brunswick respectively but the mapping is not exact. Finally, the narratives have continued to evolve, creating a small number of the additional, third-level, storylines that are currently works in progress. At the moment, these are variants of a flexibility narrative that includes stories about the flexibility of SMRs in clean energy grids and a more expansive storyline of the flexibility of SMRs in relation to the realities of contemporary energy markets.

3.4.1. The virtues of cooperation

In our earlier work, we argued that roadmaps are essential transition tools in keeping with the core concept of pathways for innovation technology. The Federal SMR Roadmap released in 2018 and the subsequent SMR Action Plan released in 2020 outline plans and actions across Canada on how to develop SMRs. The Roadmap emphasizes that successful SMR deployment will likely require cooperation and division of labour between key actors and thus produces the first storyline, one which remains in play at an increasingly high level of abstraction:

- A “fleet-based” approach to operations to benefit from standardization and economies of multiples, e.g., to help reduce capital costs as more units are produced.
- Multiple applications for SMRs in Canada including on-grid, co-generation, and heat and power for remote communities.
- Risk sharing among governments, power utilities, and vendors with respect to issues uncovered during the early deployment phase.
- Ongoing engagement and knowledge sharing with end-users to address safety, waste management, and costs to consumers.

The Roadmap also argues that Canada’s regulatory framework and nuclear waste management regime are “well-positioned” to respond to an “SMR paradigm shift” (Canadian Small Modular Reactor Roadmap Steering Committee, 2018).
After the Roadmap, attention shifted to the provinces, which provided a more detailed picture of the road ahead in the Action Plan and the subsequent feasibility study undertaken by the major utilities who will be the initial customers for grid-scale SMR applications. One of our interview subjects (intermediary advocacy organization) complained that this turn of events has already diverged from that envisaged in the road map. He argued that the Action Plan is really a substitute for action itself, particularly on the part of the federal government, which is shirking its risk-sharing responsibilities by failing to provide the financial support necessary to ensure the timely development of SMRs. While no one else expressed this concern quite so directly, requests for additional money for SMR development can be found in both documents and have become something of a staple of public discourse on SMRs within the innovation ecosystem.

The Action Plan has revealed three distinct trajectories of development (often called three “streams” by our interview subjects, divided in terms of both potential markets and linkages with other provincial policy objectives. New Brunswick has chosen to create an ‘innovation hub’ working with two private-sector partners, Advanced Reactor Concepts (ARC) Clean Energy Canada and Moltex Energy, to advance Generation IV Plus Grid-sized SMR technology.

ARC proposes ARC-100, a technology developed by the US government’s Argonne National Labs. Its design is based on the EBR-2 (Experimental Breeder Reactor-2), a sodium-cooled fast reactor that operated for 30 years but never commercially. Moltex Energy will develop a Stable Salt Reactor-Wasteburner (SSR-W) of 300 Mwe. The design is based, in part, on two experimental reactors built decades ago at the U.S. Oak Ridge National Laboratory which operated for a brief period as part of a study of SSR designs. Both of the SMRs plan to use existing nuclear waste as fuel. In the 2020 Speech from the Throne New Brunswick’s government included remote northern communities and off-grid mining sites that are currently using diesel for electricity generation as a hypothetical market though both ARC and Moltex Energy have stated that their likely customers are provincial power utilities.

Meanwhile in Ontario, Ontario Power Generation (OPG) took the lead in trying to realize the “fleet-based approach” to SMRs. OPG has agreed to build a 300 Mwe grid scale SMR as a demonstration project at its Darlington site, with Saskatchewan and its publicly owned power utility, SaskPower, as a potential customer for up to 4 additional units, to be
delivered in the 2030s. OPG considered three options for the SMR producers: GE-Hitachi Nuclear Energy (GEH), Terrestrial Energy, and X-energy. GEH’s SMR is a Boiling Water Reactor (BWRX-300) which promises a simplified approach to licensing based on the already certified Economically Simplified Boiling Water Reactor (ESBWR) design. Terrestrial Energy’s technology uses Molten Salt as the primary coolant of the reactor. Integrated Molten Salt Reactor (IMSR-195) uses Gen-IV nuclear technology as well as X-energy’s Xe-100. X-energy is an 80 Mwe pebble-bed Gen-IV High-Temperature Gas-cooled Reactor (HTGR) that can be scaled to 320 Mwe. It made waves in the U.S. owing to positive developments related to X-energy’s commercialization of its Tri-structural Isotropic (TRISO) particle nuclear fuel (TRISO-X) (“In Boost to Canada’s Nuclear Roadmap, OPG Advances Work with Three SMR Developers,” n.d.).

In the end, GE Hitachi Nuclear Energy (GEH) has been selected by Ontario Power Generation (OPG) as the technology partner for the Darlington New Nuclear Project. GEH will work with OPG to deploy a BWRX-300 small modular reactor (SMR) at the Darlington site that could be completed as early as 2028. The potential for expedited regulatory approval of a design based on familiar technology to be built at a site already licensed for nuclear power production eventually won the day (GE Hitachi Nuclear Energy, 2021a). Whether the accelerated timetable will be possible, especially with the potential for regulatory delays and unforeseen issues with the technology itself, remains to be seen. The feasibility study was very clear that the utilities expected that the choice of a familiar design would simplify the licensing process and cries for regulatory relief have been something of a staple in the industry.

Finally, a 5 MW gas-cooled demonstration Micro Modular Reactor (MMR) is to be built at Chalk River Laboratories of the Canadian Nuclear Laboratories. The proposed project includes a nuclear plant containing an MMR reactor, and an adjacent plant, which are the main physical works related to the project. The nuclear plant provides approximately 15 MW of process heat to the adjacent plant where it is converted to electrical power (up to 5 MW of electricity) and/or heat. The electrical power could also be supplied to the area grid, over an anticipated life span of 20 years. The reactor is expected to be in service by 2026 (“Our Project - Global First Power,” n.d.).
3.4.2. Competing narratives of acceleration: more innovation or immediate deployment?

While the documents and their supporting materials are organized according to the overarching cooperation and division of labour storyline, they are also important sources of subsidiary storylines that are being developed to support SMR development and deployment. These storylines are intended both to enrol actors in a common project but also to justify their actions and legitimate them beyond the innovation ecosystem itself.

In the first storyline, SMRs are seen as an essential component of Canada’s response to climate change. The clean storyline thus relies heavily on claims that it is unlikely we can achieve net zero carbon emissions by 2050 by relying solely on renewable energy sources. The discourse argues SMRs are a must in achieving net zero GHG emissions by 2050. The Ministry of Natural Resources Canada supports the development of nuclear power and SMRs from the climate change perspective: “Our government understands the importance of nuclear energy to meeting our climate change goals… We are placing nuclear energy front and center.” (“Are small modular reactors the solution to climate change? Some Canadians think so. - Bulletin of the Atomic Scientists,” n.d.); “We don’t see a path where we reach net-zero carbon emissions by 2050 without nuclear. It is proven, it is tested and it is safe. We are good at it.” (“Canada Embraces Nuclear Energy Expansion to Lower Carbon Emissions - WSJ,” n.d.).

This focus on meeting clean energy needs according to ambitious (at least in the Canadian context) targets, is then used to justify an argument for accelerated deployment based on the choice of a familiar design and the possibility of rapid scaling-up in collaboration with SaskPower’s need to replace coal and gas-fired power generation in Saskatchewan. It is also associated with calls for expedited regulation and licensing.

In the second storyline, acceleration has longer time horizons. While generally linked to the nuclear as clean energy story, the narrative focuses on the development of more advanced and as yet commercially untested designs. While it is acknowledged that regulatory approvals might take longer (though this is not uncontested) the benefits in terms of economic development, nuclear expertise and local skills are emphasized. As noted above, this storyline is associated with developments in New Brunswick, where the use of spent fuels is also emphasized for the particular choice of design.
Our interviews revealed some interesting intermediary work that tries to hold the community together by arguing that developments in Ontario and New Brunswick should not be seen as in competition with one another or as part of a winner-takes-all game. This extract is from an intermediary reflecting on the choice of the GEH design in Ontario:

“We selected the GE-Hitachi BWRX-300 boiling water reactor as the right fit for Ontario, basically, because it brought the lowest risk. I don’t mean safety risk, I mean risk of deployment on our schedule, on our budget, you know, using standard known fuel and technologies. Some of the other options that we were looking at were excellent. But in fact, they’re all interesting, some of them were really excellent and just were perhaps more complicated, or perhaps we felt it would take a little longer to deploy them, or there were more risks for our site and our application, even though they might be very suitable and very appropriate for other deployments. So not a knock against those as much as we just went for the one that we felt made the most sense for us at this time. So that's the one project and I did say one reactor, but the site allows for up to four reactors, so we may choose at a later date to expand the planning to additional units of that site.”

Reference to “three streams” and arguments that each of the streams remains open to any actor in the ecosystem is a frequent comment amongst our intermediaries, as is the idea that major players such as OPG might return to a different stream in future: “New Brunswick Power with their ARC and Moltex technologies that they’re supporting is the first mover in Canada in stream two. But we are still collaborating with them to support them in that. And we’re interested to support other users, end users of stream two technology, even if we’re not the first mover in that one.”

3.4.3. Flexibility stories

Beyond these dominant contemporary narratives of acceleration is a third narrative level still in development that is trying to build consensus around the flexibility of SMRs compared with larger reactors, both traditional large reactors and new designs. Part of the motivation is to defuse some of the antagonism between nuclear energy and other energy sources by presenting them as complementary. What is interesting about this storyline and the others related to it is that it starts to drive a wedge between SMRs and large nuclear
installations. The flexibility and responsiveness of SMRs are contrasted favourably with the alleged lack of these desirable attributes in traditional full-size nuclear plants. This feature of the language around SMRs is not a new one. It was also part of the arguments about acceleration, i.e., that large nuclear power plants are too costly and slow to be built or refurbished. “Stabilizing the climate is urgent, nuclear power is slow” (“Canada Embraces Nuclear Energy Expansion to Lower Carbon Emissions - WSJ,” n.d.). In these “third generation” stories, however, flexibility takes on a more central feature of the narrative and, as we shall see, this creates a real challenge for intermediaries.

In addition to flexible applications and lower building costs, it is sometimes claimed that SMRs can be configured with load-following characteristics that make them capable of operating flexibly in electricity systems with variable residual loads, such as in regions pursuing the large penetration of variable renewable energy (VRE) (wind, solar photovoltaic (PV)). Support of VRE deployment could also be considered through the lens of integrated ‘hybrid’ energy systems, which means coupling SMRs with non-electric applications (hydrogen, synthetic fuels, and desalination) as a means of supporting the integration of wind and solar PV. The storyline indicates that SMRs would potentially fulfill the baseload capacity for renewable energy sources. “A small design makes the reactor more flexible, which fits well with other carbon-free energy sources on the grid, like wind and solar, whose output can’t be dialled up by the grid operator. GE Hitachi’s reactor plan is to fill in the difference between variable demand and variable supply, and unlike fossil gas, which does that job today, the reactor will meet the changing need with zero-carbon electricity. With a simpler design and lower capital cost, the price of this energy will be competitive with fossil gas.” (“The BWRX-300 Keeps It Simple—and Small—to Pair Well With Wind and Solar,” n.d.). However, there is little evidence to support the possibility that SMRs can be paired with intermittent renewable technologies in a hybrid grid.

The economic development actors argue that the economics of mass production would be achieved with the mix of large SMRs and micro SMRs producing power and heat for remote communities and mining sites. The argument towards going with smaller reactors, not large NPPs is that “smaller reactors will be able to supply low-carbon electricity and heat to remote regions and other situations where gigawatt-scale capacities would be too much.” (Clifford, 2021). However, this market remains to be established. There is research that the potential market for SMRs in Canada is currently too small to justify investment in
manufacturing facilities for SMR construction and the cost of generating electricity using SMRs is significantly higher than the corresponding costs of electricity generation using diesel, wind, solar, or some combination thereof (Froese et al., 2020). Some believe that SMRs might reduce the construction cost with respect to large reactors, but it is unlikely that SMRs will present a lower cost of generating each unit of electrical energy than large reactors. Ramana and Mian (2014) argue SMR competitiveness is even worse if compared to other energy sources (e.g. coal and natural gas-based thermal power) (Ramana & Mian, 2014). Still, SMR proponents argue that other factors could offset this difference, effectively reversing the economies of scale. For example, efficiencies associated with the economics of mass production could lower costs if SMRs are eventually built and sold in large numbers. Such factors are speculative at this point, however, and the degree to which they might reduce costs has not been the subject of any consensus (Lyman, 2013).

Finally, there is a complex and, at present, aspirational storyline about SMRs and markets. While it is noteworthy that SMR development in Canada is being undertaken in provinces with state-owned power utilities or specialized providers like OPG, energy market liberalization has not gone unnoticed. “The market role of the big industrial consumers of power brings them to the table as an actor in a way we haven’t seen before in energy policy making” (Industry interview). SMRs are identified as potentially bringing nuclear back within the possibility of private capital financing but also as posing risks to operators exposed to market forces and political risks to governments facing a potential backlash from consumers if SMR adoption is associated with energy price increases. SaskPower has raised this issue directly, e.g. “We know many of our customers worry about climate change. There's also concern about how climate change will impact Saskatchewan's economy.” (“Planning Our Power Future,” n.d.). These concerns will intensify if SMR development takes place in provinces with more liberalized markets, such as Alberta, and for application outside power generation for utility grids.

Intermediaries are very much aware of this but, as yet, are elaborating the narrative rather than using it to advance a position: “I think there's been a big shift. Certainly, if you look at the build-out of the CANDU fleet that was very much driven by governments, right, AECL in particular. Clearly, the federal government is no longer in that business. And it's going to be driven more by utilities, oil sand companies, other energy users like mines” (Advocacy intermediary).
“Now the market is actually playing a more important role in decarbonization than policymakers are. And so, we're seeing things where it's the big industrial users that are talking about SMRs and microreactors, as opposed to governments. Government plays a role in supporting clean energy. Governments can be supportive of decarbonization, they can be supportive of all the technologies that achieve decarbonization, and then allow the market to begin to price in decarbonization and pursue the technologies that achieve that, like get out of the way of that process, let investors and let companies make the decisions on how they're going to decarbonize under this electron accountability” (Industry interview). “OPG stepped up to partner with vendors and help with their designs and planning. Technology companies will end up being partners with utilities and other users” (Industry interview). This could lead to a potential new group of incumbent-oriented transition intermediaries.

3.5. DISCUSSION AND POLICY IMPLICATIONS

Our analysis of the role of intermediaries in accelerating SMR deployment broadly supports and extends the conclusions of van Lente et al. First, intermediaries seek to clarify their position with respect to the dominant storylines. Although not all intermediaries are “system intermediaries” in the sense used by van Lente et al., the search for legitimation tends to force intermediaries to take a whole-system perspective when talking about policy. They may be advocates for an industrial stakeholder or a customer but their credibility as an intermediary ultimately depends on them being able to transcend narrow advocacy and argue for the system-level benefits of what they propose. The original (and, arguably, still dominant) storyline of cooperation and a mutually beneficial division of labour within the SMR innovation ecosystem is well suited to this sort of discursive strategy. Only one of our interview subjects explicitly rejected this narrative as no longer relevant or useful.

Second, intermediaries both benefit and suffer from this imperative to be explicit about their positioning with respect to the major storylines. As theorists of discourse coalitions have long argued, positioning oneself with respect to a compelling narrative is a powerful way of enlisting allies (Lovell, 2008; Markard, Rinscheid, & Widdel, 2021). However, in the SMR case, we see that positioning comes at a cost as soon as the very high-level story of cooperation at all levels starts to break down into more detailed narratives. The simmering conflict between advocates of SMRs and the “big nuclear” establishment may
eventually break into open warfare. SMR advocates will then be fighting on two fronts, on one side against their traditional anti-nuclear opponents and on the other against their erstwhile professional and corporate colleagues who still advocate for big reactor technologies. In the UK, for example, there is an attempt to create an even “bigger tent” narrative in which SMRs are the bridge to a new generation of large reactors (Bodel, Bull, Butler, Matthews, & Livens, 2022). We do not yet see this in Canada, at least in our documents and interviews, but something along these lines may be attempted here. At present, this is unlikely to happen because most of the intermediaries are incumbents.

Third, and going beyond van Lente et al. (2020), we see the way in which intermediaries are sometimes forced to resolve this conflict between their advocacy positions and their presumptive roles as honest brokers by helping in the development of new storylines or, at least, significant modifications of the old ones. We have tracked the evolution of SMR storylines in Canada through three generations. The original big tent story of universal cooperation and mutual benefit, followed by the bifurcation into stories about the immediate need for deployment versus stories about the need for faster, home-grown innovation. And we have speculated a little about a third generation of stories currently under development.

While we have presented these stories from a contemporary perspective, which makes the older stories look more “abstract”, it is important to be clear that this is not how they were experienced by those who crafted and used them. The original storyline solved a critical problem about how to construct a viable policy community from a loose network of actors with different capabilities, interests, and ambitions in order to put SMR deployment onto the policy agenda. Arguably, it was already fraying by the time of the Action Plan, but it is still invoked today, though increasingly like a “foundation story” rather than a concrete guide to action. The second-level storylines are undergoing the same process, in which the working out of the details generates new narratives with consequences that are both potentially enabling and potentially disabling for key actors. Intermediaries must position themselves carefully with respect to these new developments.

3.5.1 Policy implications

From a policy perspective, the SMR story to date has some interesting features. First, governments need to be aware that their own governance activities, in this case, their
successful efforts to coordinate a fragmented field, will likely be material for a narrative that participants will use to understand how governments will behave in future. This kind of commitment may be implicit or, as in this case, quite explicit in documents such as MoUs, roadmaps and action plans. Whether the latter is a useful renewal of such commitments or an indication that disagreements have emerged that need plastering over is not something we speculate upon here. There is plenty of evidence, however, that governments, particularly the federal government, saw this exercise in large part as the generation of a narrative.

Second, these narratives will take on a life of their own. The SMR case supports the general conclusion of the literature in this field that the actions of intermediaries are key drivers of change. Governments should therefore take a careful view of their relationships with intermediaries. They can support them financially (or withhold this support) and they can sometimes alter the mandates of existing organizations to enable or disable their functions as intermediaries within the larger innovation ecosystem. The role of the CNL in this respect is currently an interesting one. We have not treated CNL as an intermediary in this study but there is certainly a case to be answered that we should have done. However, the bifurcation of the storyline into narratives about accelerating deployment and accelerating innovation demonstrates that governments cannot always control this dynamic and, as we have argued, the consequences of this bifurcation for the prospects of SMRs are still unclear.

Finally, whether intermediaries should be considered a policy instrument in their own right, that is, entities that could be deployed by governments to solve problems instead of or in combination with more familiar policy instruments such as regulation and subsidies, is an interesting one but perhaps falls within the scope of the qualification about the limits of lesson-drawing across jurisdictions. Intermediary organizations, particularly the systemic intermediaries studied by van Lente et al. may be familiar features of the policy landscape in Europe, but they are less so in Canada and would face significant problems of legitimacy if they were to engage in anything more than information and brokering roles.
CHAPTER 4. COMMUNITY GOVERNANCE FOR SMR DEVELOPMENT: LESSONS FROM NORTHERN AND INDIGENOUS ENERGY PROJECTS

A version of this chapter has been submitted to the journal *Energy Research and Social Science*.

This chapter includes recommendations for the building of partnerships with communities to develop local clean energy production that can benefit all parties. Four case studies of renewable energy projects in northern, remote, and Indigenous communities, provide an understanding of why these communities were interested in energy projects, what they hoped to achieve, and their experience with their partners. Based on that I compare it with government and industry partners’ interviews that reveal a fundamental misalignment of expectations between Indigenous communities and their partners. The results underline the importance of Indigenous intermediaries who can move easily between the communities and the larger energy production context. With the proposed potential application of microreactors in remote communities, the results reveal the need for the construction of a safe space where communities can frame the discussion within Indigenous worldviews and lived experience. Policy recommendations for how this space can be constructed and protected are advised.

4.1. INTRODUCTION

Northern, remote, Indigenous communities are among the most vulnerable to the impacts of climate change (Furgal & Seguin, 2006; NCCIH, 2022; Peace & Myers, 2012; Prowse et al., 2009; UNDESA, 2008). This risk drives the need for both enhanced energy security and an accelerated energy transition for those communities. Sustainability transitions theories have proposed a number of transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption. A sustainable energy transition is fundamental for northern, remote, and Indigenous communities; however, there is no unified consensus on an appropriate framework of what
the unique sustainability transition and engagement process for Indigenous communities could look like.

Indigenous communities historically have unique perspectives on sustainability different from the European-centric approaches found in the sustainability transitions literature (Doyon et al., 2021; Kouril, 2015; Sheridan & Longboat, 2006; Throsby & Petetskaya, 2016; Tom et al., 2019; Virtanen et al., 2020). With the accelerated development of technology and innovation, Indigenous nations see value in engaging in the global prospects of energy transition but want to do it on their terms. In Canada, the energy transition is for the most part driven by the federal and provincial governments and by the energy industry. Discussion of appropriate technologies focusing on community energy needs is limited. The rapid development of small nuclear in Canada, in the shape of small modular reactors (SMRs), provides a good example of this disconnect and its potential consequences. Microreactors (producing less than 5 MWe) are specifically proposed for remote communities and resource extraction projects. Larger SMRs (up to 300 MWe) are generally of direct interest to provincially owned utility companies but even here the likely proximity of Indigenous communities and their traditional lands will be important factors in siting and operations. Yet the dominant narrative remains that of contributing to broad societal clean energy goals rather than community visions of energy futures.

To deploy innovative clean energy technology in Canada, either renewable or SMR, the developers are required to fulfill their duty to consult and accommodate with potentially impacted Indigenous communities (Government of Canada, 2019). These requirements are a well-known feature of the constitutionally protected rights of Indigenous peoples in Canada and there is no suggestion that the proponents of SMRs fail to understand this or will try to evade their obligations. However, the interviews conducted for this study reveal that there is no clear orientation on the part of industry and government in understanding Indigenous perspectives on the interaction of energy security and sustainability with respect to clean energy technologies. The industry and government approach is a conventional one where work with the community is limited to their understanding of engagement and how it should be conducted.

Both parties stress the importance of ‘intermediaries’ in bringing about change but they think of their roles differently. Industry and government see the process as a linear path
to material abundance and individual achievement where actors are enablers of the transition in the socio-technical space. This view is based on utilitarian ideas of development and modernization. Indigenous communities have a different, unique perspective of an integrated sustainability transition where ‘change agents’ (Hägerstrand, 1952; Rogers, 1995), create a space which helps to align and connect the community and industry and government needs.

This divergent approach to change means there is a disconnect between Indigenous community and government and industry perspectives on the sustainability transition. Traditional sustainability transition theories are more centered around enabling technological development, where social factors are used mainly to explain technological change. However, recent research shifts that focus toward the combination of the technical and social where factors like institutions, culture and behavioural patterns play more prominent roles as drivers of change (Holtz, Brugnach, & Pahl-Wostl, 2008). Despite the global scale of technological change, national or regional differences affect the way technology can be applied and its results. In some technology, the role of institutions and actors is emphasized more. The shift is related to societal functions considered on a level of a certain region or a nation (Holtz et al., 2008).

Thus, in this study, I consider socio-technical regimes as complex systems that perform societal functions. Governance encompasses the coordination and steering of actors by formal and informal institutions to achieve system goals. The community case studies reveal how their goals, perceptions, knowledge and values, technological possibilities, institutional settings, and infrastructure create a different vision of a socio-technical system and its governance at the regime level. These differences challenge the intermediaries to be true to the communities’ vision as they try to translate it to government and industry. This view aligns with actor-network theory (ANT) that advocates bypassing the traditional dualism of not only nature/culture but also that of subject/object and agency/structure. The ANT advocates propose that we should get on instead with tackling the world of actualities – networks or assemblages which contain unique, complex, and changing populations of people, organisms, things, substances, and processes (Jones, 2009; Latour, 2007).

The societal factors include barriers that prevent Indigenous communities from getting into the market, related to the agendas of the federal and provincial governments on one side and communities on the other. The governments see acceleration of clean energy as part of
their climate change emissions reduction plans while Indigenous nations view it as contributing to socio-economic stability in a way that aligns with Indigenous worldview. Acceleration and transition to clean energy purely for climate mitigation purposes are poorly aligned with what Indigenous nations are experiencing. In many cases, the drawback of energy transition is not even about the capacity building of Indigenous nations – that has been an argument for decades and not much has changed – but about the linking of the skills and tools that now exist or can be potentially accumulated within the communities and nations, with the ‘mainstream’ government and industry requirements. Transition for communities involves getting into something far more technical and difficult where they need an intermediary who can provide guidance and support in every stage of the project development process. From the sustainability transitions theory perspective, Indigenous intermediaries can modify the socio-technical regime where a different vision of governance takes place. This research reveals that Indigenous-based intermediaries have a vision that is different from a non-Indigenous-based intermediary. Both are driven by a common goal of a sustainable future but have a different understanding of the process and outcomes. Indigenous-based intermediaries have a role in creating a space that can take the form of formal and informal networks, formal, institutionalized space and informal, non-institutionalized space.

Thus, this paper’s goal is to understand the role of intermediaries and space in sustainability transition and provide support in translating their vision to government and industry in application to northern, remote, and Indigenous communities. The argument is based on the lessons from other clean energy technologies that may be relevant for SMRs and the role of intermediaries and storylines in SMR development from our previous works.

In section 2, I briefly review the literature on sustainability transitions and community governance, including previous work on the lessons of other clean energy technologies that may be relevant for SMRs and on the role of intermediaries and storylines around SMRs (Iakovleva & Rayner, 2023; Iakovleva et al., 2021). In Section 3, I describe interviewed community energy case studies. In Section 4, I study those communities’ perspective, while in Section 5 I investigate the government/industry perspective. Then I analyze those perspectives to see whether there is an alignment or and discrepancy between those in Section 6. Section 7 provides brief policy recommendations based on the results and Section 8 concludes the paper.
4.2. THEORETICAL FRAMEWORK AND METHOD

4.2.1. Theoretical framework

There is a literature that investigates the sociocultural implications of the transition to renewable energies in Indigenous communities, particularly off-grid diesel-powered communities in Canada (Bledsoe, 2022; Cook, 2019; Karanasios, 2018; Savic & Hoicka, 2021; St. Denis & Parker, 2009). However, limited research has been conducted on community-informed approaches embedded in a broader societal transition, especially with application to SMRs.

This study takes a sustainability transitions approach, specifically the Multi-Level Perspective (MLP) that focuses on the problem of taking innovative technologies from the protected “niche” environments they have inhabited during research and development and supporting their large-scale adoption in more competitive environments, often dominated by incumbent technologies and institutions hostile to innovation (Geels, 2014). Specifically, I draw on the tradition of discourse analysis in the transitions literature, which emphasizes the construction of persuasive stories about the potential of new technologies in this larger societal context to enrol allies and change institutions. This literature “locates important change processes as resting in actors strategically re-telling the past to make new sense of the present and envision alternative futures. Actors develop narratives in an attempt to reshape perspectives and patterns of societal action and enable institutional reforms” (Smith & Raven, 2012, p. 1032).

The theory illuminates an important similarity and a difference between the renewable energy cases and SMRs. The renewable technologies – solar PV, small-scale hydro, and biomass – had all broken out of their original niches and achieved broad social acceptance by the time the Indigenous communities came to consider them. The challenge for their proponents was to have them adopted in a new context – remote, Indigenous communities – that posed additional challenges which, I will argue, were not well understood by proponents because of a failure to listen carefully to what their community partners were telling them. SMRs, on the other hand, are still very much a niche technology, and proponents will have to surmount the double challenge of empowering an unfamiliar technology in an unfamiliar
context, a case in which the technology stands very little chance of serious consideration unless the community context receives more careful attention.

In addition, community energy discourses are particularly good examples of Latour’s assemblages of human and non-human actors taking part in stories about the communities’ experiences of past attempts at collaboration and their hopes and fears about the future (Latour, 2007). In many ways, the community narratives are much more self-aware about the potential impact of technology on society than those constructed by industry and government. The latter tend to be more policy-oriented but take for granted community valuations of policy objectives like greenhouse gas mitigation. As a result, they usually fail to engage with a broader understanding of sustainability and ‘the good life’ which are always present in the community discourses.

I also draw on the concept of intermediaries in the sustainability transitions literature, defined as “organization(s) or bod(ies) that act [as] an agent or broker in any aspect of the innovation process between two or more parties” (Howells, 2006, p. 720). Intermediary actors and networks are the key agents who develop and spread the discourses that seek to empower technologies in their quest to escape the niche and survive and prosper in the broader regime. However, there is the role of power and politics in the governance of socio-technical transitions. As such, institutionally privileged actors are able to make more forceful changes to multi-level dynamics compared to many others that play a (less strategic) role (Geels, 2004; Smith, Stirling, & Berkhout, 2005). I emphasize that SMRs cannot be adopted unless political obstacles are systematically addressed which requires intermediaries to help guide the process by linking actors, activities, skills, and resources (Iakovleva & Rayner, 2023).

Therefore, I will investigate community governance of the energy projects and the role of intermediaries using data from interviews that will help create a perspective of Indigenous communities’ governance that will provide a comprehensive understanding of the existing socio-technical regime.

4.2.2. Research question and method

This paper is qualitative research with a narrative approach using the methods of secondary documentary research and interviews. I prepared and organized data, including
public documents on communities and community projects, websites of relevant First Nations, Tribal Councils, relevant Indigenous organizations, government agencies, utility companies, intermediary organizations, and SMR vendors for preliminary analysis. Between May 2022 and January 2023, I conducted 21 interviews with government, industry, and community projects representatives. After each interview, I made a transcript of the interview verbatim, which made up to twenty-one interview transcripts with policymakers, utility companies, SMR vendors, intermediaries, and community projects leaders concerned with energy futures. Interview subjects in this paper are not identified by name but according to a classification of their organization: 7 interview subjects came from industry (5 utilities, 1 vendor and 1 other); 6 came from intermediary organizations (3 advocacy organizations and 3 brokers); 7 from community organizations and 1 academic.

Each transcript was coded using NVivo software for qualitative data thematic analysis. Initially identified themes were coded as nodes, which helped me to develop a data coding system establishing a set of codes that can be applied to further categorize data. After that, I identified recurring themes and linked them together in one code with overarching themes and subthemes. After initial coding, I have done a second revision of the data. This helped to build revised codes for themes for industry/government and community projects’ perspectives respectively. From these, I developed the discussion section and the framework of ‘good practices’ for community projects in application for SMRs. For community projects, I coded community projects’ development process via interviews with project leaders and representatives (could be both Indigenous and/or non-Indigenous) that included two people for each case study, except for the Tazi Twé project, where there is one community representative. The project had been shelved a while ago and it was challenging to find multiple representatives for the project, however, I interviewed utility representatives who directly worked with the project development at the time.

Based on the hypothesis that there is a disconnect between government and industry and northern and Indigenous community governance and decision-making, I am studying community projects’ governance to find a way to reconcile the perspectives to create a community-based and informed policy environment for accelerated technology implementation that would contribute to the sustainability transition.

This leads to my research questions:
1) How can insights provided from sustainability transitions case study lessons and the role of intermediaries and storylines in SMR development help us understand the community governance of energy projects in sustainable energy transitions for innovative technology, thus, create a policy environment for innovative technology adoption in northern and Indigenous areas?

2) Based on the experience of the community energy projects what are the policy recommendations for innovative technology adoption in northern and Indigenous areas for potential application for SMR projects?

To answer these questions, I will study innovative energy technology case studies from the community governance lens then I will apply the same lens to the industry and government representatives’ data to learn whether there is an alignment or discrepancy between the perspectives of community projects and industry and government representatives in the development of the innovative technology projects. This research takes a generalized approach to innovative technologies by including renewable energy and SMRs in the category of clean energy technology. The result will inform us of policy recommendations for the community innovative energy technology projects adoption in northern and Indigenous areas in application for SMRs.

This paper examines the case studies of innovative energy technologies, particularly renewable energy projects, that are driven and led by northern and Indigenous communities. They are examples of Indigenous-owned and led projects that create a difference in their communities, including energy security, emissions offset, infrastructure improvement, and investment opportunities. The selected projects are four northern and Indigenous communities’ projects (community-based case studies). Two of them represent a single community initiative whereas the other two are a group initiative of the communities. Community projects were also selected on the basis of the technology: biomass, hydro, and solar in on-grid and remote communities. Another factor was the location: three of the projects are located in Saskatchewan, however, they represent diverse technologies and successful and unsuccessful projects. The Alberta project is a remote off-grid community project case. See Figure 4.1 for approximate project locations.
4.3. COMMUNITY PROJECTS

4.3.1. Meadow Lake Tribal Council biomass project

Meadow Lake Tribal Council (MLTC) is comprised of nine First Nations in the northwest of Saskatchewan with a population of about 16,000 on and off reserves. Like many rural First Nations, most of those in the MLTC have limited opportunities for economic development, so the main goal for the project was to generate revenue to fund their operations, services, and programs by providing clean energy from waste. Forestry is important in northwestern Saskatchewan, though harsh conditions and distance from markets put limitations on the development of the industry. MLTC invested in two sawmills: one in Meadow Lake, and most recently one in Glaslyn designed for more intensive utilization of timber, including the production of posts, rails, and wood residues (biomass). The Glaslyn mill is now a 100% Indigenous-owned facility recycling waste from three existing mills in the area.

In 2018 MLTC secured $52.5 million from the Canada Infrastructure Green Energy to support the Biomass Project and made a 6.6 MW power purchase agreement with SaskPower, the provincial electrical utility. While the government provided funding, the planning,
operations, and development were done by MLTC, choosing self-management over contracting externally. To receive federal funding for the project, MLTC had to create a slightly complex management structure involving a not-for-profit corporation which returns dividends to MLTC Resource Development (RDI), an entity governed by a board comprised of the Chiefs of the nine First Nations, the Chief of the Tribal Council and two external members, for distribution.

4.3.2. Fort Chipewyan solar project

Fort Chipewyan is a remote community in northern Alberta with a population of approximately 1200 people. The Fort Chipewyan Solar Project is the first and largest off-grid solar farm in Canada. For the community, solar was seen as the most viable option to offset the use of diesel generators without investing in expensive infrastructure. With the help of ATCO, a utility, Three Nations Energy (3NE) was created. It is owned collaboratively by the Athabasca Chipewyan First Nation (ACFN), Mikisew Cree First Nation and Fort Chipewyan Métis Association. The 3NE Board of Directors consists of two representatives from each of the participating organizations.

In this case, 3NE invited Green Planet Energy Analytics, an Alberta-based clean energy company, to help design, manage, and build the solar farm. The result is a total of 2.95MW of capacity, comprising 2.35 MW owned by 3NE and 600 kW owned by ATCO. The entire cost of the project was about $7.7 million, with $4.5 million provided by Natural Resources Canada and the rest by the Government of Alberta, which also provided funding for the original Community Energy Plan.

The solar farm was built to offset diesel emissions (25% on an annualized approach) and to provide additional support to the local grid. It was also intended to give the community a greater stake in their own energy system. 3NE owns the solar farm and sells the electricity under the provincial Small Scale Generation Regulation, or SSGR. 85% of revenue is divided equally amongst the three owners, and 15% is held for energy education and stewardship. However, 85% is approximately $50,000 to $70,000 a year, which is insufficient for community programming.
Unlike Saskatchewan, Alberta has a partially privatized energy market so 3NE sells to the Alberta Electric System Operator (AESO), while ATCO manages the local grid. ATCO also has a maintenance and service contract and operates a battery storage for the solar project, which is connected to a 6 MW solar farm of its own. They are responsible for ensuring that the solar farm is maintained and operated in a way that integrates with their larger system. Interview subjects agreed that one of the factors that allowed the success of the project was the collaborative approach and the cooperation of ATCO as the existing main utility service in Fort Chipewyan and three Indigenous groups. Three different Indigenous entities agreed on ownership, percentage, and project share percentage and 3NE spent six months to a year to increase the community’s comfort level with the idea of building and owning a solar project in collaboration with ATCO.

4.3.3. Tazi Twé hydro project

Black Lake Denesuline First Nation (Black Lake) is located in the far north of the province, one of the 12 members of the Prince Albert Grand Council. A peculiarity of the Saskatchewan power grid is the existence of a separate northern grid based on hydropower with connections to Manitoba but not to the rest of Saskatchewan. Black Lake proposed to increase capacity on the northern grid with Tazi Twé, a run-of-the-river 50 MW hydro project. Lacking experience with large-scale infrastructure projects, Black Lake turned to the Prince Albert Development Corporation (PADC), the economic development arm of the Prince Albert Grand Council, and to SaskPower as a partner.

The deal offered by SaskPower included a 49% ownership interest for the First Nation with a 50/50 revenue split. Unlike the situation in Alberta, SaskPower is the sole power purchaser in Saskatchewan and would have been simultaneously a purchaser and a business partner. They were naturally interested in buying the power at the cheapest rate possible, while the nation’s interests lay in maximizing revenue. The environmental impact assessment process for the project took over three years, during which time the estimated cost of the project inevitably increased while the main customer for the electricity, the northern Saskatchewan uranium mines, entered a prolonged period of low prices, resulting in mine closures and reduced demand.
In the end, the project was postponed. Thus, this project represents a case of failure, indicating not just how regulatory hurdles can affect community energy projects but also the challenge of working with a monopoly power purchaser. Nevertheless, working with SaskPower created the opportunity to develop a number of energy efficiency projects in the community.

4.3.4. Muskoday solar projects

Muskoday Solar Projects are developed by Muskoday First Nation, a member of the Saskatoon Tribal Council. Band membership is approximately 2200, of which about 780 live in the community, which is located in the area covered by the main, southern section of the Saskatchewan power grid. There are 2 solar projects overseen by the Nation’s economic development arm, the Muskoday Economic Development Authority (MEDA). The first, in 2017, was a small community development project to provide solar panels for three community buildings, funded in part by the federal government’s Low Carbon Energy Challenge. Muskoday First Nation applied for $500,000 but received only $375,000 in funding from the federal program, financing the balance themselves. The second project was intended to generate revenue from selling power to the grid under a power purchasing agreement with SaskPower. Originally proposed as a 1 MW project the project was eventually reduced to 324 kW because of funding difficulties and the risks of financing agreements. Though the amounts may appear small, the project received only $250,000 from the federal government and would have been required to generate close to capacity in order to finance larger bank loans, a risky proposition with solar power.

Planning and support for the projects were provided by the First Nations Power Authority and the Muskoday Economic Development Authority. MEDA’s Board consists of seven members, four Muskoday First Nation members and three independent members. Grants were essential to the feasibility of the projects. They were never sufficient to cover all the costs and they involved the same circuitous process observed at Meadow Lake; MEDA prepared the application, the Muskoday First Nation formally applied for the grant, and then turned the money over to MEDA. Like Meadow Lake, both Muskoday and Tazi Twé ended up with a more top-down approach in contrast to the more bottom-up governance found at Fort Chipewyan.
4.4. KEY THEMES FROM THE COMMUNITY INTERVIEWS

4.4.1. High level goals: economic self-sufficiency and sustainability

For all those interviewed, one of the main goals of energy projects was to generate revenue to fund programs and services. The nations want to become self-sustaining; the interviewees emphasize that they “don’t want control through ‘handouts’” (community interviewee #1). The other goal is to reduce GHG emissions and gain energy security by creating clean energy projects which also align with the Indigenous perspective of respecting the land that provides physical, spiritual, and economic benefits and leaving no waste. The findings show that escaping dependence is the main driver behind the nations’ renewable energy project development. The federal transfers are not enough so communities still face the lack of finance for community programs and services. Therefore, communities look for options that can help gain self-sufficiency with projects, but which also align with the Indigenous worldview.

4.4.2. Challenges and opportunities: process, recognition, and capacity building

The community leaders as well as government and industry agree there is a need for a better process when it comes to the planning and implementation of energy projects. Interestingly, community leaders see the pre-planning phase as the most difficult. Funding is certainly a challenge, but their frustrations revolved around the failure of government and industry to see Indigenous communities as equal partners and to ensure that the communities have the decision-making space and capacity to turn that equal vision into reality: “for those First Nations wanting to get more information and explore the possibilities, there has to be a more streamlined process. As far as the capacity you have to build capacity from within and do your research properly. But I think there needs to be more willingness by the government and Crown corporations to walk down that road together. It’s in everybody’s interest” (community interviewee #5). Achieving equality in part requires a change of attitude but that change comes with a responsibility to rethink what true partnership involves: “through renewable energy projects government can really step in and they can seriously support communities. The Crown corporations, like SaskPower, have got to get away from the attitude of it’s all about bottom line. Government has a real role in trying to balance and change some of those attitudes” (community interviewee #1).
For these community leaders, the future of their communities is tied up with the planning process and funding in complex ways. For communities it seems like a one-sided approach that they need to come up with proposals, make inquiries and go to a power utility: “they find it hard to deal for First Nations with Crown Corporations in the community” (community interviewee #5). When it comes to who has more influence in decision-making, the communities argue that it is “those who can control the purse strings at provincial and SaskPower level” (community interviewee #5). Whether the utility is public or private, the concerns are similar: “In Saskatchewan, we’re limited to one purchaser, so they pretty much hold the checkbook”. SaskPower has negotiating power and control in a number of aspects, “you have a group there, that’s a gatekeeper” (community interview #1). This is equally applicable to the Alberta case where ATCO and AESO are seen as the main decision-makers.

“Government plays a key role, absolutely. Without government, it wouldn’t happen but at the same time it’s not an easy process…” (community interviewee #2).

This broad perception of inequality is supported by two specific areas where community leaders mentioned capacity deficits. The first is funding in a context where the partner is applying strict commercial criteria to the assessment of a project: “Any kind of project that’s going to generate sufficient energy that’s worth selling back to SaskPower is going to be costly” (community interviewee #5). All the community representatives emphasize the difficulty in raising the finances for starting the project and the time that it will take to recoup the investment: “…the cost of constructing them can be huge. And you've got to recoup that money over a long period of time” (community interviewee #1); “Financial support is the biggest stumbling block to any project, and we that’s where we need to be better prepared to get back approval on projects, that’s, and funding, and trying to persuade governments to when we succeed, everybody succeeds, and leverage some kind of support that way, in terms of helping with the project” (community interviewee #5). The climate agenda created “a window of opportunity” for Indigenous nations and for government to find less expensive energy options that have not required much capital cost. So, the government started to develop clean energy grants/funding that consequently became in most cases the only way for First Nations to develop their renewable projects.
Even then, when a part of the project needed to be financially covered by the nations, they encountered many difficulties. The revenue for all projects was modest so the projects could not have proceeded without forgivable grants. Indigenous groups from some of the case studies were able to successfully secure parts of their funding from the federal government and another part from a commercial bank: “First start one has to look at is the overall cost. And then you look at your return on investment… we don’t have money to run the programs as it is. So, we’re like any other business we have to go to the banks with hat in hand to finance” (community interviewee #5). In the case studies, interviewees emphasize that the projects were not considered profitable from an investment perspective. They argue that PPAs are not lucrative but it’s a stable revenue model.

The challenge posed by rising interest rates is that the same revenue could be generated from investment rather than capital expenditure. While this might not seem like a problem, the communities saw projects as essential to developing their own capacities. Even though the return on investment for the projects would not meet standard investment criteria, it made sense for other reasons. For Indigenous nations, it was about becoming more self-sufficient. Even then, for all the case study projects, the reasons behind developing their projects filter down to financial support of the programming for the community, hence more programs and services for First Nations.

Despite difficulties with acquiring the funding/grants, interviewees agree that the government has a role in finance and public support. They emphasize that the work with the federal government was more straightforward and within predictable timeframes than with the provincial government: “the federal one was quite straightforward with respect to what needed to be done and timelines and everything” (community interviewee #5). However, the funding is paid by the government but brought back through the province. And since Saskatchewan is limited to one power purchaser, interviewees argue that “SaskPower held more power, and acted as customer, not as purchaser” (community interviewee). Community interviewees felt like they couldn’t make better returns for their communities, as there is gatekeeping. The government creates processes where First Nations would be excluded from pursuing some of those opportunities to begin with. They emphasize that the government needs to think about reasons other than just the cost of developing renewable energy projects. They see that the SaskPower policy started creating opportunities for Indigenous people, but they need the provincial government to take a leadership role.
Thus, the financial issues are directly connected to the other capacity challenge, human capacity: “Government can be their own worst enemy... they come up with various grant funding opportunities that are well intentioned, but quite often the community doesn’t have the bench strength or sophistication to apply for these grants or administer these grants, etc...it excludes many communities that might be interested to begin with or that would be interested at a higher level but simply can’t go through the process itself” (community interviewee #2). In Fort Chipewyan case, the process was perceived to be onerous even though their industry partner was responsible for the application: “when you have industry experts [ATCO] that are challenged by some of the bottlenecks of government as well, I don’t know how any individual community could be successful in getting millions of dollars in funding for such projects, despite their best intentions” (community interviewee #2). Once successful, the nation found that the government wanted to deal with its industry partner and not with the community: “there was a collaborative approach but … NRCan wanted ATCO to administer the bank accounts, process payments for a project that was supposed to be Indigenous. So, we [3NE] had to go back and lobby the government to allow us to actually oversee the funds... And there were minimum standards of accountability that had to be adhered to demonstrate that we were capable of administering funds, etc.” (community interviewee #2).

The power differential in decision-making is aggravated by the non-homogeneity of the Indigenous communities. Even though there is “no competing” policy within nations when it comes to economic/business project development, Indigenous communities are not homogenous within the nations. The community project leader pointed out that “people within the communities have very different perspectives… so often government and media industry, they kind of look at it as a blob of the same and they fail to recognize the complexity” (community interviewee #3); “It’s a very complex and dynamic environment” (community interviewee #3). For instance, in the Tazi Twé project, there were at least three factions within the community: those whose overriding concern is the protection of the environment, those who want business development driven by financial interests, and those driven by personal political interests. The latter maintain the middle ground position when it comes to new projects as it would most likely affect their voting demographics. Some advocates of development argue that they have to understand and accept the politics of their communities: “Then you had the leadership who were trying to remain leaders and they kept
saying “we will do it as we’re directed by the community”. So, they basically rode defence and wouldn’t assume a leadership position because the community was split between those who supported and those who didn’t support it. There’s a very interesting political dynamic around projects and it’s essential” (community interviewee #3). Others maintain that successful projects are a result of strong leadership backed by the community. Thus, in the Tazi Twé case, they argue that “the leadership was standing on the sideline… and ‘yes’ side won… had the leadership truly been leaders and taking a stand? Maybe that would have been different, maybe the majority would have been stronger”; “The project would have gone ahead, had not the economic conditions changed, but it was a struggle all the way through because there was no consensus in the community or the leadership” (community interviewee #3).

Another division can be generational. “Elders group that was generally not supportive. Number of reasons: afraid of change; hoping to go back to the old ways; stressing independence; wondering why they couldn’t bring a diesel generator back in to generate power; concerned about the land and the impact on the environment” (community interviewee #3). However, even within Elders, there’s a split between those focusing on the future and those wanting to go back to the past: “Some saw this as a future for the children, the profits generated from this project would have made a fundamental change in the community. Over time, the community could have become financially independent. It would have provided employment opportunities and training. The young people, particularly the males were supportive because they wanted jobs, particularly through the construction… to obtain skills and income” (community interviewee #3). Another group was indifferent to the project since “over 60% of the homes in the community are on social assistance… the government pays all power bills” (community interviewee #3).

4.4.3. Energy projects continue to be framed within Indigenous worldviews

Community interviews reveal that in developing innovative technology projects like renewable energy there is an alignment with Indigenous worldview and the storyline of a cycle/circularity: “First of all, I think, what you have to consider is First Nations worldview. First Nations consider Mother Earth the most important thing because everything we get, we get from Mother Earth for use, benefit, and survival”; “So, it fits in with our worldview to develop these natural resources: sun, wind, geothermal, but that’s so expensive to develop
geothermal. Wind and sun, we think we will always have, at least we hope we will. So, why not utilize as best we can and more than fossil fuels so pollute Mother Earth” (community interviewee #5). For Meadow Lake Tribal Council the goal of the biomass project for the community is to “become more self-sustaining, generate more revenue, and then better fund programs and services… there’s also the goal of clean energy and not wasting”; “And it creates employment as well” (community interviewee #4). There’s a very traditional teaching around it is “not one piece of the tree should go to waste, everything should be used” (community interviewee #4). For the majority of the communities, the broader objectives of the renewable energy projects align with their traditional worldview and concepts. Such as for Cree people it is a concept of ‘pimachesowin’, an ‘ability to make a good living’, similar to the Anishinaabe Peoples concept of bimaadiziwin, the ‘Good Life’, and ‘ayii yorege’, ‘teachings of good spirits’ in my Sakha/Yakut peoples’ culture. The concept of ‘making a good living’ unites the idea of the land, good conduct, and self-sufficiency, which includes values such as self-worth, dignity, and independence that are essential to a community’s or a nation’s security. The latter is especially relevant today in the context of the threat of environmental and technological disasters. In this context, it has an importance for Indigenous Peoples in the ‘rebuilding’ of the communities and in decolonization (Iakovleva, 2022).

These priorities are not the main reason for industry and government seeking partnerships. They are oftentimes driven by the incentives of economic benefits and recently climate change agenda. However, climate change is linked to sustainability, which presumably has different meanings for communities and industry/government. Therefore, learning the government/industry perspective will help to understand their position when it comes to building clean energy projects in northern, remote, and Indigenous communities, which is then will support uncovering whether there is an alignment or discrepancy in Indigenous communities and industry/government perspectives.

4.5. LESSONS FOR SMR DEVELOPMENT

Interview subjects were asked about SMRs and, while they are not currently under consideration, the general sentiment is neutral. “There’s been little or no discussion on what communities think of SMRs as far as environmental issue because there’s lots of those issues around and that will take a great deal of discussion. But as far as an opportunity for a community that feels they’re comfortable with it produce electricity and heat, district heating
system, it’s probably a tremendously smart idea. With these new, safer microgeneration systems, the one that generate 5 MW, you’re able to do just like we did with the biomass”; “the federal government, they have to get off a diesel grant program out there right now” (community interviewee #1). Community acceptance is another big challenge with any type of ‘new’ project: “if you’re talking about nuclear, time will tell… to be honest with you, it was challenging enough to get community buy in for a solar project”; “Swaying public opinion in a small community, it would be very challenging to say the least, not impossible but challenging”; “Alberta government is hoping to [get SMRs] in the oil sands, and maybe further into the north but you need to consult; you need buy-in from the locals… There’re many unforeseen challenges yet to be recognized” (community interviewee #2).

Ironically, SMRs are not considered feasible for power production in Saskatchewan’s uranium mines, which are currently powered by hydro on the northern grid. “in the north, that would be absolute last place they would put a small nuclear reactor” (community interviewee #3). Uranium mines buy power at cheap cost, locked in agreements for multi years. If a SMR was proposed located in northern Saskatchewan, you’d have the same split [in views]… They [Elders] have two different views of the world” (community interviewee #3).

The concern over waste is still one of the main issues, however, and the community leader hoped that a solution to the current practice of on-site storage of spent fuel could be found: “I’ve got a little bit of mixed feelings on nuclear energy…personally, I’m on the fence a little. The biggest story is the waste… I know that tremendous potential it has. There’s got to be a way that modern technology can deal with it that’s going to be sustainable into the future… I think it can be done… also going to cost a lot of money. But in order to save money or make money, you got to spend money as well, too” (community interviewee #5).

The overarching theme around the work with communities in the development of SMRs and other clean energy projects the government/industry interviewees see in building relationships by inviting and listening to the communities as a way to amend past relationships and actions. The analysis of the main storyline demonstrated that governments cannot always control the dynamic, however, it is still a political strategy to argue for empowering the niche (Iakovleva & Rayner, 2023). The government and industry do make an effort, but this is done as Smith and Raven (2012) put it in a way that presents “important change processes as resting in actors strategically re-telling the past to make new sense of the
present and envision alternative futures” (Smith & Raven, 2012, p. 1032). This is clearly uncovered in the interviews’ context of connecting past actions to create a better future by the industry/government interviewees: “we've all learned over the years that it does have to be a partnering and a two-way conversation; it can’t be ‘this is what we're trying to do’. And that's one of the things that we've heard about is that don't come with what you plan to do, come with ‘this is what we're interested in doing’ and listen, so that it becomes a collaborative partnership on the outcome of a project and not a one-way this is what we're going to do, because that is showing, you know, we've seen in Canada that that type of relationship is not successful in the long run” (intermediary interviewee #1).

As such, actors in the government and industry see the development of SMRs as “a window of opportunity” to amend the relationships damaged in the past with larger nuclear plants. “It is a matter of understanding where the relationship exists today, what is the history of the relationship, and being very respectful of legacy issues” (industry interviewee #2). Both federal and provincial governments and electricity utilities have difficult legacies with Indigenous communities in Canada in developing any type of energy projects. They base the argumentation of building new relationships on documents such as Truth and Reconciliation Recommendations and the Calls to Action: “we're trying to take things slow, not move too quickly, that we can't bring those relationships along for this journey. We have 13 years before we could be operating a nuclear power plant. It seems like a long time, but it's really not. And so, we're trying to make sure that we're not moving too quickly, that we blow by those communities, the broad public and Indigenous people in the province, right? And so, it's a journey that we're going to take together, and you just try to be very respectful of every situation, and what the history and legacy is” (industry interviewee #2).

These statements reveal the difference between Indigenous/community and industry/government perspectives in understanding the matter of “timing”. It is impossible to say how long building trust and relationships to reconcile relations with Indigenous nations will take but for the government and industry, it is just an objective like any other and put in the timeframe of what will work for the project. As such building relationships with communities is planned to take as long as the development of the project, while for Indigenous nations it is perceived differently and will take a longer time. Reconciliation is a long process, that may take decades and longer.
This is not to say that the communities in the case studies deliberately drew out the process. In fact, the reverse is true because the consequences of failure were so much greater for the communities. It represented the community’s lack of decision-making power, which didn’t affect the industry to the same extent. The industry/government fails to understand the power differential and that engagement with communities would not grant decision-making power to the communities: “I think, in order for this model to be successful, more companies are going to have to engage with their impact communities the way we’ve been doing for decades, and that that’s a great outcome. So, communities need to decide, you know, what is decarbonization, a goal of theirs? Is it really truly a goal? What's it based on? Is it because we're worried about emissions? Or is it because we're trying to eliminate energy poverty and energy insecurity? Figure out what really is the main driver there, figure out what the needs are, and then be prepared to make long-run decisions, you know, like, the thing about investing in a nuclear power plant or a hydroelectric dam is you're asking folks today to make an 80-year decision… somebody had to have the courage 60 years ago to make that capital decision and to get the community support, and then generations just benefited from it” (industry interviewee #3).

This informs how government/industry sees the perspective as giving the communities a choice by providing all the benefits of clean energy, i.e. SMRs, and then expecting the communities to make a decision and accept the technology: … “if they were presented clear, evidence-based options, I don't see how all of them would say no” (intermediary interviewee #4); “I think our biggest challenge is to learn how to be humble, and to listen, and to acknowledge that we don't have all the answers and that communities are dealing with things that we don't understand that don't have basic solutions and they certainly don't have engineering solutions. And so, I think it's on us, right? Like, Indigenous communities know what they want, they know what they're doing, they know what their priorities are, they are the experts in their own lives and history. And if we forget that or ignore that, we're going to blow up our own projects, right?” (industry interviewee #5); “From our perspective, it's about inviting communities in, welcoming them to learn from our knowledge, to learn from our experience in the industry, and, you know, not forcing information upon a community that they may not want. So, it's a subtle distinction, but, you know, the key is to invite communities, welcome them to learn, but not ordering them to learn, if you can see the difference” (industry interviewee #6).
The existing power differential creates this imbalance where even with informing communities of options and providing the necessary data would not help to gain acceptance and meaningfully engage with communities. This shows how the government/industry approach is unilateral, where government/industry actors seem to not envision a full picture and have not engaged with the communities as equals. The actions by the government and industry are very fragmentary which informs this one-dimensional approach.

“I think we often forget that, we forget the human element of building trust and building relationships. And that is something that I think policymakers can't afford to forget” (industry interviewee #5); “I think over time, it's like any relationship, it's built on a relationship, get to know each other for who we each are, and then establishing trust and willingness to work together. And some days, there are going to be things that both parties can't agree upon. But if you have a trusting relationship, you can deal with the deltas in a much easier way than you could have if you have an adversarial relationship. So, listen, commit to be better on ongoing way, measure your performance and prove that you are getting better, and then strive to be even better the next time” (industry interviewee #7); “I think that just open and frequent communication is the starting point. And, once again, it needs to be two-way communication. It's not just coming with a message, it's listening to what the concerns are of the different communities and then collaboratively working to find an answer if there are concerns… listening to understand what those concerns are is critical” (intermediary interviewee #1); “you want to have a partnership, where you have the trust of the energy developers and the communities and that type of trust, you can't build that trust overnight. So, in my mind is a very long-term strategy and goal that you need to develop over years and years, so that there's trust” (intermediary interviewee #1). The government/industry wants to approach communities in a meaningful way, but it seems there is a lack of unanimity and understanding of where to start and how to approach communities. The latter, as it is also emphasized by the community interviewees, mostly left to an Indigenous advisor or specialist in a utility organization or government to carry all the responsibilities in working on building trust and relationships with Indigenous communities.

Among the fragmentary actions that government/industry takes as empowerment approaches is the idea of providing equity participation to Indigenous groups in SMR projects. There is no clear picture among the interviewees on the process, but it is again based on referring to the amendment of past actions. The interviewees admit that historically
Indigenous communities had not been part of the equation and that needs to change: “But if you look historically at the way energy development has occurred in this country. That [Indigenous side] has not been a player. It's something new” (intermediary interviewee #8); “Indigenous people are rights holders, but they're to me, they're number one on the list of influencers. And they have to be brought along, and this is an opportunity for them to be involved from the ground up in a new industry being developed” (intermediary interviewee #9); “I think there is an interesting way in which we can have more of our interests aligned with the community. And that involves providing a minimum level of equity participation in a project. So, in other words, the community could be owners of the project, owners of the industrial facility (industry interviewee #6); “I think we need to look for opportunities for Indigenous communities to become true stakeholders in the deployment of SMRs. There have been, I'm aware that there have been discussions. I'm not sure at what level yet but there have been discussions of some Indigenous communities wanted to take on a larger stakeholder, larger share of deploying SMRs” (intermediary interviewee #1).

Other actions include attempts to legitimize the work towards Indigenous engagement. The first includes organizational policy documents such as Ontario Power Generation’s Reconciliation Action Plan: “it’s got some real metrics on there. So, this is not just words, this basically says we're going to spend X dollars in the next 10 years with Indigenous companies and committing to us, and we're measuring our performance against that, we'll continue to measure performance and publicly convey whether we achieved those goals that we set out” (industry interviewee #7). The other legitimization attempt is the work with intermediaries: “we have started that process of Indigenous engagement. So, for example, we're a member of the First Nations Power Authority, which is an Indigenous organization, non-profit Indigenous organization, seeking to deploy clean energy solutions to Indigenous communities” (industry interviewee #6). The third one is community agreements: “[Organization] has signed five agreements. Those agreements aren't agreements for the communities to support the project, it's agreements for the communities to actually have an informed opinion about the project. In my mind, success isn't limited to a community deciding that they're going to partner with us and support the project” (industry interviewee #5). These actions are a step forward despite being fragmentary.
The following section discusses an alignment or discrepancy between the community and governance/industry perspectives and the role of it in creating a framework for work for both parties in building innovative energy projects.

4.6. DISCUSSION

Governments, both federal and provincial, have decision-making power when it comes to any energy project development in northern, remote, and Indigenous communities. Utilities may also have a role, especially if they are private corporations. The previous sections show government and industry have the power to walk away from new projects at anytime, as in the Tazi Twé case study, while communities are more dependent on the government and industry. The system is set up so that it creates organizational barriers for Indigenous nations in funding, regulation, and overall project development.

Although most projects are 100% Indigenous-owned, the case studies reveal the complexity of the federal funding distribution system and the power imbalance it creates. Economic development agencies or similar types of organization generally take the lead in project management, but the governance arrangements are set up so that the federal government does not release funds directly to economic development authorities but to First Nations, where nations distribute them back to the economic development arms. In the Meadow Lake case study, the process had been even more complicated, where they had to create a separate not-for-profit company in order to receive funding from the federal government.

Another barrier is non-transparency and discretion of federal and provincial funding decisions. First Nations that applied for a certain amount of funding were almost never successful in getting the requested amount. They received less than asked. This is a special problem for First Nations as they are limited in options to make up for those shortfalls. In comparison with private corporations that can make up for the shortfalls with external investments, First Nations encounter difficulty raising finance for the projects to begin with and recouping the investment if they succeed in getting one. This tendency creates a lack of trust from Indigenous nations when it comes to even start developing innovative energy projects which also does not come with the use of roadmaps.
Communities experience a lack of information on how and where to begin with the innovative technology development process and they emphasize a lack of awareness of other community project experience. They argue that there is no guide/playbook in terms of where to start, “here’s your project that you’re looking to do, and here’s everything that you’re going to have to know. It can be tough, especially for first time nations” (community interviewee #6). The necessity of roadmaps is clear from the broader lessons of the transitions literature (Iakovleva et al., 2021). But the government/industry roadmaps and action plans have no practical application in communities, and they barely include communities, except for ‘checking the box’ of community engagement. There are some attempts to create local roadmaps, for example, Ontario Power Generation and Athabasca Chipewyan First Nation came up with the Reconciliation Action Plan and the Community Energy Plan respectively. However, there’s no comprehensive plan that represents both government/industry and community roadmap/guideline towards the development of clean energy technology. Even though government and industry interviewees voice the need for a streamlined process in the energy development process, overall, they seem to have a unilateral understanding of where to start with community engagement, mostly founding their actions on narratives of building trust and relationships as a way of amending past actions. However, the relationship between government and industry or utility can also be nuanced, for example, in the way that the provincial government can play a role in directing a Crown corporation which is different from private organization. While private organizations would need to be involved and held accountable for the decision-making, Crown corporations are tied to governments, therefore, if the project fails, the government can put responsibility on the Crown corporation, and the opposite, if the project succeeds governments can take all the credit. Overall, governments see conducting business with Indigenous nations in energy projects as a risky venture. Most communities have no prior relationship with Crown corporations on any energy projects. Therefore, communities also voice the need for a streamlined process both in funding and regulation and the importance of the role of government where policy decisions should be taken. As such, community interviewees emphasize the need for the creation of a space.

Creating a space is important for the community interviewees. The concept of space in this context entails several meanings. On one hand, it is similar to the idea of “safe space”, Indigenous space, that can take the form of formal and informal networks. Formal networks could be an institutionalized space that potentially includes funding opportunities, e.g., procurement opportunities, access to private capital, funding platform to build on, etc.;
decision-making power, e.g., expedited regulation for community projects, community decision on technology options, etc.; infrastructure development plans, and others. Informal networks could be a non-institutionalized space where communities connect with other communities in learning from each other and approaching industry and government, where they also get information on processes around project development, and training. On the other hand, the idea of space is similar to the idea where space creates time. It allows communities to take time to examine more and make an informed decision about the project development. So, in addition to safe space, there is a need for space created through implications of government/industry actions. Overall, that is what the engagement process includes.

However, industry/government sees the engagement process only from the regulatory lens where in fact what is needed is time to engage with communities beyond legal processes and create space for a ‘dialogue’, long-term reciprocal engagement process. Another issue is the question of a degree of institutionalization where informal networks can become institutionalized but may not necessarily take this path. In this context, it contrasts the traditional idea of institutional arrangement and aligns with the Indigenous worldview of space, where informal networks can act as non-formalized spaces where nations reciprocate and build relationships. By creating that space government and industry’s role is to create possibilities for communities to explore, so that communities will not miss opportunities as it was in the past.

So, there is a role for intermediaries in helping to create and manage the space where it would be possible to find ways to align the perspectives of government/industry and communities. From the sustainability transitions multi-level perspective, intermediaries can create a shift in a socio-technical regime. In our previous paper on intermediaries (Iakovleva & Rayner, 2023), intermediaries were studied from the lens of enabling technology adoption or “bridging the ‘valley of death’ between R&D and market introduction” (Schot & Geels, 2008, p. 538) where we found out that intermediaries act as policy entrepreneurs, i.e., “actors who engage in collaborative efforts in and around government to promote policy innovations” (Mintrom, 2019, p. 319). Most vendors and utilities interviewees mentioned First Nations Power Authority as an organization they work with to build meaningful engagement with Indigenous communities. The vendors argue that they have a collaborative relationship where FNPA helps to understand Indigenous issues and vendors help FNPA understand the technology, and what’s involved with the process of licensing, construction, and operation. They point out though that it’s not a systematic approach yet. However, the process should be
both systematic, formal, and less systematic, informal. FNPA represents an organization that
the government and industry understand. It is a formal institution with a clearly organized
structure, therefore, ‘easy’ to work with as opposed to First Nations and their organizational
systems. However, FNPA is an Indigenous organization that also works to support First
Nations, therefore, it acts as a policy broker.

In this research, I look at the innovation process from the lens of innovation
deployment, where intermediaries act more as policy brokers, getting closer in meaning to the
earlier concept of ‘change agents’ (Hägerstrand, 1952; Rogers, 1995) that not only have a role
in linking but helping transform the ideas and transfer knowledge (Hargadon & Sutton, 1997).
They also embody traits of intermediaries that initiate change within science networks and
more localized configurations, local collectives (Callon, 1980; Callon, 1994). The
reconfigurations produced by these “collectives” depend for the most part on elements that
are brought together on the local culture that they constitute. The collectives and their
elements can be drawn together, in confronting each other or interacting with each other
through representatives. Those representatives are intermediaries. The local collective can
propose some original, innovative reconfigurations linking together networks that had been
separate (Latour, 1987; O’Connell, 1993).

Therefore, intermediaries play an important role but the precise type and role of
successful intermediaries are, as the innovation literature concedes, context-dependent. In the
local collectives’ context, intermediaries are representatives of networks, therefore, the role of
intermediaries is also network-dependent. Communities have had intermediaries involved in
the process. The case studies demonstrated that for the projects to be successful the
communities need to be the ones to decide on the project, however, providing decision-
making is not enough, they also need space. There is still a role for an intermediary chosen by
the community, e.g., FNPA, Green Planet Energy Analytics. In the case of Fort Chipewyan
the utility, the Green Planet Energy Analytics company was hired by the 3NE to build and
manage the project. In Meadow Lake, the project was historically contingent on the resources
that have been developing in the area for decades. With the leadership of the community and
the help of the intermediary organization of FNPA, they were strengthening their work in the
development of biomass plants. Muskoday First Nation worked closely with FNPA which
helped them to recognize potential in SaskPower’s call for proposals in building solar projects
in the Indigenous communities. The Black Lake First Nation needed support from the intermediary who would have helped them build the case and work with SaskPower.

The role of FNPA is seen as lobbying on behalf of First Nations, where the nations acting individually were unsuccessful or inactive. Additionally, FNPA stands as a consulting agency when nations need help with assisting with administrative processes and other organizational barriers. FNPA could be seen as an ‘incumbent-oriented intermediary’ since it is mostly funded by the federal government and Crown corporation, however, from the community projects’ perspective, FNPA can help provide support in creating that space of formal and informal networks. FNPA acts as a policy broker in ‘creating the space’ for Indigenous nations.

Indigenous nations need a space created where they can build on and where they can be present in more spaces than just the Indigenous Relations team. The work with Indigenous communities at the Crown corporation level is unilateral in Indigenous energy projects, there the Indigenous Relations team is the one that covers many grounds, spanning over different areas and technologies. The broadness of responsibilities meaning for specialists to be the jack of all trades creates the shortage of more thorough work with communities on certain projects. Therefore, this calls for skilled specialists in capacity and management side and that’s where training is needed, in particular training in transferrable skills. The education system provides specialists who can take on specific professions but there is a need for project management and evaluation skills for energy technology development in Indigenous areas.

Management of the projects plays a great role in project success or failure. The case study projects reveal similarities in governance structures. For the Muskoday First Nation solar projects, Meadow Lake Tribal Council biomass project, and Tazi Twé hydro project, an economic development arm played an important role as the project lead. In case of Fort Chipewyan solar farm, the nations formed a collaboration of three First Nations and hired a side company to manage the project. If First Nation bands or a Tribal Council develop projects independently as in Muskoday, Meadow Lake and Black Lake projects, they develop and manage projects through Economic Development agencies. If two or more nations develop projects together in collaboration like the Fort Chipewyan project involving the Athabasca Chipewyan First Nation, Mikisew Cree First Nation, and Fort Chipewyan Métis Nation, they create a separate organization to oversee the project, in this case, 3NE.
Therefore, in finding the governance structure that fits the requirements of government and communities the closest structure would be a form of energy cooperative, where every party can benefit if the project succeeds.

As we can see, intermediaries, creating space and capacity building are important factors in innovative technology adoption. Communities emphasize that nations need to make decisions but the governments play an important role in initiating the change to make that decision. Therefore, based on what was discussed above I propose policy recommendations, or ‘good practices’, for sustainable innovative technology adoption in northern and Indigenous areas that can potentially be applicable to future development of SMRs.

4.7. POLICY RECOMMENDATIONS

Based on the discussion of the interviews with government/industry and communities I identify the following policy recommendations, or ‘good practices’ for innovative technology adoption. These recommendations are driven by the perspective of northern, remote, Indigenous communities in their renewable energy technology development but included in a broader narrative of clean energy technology development. Learning from the already existing experience and knowledge of the communities on renewable energy as clean energy will provide advantages for both the industry in developing the technology, as well as communities to have a comprehensive understanding and an informed decision on the development of clean energy technology and potentially SMR projects. The federal government, utility companies, and SMR vendors argue that nuclear energy will play a key role in meeting Canada’s net-zero goals, in particular, SMRs (GE Hitachi Nuclear Energy, 2021b; “Planning Our Power Future,” n.d.). However, large reactors are less relevant for northern, remote, Indigenous communities unless it is a mining site application, and currently, there’s no existing development of SMRs in the communities, but there are other projects such as renewable energy projects that we can learn from in application to SMRs. With mining as the most probable application for SMRs, there is an issue of proximity with communities and perspectives that might go into disarray with the industry perspective on SMR projects’ development. Developing innovative technology projects that include a community governance perspective will help advance the technology and energy transition not only in accordance with industry/government development goals but more importantly
with Indigenous communities’ goals and in pursuant to reconciliation with Indigenous nations.

Before providing recommendations, it is important to remember that every community is unique, Indigenous communities are not homogenous. Every one of them has a unique history, background, knowledge, experience, and people, so it is essential to not generalize communities and approach each one individually with a focus on local priorities to build relationships and develop a shared vision. Communities are not only different from one another, but they are also not homogenous within communities. There are factions of different groups, political interests, and Elders within nations that would support or oppose the same project. The governance systems of Indigenous nations are complex and different from Western systems. Socio-cultural practices are deeply embedded and drive governance systems and community operations. As such, there is a special role for Elders, knowledge keepers whose voices are as important in decision-making as the voices of Chiefs and Councils in the existing systems of First Nations Bands/Tribal Councils imposed by the Indian Act. Thus, traditional forms of governance exist with the colonial ones. So, it is important to remember the uniqueness of the communities and avoid deepening the division within communities with policies.

Hence, creating a space in the form of formal and informal networks that will benefit communities is important. Case studies reveal that First Nations’ experience is exacerbated by the history of complicated relationships with governments and Crown corporations which made them hesitant if they fail to get help, including financial and administrative help. Therefore, building a portfolio and regaining confidence will require space, even more in developing a priori contentious niche such as SMR development.

**Create space in the form of formal and informal networks:**

There are a number of approaches to creating the space. The form of formal network that I propose includes a general partnership of Indigenous owners in the form of cooperatives that can help develop projects and increase Indigenous participation in the energy sector as equal partners. When it comes to developing innovative technology, the form of ownership and cooperation that aligns with Indigenous-based concepts of reciprocity and connection as in the case of the Three Nations Energy proves to be efficient. 3NE is in the process of
diversifying its economic portfolio by investing in a large $145 million portfolio of solar farms in the south of Alberta. In building that structure the initial step should be a policy decision of the government in providing economic guarantees with equity partnerships for Indigenous nations. Industry/government seeking to develop clean energy technology and especially SMRs need to discuss equity arrangements with Indigenous nations impacted by the projects, but most importantly Indigenous nations need to come up with the arrangements and the amount of equity themselves.

**Let communities decide on the space arrangements:**

In creating the space co-creation, co-governance and co-development are important constituents of the relationship between government/industry and Indigenous nations. Remedying the power balance is of utmost importance. Governments need to recognize the levels of Indigenous governments and to not interfere while delimiting their control in regulatory and policy arrangements. Based on that Indigenous nations can create their own arrangements. This research reveals there is a gap between Indigenous communities and industry/government in understanding and perception of the term space and ‘time’. Building trust and relationships to work with and reconcile relations with Indigenous communities take a long time but for the government and industry, it is put in the timeframe of what will work for the project, while for Indigenous nations it is perceived as a long-term continuous process. Another aspect is that ‘time’ as an embodiment of the concept of ‘space’ can create a difference in the development of new projects along with the formal space. Streamlining the process is seen as beneficial for both sides, however, the industry/government's understanding of streamlining the process can make internal division worse as the discussion section revealed. We need to listen to what communities say about the streamlining of the process. First, governments need to create a clear, transparent system of the process of support for the community projects’ development. Second, communities can streamline the process with forming community energy plans to educate people as to what possibilities for communities and advancing energy priorities for the community. This needs to be substantiated with training specialists in project management and helping to build local employment.

**Include intermediaries chosen by the community:**
An important discrepancy between government/industry and communities is the difference in the meaning of successful intermediation. For government/industry successful intermediation is the one that led to success in technology. While for communities it means taking into consideration community perspective and making an informed decision. In creating that space, Indigenous nations require assistance from intermediaries chosen by the community. Intermediaries’ role is in being a trustee for both sides but advocating and advancing the community perspective and building the space, e.g., such organizations could be FNPA, or other intermediary organizations that act as policy brokers. FNPA is an example of an intermediary that has an independent position in intermediation where it stays open-minded and unbiased towards either of the sides and creates space of its own. Intermediaries’ role for government/industry is to help understand communities and contribute to an authentic and meaningful engagement with Indigenous nations.

Align with Truth and Reconciliation Calls to Action:

Committing to meaningful consultation, building respectful relationships, obtaining the free, prior, and informed consent of Indigenous peoples before proceeding with economic development projects and ensuring that Indigenous communities gain long-term sustainable benefits from economic development projects, are included in the Truth and Reconciliation Calls to Action and I am attempting to align my recommendations with these goals. Therefore, ‘good practices’ should be community-based and community-driven by intermediaries to create that space where Indigenous communities are informed, educated, and empowered.

4.8. CONCLUSION

This paper discussed the northern, remote, Indigenous innovative energy technology development and alignment/discrepancy between the community and government/industry perspective on innovative technology adoption in northern, remote, Indigenous areas. The results show a number of discrepancies between northern and Indigenous and government and industry perspectives. As such, current global policy actions in sustainability transition are significantly driven by the climate emergency while Indigenous nations' development of clean energy projects, though recognizing the climate emergency and experiencing its effects, are driven by energy security. Communities are in a position where their energy transition takes
place where they are, while still managing poverty, creating economic development opportunities. And this problem is exacerbated by the heterogeneity of Indigenous communities, both among and within communities.

For this research, I focused on the socio-technical regime in the context of sustainability transitions and the narratives. Community interviews express frustration with the socio-technical regime and call for a different approach to developing innovative energy technology for Indigenous nations. The approach that is based on the combination of Indigenous worldview in the technology development based on connection to the land and circularity of the process, i.e., leaving no waste, as well as a desire to pursue economic development, ownership, and self-sufficiency. The results show there is a need for a governance approach that expands the limits of the local network where communities can influence a much more institutionalized socio-technical regime. Therefore, community-driven intermediaries play an important role where they can create the space that links niche and regime in scope that is outside of a traditional understanding of the socio-technical niche.

The recommendations of this paper are intended to apply to any technology, including SMRs. However, SMRs are a more complex technology than renewable energy technology, so, it is hard to predict their relevance in northern, remote, and Indigenous applications. For SMRs to be implemented and scaled in commercial sizes it needs to gain community acceptance where SMRs can compete at the same level as renewables, which can only be achieved if government and industry work towards resolving the misalignment of their and communities’ perspectives.
CHAPTER 5. CONCLUSION AND POLICY RECOMMENDATIONS

This dissertation asked whether a sustainable energy transition is possible in northern, remote, and Indigenous communities, in particular a transition to implementation of clean energy such as SMRs, taking into consideration not only broad policy, socio-economic, and environmental concerns but also Indigenous worldviews and experience. Chapter 2 provided a systematic literature review of sustainability transitions literature and an analysis of its case studies where sustainability transitions theories were applied that revealed lessons for consequent application in Chapters 3 and 4. Chapter 3 applied lessons from Chapter 2 and indicated discourses around the development of SMRs in Canada and revealed the importance of the role of intermediaries for the successful implementation of innovative technology. Based on the results, Chapter 4 applied a community-based approach with case studies to create a framework for northern, remote, Indigenous communities’ sustainable innovative technology implementation.

The dissertation also aimed to demonstrate how sustainability transitions theories can be modified to acknowledge the Indigenous vision of an energy transition that respects Indigenous worldviews. As a result, the first goal has expanded to contribute to the creation of the framework of what the unique sustainability transition and engagement process for Indigenous communities could look like. Energy transitions research commonly focuses on top-down energy developments, driven by the government and industry agenda, while this research took a different angle of looking at an energy transition. The research included the perspective of northern, remote, Indigenous communities who find themselves caught in a socio-technical regime created and governed by others, and attempted to understand the role they could play in bringing about their own energy transitions. For northern, remote, and Indigenous contexts that means sustainable energy transition which includes communities’ experience and worldview. This dissertation has demonstrated that “classic” sustainability transitions theories have limitations in application to the Indigenous context. Accounts of the relations between socio-technical niche, regime, and landscape oftentimes do not include any Indigenous perspective or restrict Indigenous context to a passive “technology taker” rather
than a site and partner of innovation development (Bennett, Blythe, Cisneros-Montemayor, Singh, & Sumaila, 2019; Köhler et al., 2019b).

It is worth noting that Indigenous nations can and do create economic opportunities outside of the relationship between government, industry, and communities (references), however, this research studied particular projects and their governance within those relations. Economic reconciliation plays an important role for Indigenous nations. Becoming self-sufficient and having a chance to create opportunities free from top-down, paternalistic limitations and restrictions is a pathway for independence and reconciliation for Indigenous nations (see Chapter 4, p.). Hence, this research has underlined the importance for Indigenous nations to lead their energy transition and the need for different frames and processes that include Indigenous perspectives.

In Chapter 3, I discuss that in the energy trilemma that is commonly used by policymakers, the contemporary focus on sustainability and security has shifted the balance and created a sense of urgency and demand for rapid response, including a reorganization of energy policy priorities. However, as Chapter 4 has demonstrated the energy trilemma is shown to be insufficient. The three constituents of the trilemma, which are security, efficiency, and sustainability, represent the Western understandings of energy and its uses. In particular, the trilemma’s approach to sustainability does not include the Indigenous context of sustainability, which is a holistic term that is experienced in relationships with land, language, and knowledge systems (references). The latter encompasses much more than a reliance on technology as a solution to environmental problems and climate change. The meaning of efficiency and security in energy trilemma similarly differ in Indigenous and non-Indigenous contexts, so that most of the time, Indigenous communities find themselves in the classic Western context/understandings of energy issues.

The energy trilemma also aligns with the prevailing theory of ecomodernism, one that sees continuous technological innovation as the solution to environmental problems and consequently to sustainability (Latour, 2016; MacCabe, 2015). The IPCC emphasizes a need for policies that promote diversification of the economy and the energy sector (IPCC, 2018). Even though reaching net zero by 2050 as advised by the Paris Agreement seems highly unlikely, there are actions taken toward energy sector diversification in a fight against climate change. However, for communities, in particular, off-grid communities, the immediate
challenge is less about energy efficiency and emissions reduction but securing stable operation of the current energy systems, which are mainly diesel-fueled. Thus, efficiency had been given the least thought in the energy project development in those areas, while, in the global context of the climate change agenda, energy efficiency is a focus of the energy transition (“Energy efficiency,” 2001; IPCC, 2018; Lu, Chiu, Chiu, & Chang, 2022).

As this dissertation demonstrates there is a substantial gap in understanding the goals of clean energy technology implementation between government/industry and communities which must be amended to achieve the successful implementation of SMRs. A revised approach that aligns the perspective of government/industry and community, based on a strong understanding of the societal aspects of technological innovation, should be considered, potentially expediting the adoption of the technologies. Technology without Indigenous communities’ acceptance will struggle to become realized in northern, remote, and Indigenous applications.

Chapter 3 has shown that these differences in outlook and emphasis are evident in the framing of small nuclear technologies. In Canada SMRs, in the shape of microreactors, are being proposed by the government and industry as one of the most promising technologies in the energy sector as a potential solution for energy problems in northern, remote, Indigenous communities (Canadian Nuclear Association, 2018; Canadian Small Modular Reactor Roadmap Steering Committee, 2018; OPG, 2021). SMRs appear, scientifically, to have the potential to contribute to the reduction of greenhouse gas emissions. The scholarly literature points to a path toward policy acceptance for SMRs but the analysis also makes it clear that the outcome is far from certain. Very small reactors are a distinct niche, involving innovative designs and likely further away from commercialization than larger SMRs, as is shown with provinces advancing on-grid application of existing SMRs such as the current OPG and SaskPower choice of GE-Hitachi design, but there are also regulatory hurdles. SMRs, especially microreactors, proposed for remote applications, including mining sites, will require thorough work with communities.

This dissertation has analyzed the narratives the government and industry use to advocate for small reactors and the critical role that intermediaries play in trying to translate these narratives for Indigenous communities. The context for the analysis is, however, limited to the existing documents and events at the time the research was conducted. The pace for
SMR development might not seem fast but decisions can have more than just incremental impact, they can change the direction of SMR development and modify the narratives. As Chapter 3 has demonstrated, the original storyline for SMRs, or a “foundation story” was created by the government and proponents to justify the choice for the currently developing GE-Hitachi design. The federal government, in particular, used documents such as MoUs, roadmaps and action plans to generate this foundational narrative. Subsequent developments have generated new narratives with consequences that are potentially enabling or disabling for key actors, including Indigenous communities.

The question for microreactors is their application in northern, remote, consequently Indigenous areas. Here, however, as Chapter 4 demonstrated, the “foundation story” is very much disconnected from the Indigenous perspective. Realistically, SMRs’ potential primary application in remote locations is going to be at mining sites. Unless the costs go down, and modularity is widely implemented, there would not be widespread application of SMRs in the communities without mines. Therefore, as substantiated by Chapter 2, current policies and policy documents provide no practical application for much of the Indigenous context. The research suggests that new approaches to policymaking and engagement are required.

Chapter 4 discussions on Indigenous engagement within the energy sector demonstrate the need for a shift towards seeing Indigenous groups as partners and collaborators and having equity in projects. However, as this research has shown the process has so far not taken shape. So far, all the discussions in government and industry included Indigenous engagement (as early as possible) as part of the requisites and regulatory obligation, but no comprehensive understanding of what this actually entails has been formulated. There is a misalignment between government and industry and Indigenous perspectives and expectations on the role of Indigenous counterparts in the energy transitions.

The main driver in energy project development for industry and government is to meet financial goals. However, as Chapter 4 demonstrated their goals are also constrained by the need to achieve the targets set by the climate change agenda and meaningful engagement with Indigenous counterparts. In doing the latter, industry and government found their actions on the narrative of climate change and the need for an accelerated transition that simultaneously includes building trust and relationships as part of the engagement and reconciliation process with Indigenous nations. However, there seems to be a lack of understanding of the
engagement process and in some matters of consultation as well, since the concepts continue
to be used interchangeably by the industry and government. Engagement in the Indigenous
context goes beyond the legal minimum required by a regulatory lens; it is about creating
space of a ‘dialogue’, a long-term reciprocal engagement process. Hence, there is presumably
always going to be a gap between Indigenous communities and industry and government
perspectives. By creating the space of formal and informal networks government/industry can
contribute to ‘bridging’ it and amending past relations. Intermediaries play a key role in
revising old narratives and developing new and more relevant ones. In building the space,
there is a special role for intermediaries in Indigenous communities’ context.

In Indigenous communities, intermediaries become ‘change agents’ (Hägerstrand,
1952; Rogers, 1995) who can move easily between the communities and the larger energy
production context. The role of intermediaries changed from policy entrepreneurs to policy
brokers in the Indigenous context. Policy brokers not only link but also help transform ideas
and transfer knowledge. They initiate change within science networks and local collectives.
The elements are brought together on the local culture that they constitute. Intermediaries help
to create and manage the space where it would be possible to find ways to align the
perspectives of government/industry and communities. A good intermediary will have a role
in connecting one side to another. For Indigenous intermediaries that would help to persuade
the government/industry to do what you want to do, which means ‘selling but not selling out’.

What intermediaries mean for Indigenous communities is emphasized by the leaders
interviewed for this dissertation in Chapter 4. They argue that the adoption of new technology
must align with their goal of self-sufficiency through economic development, in particular,
the development of independent sources of revenue that will help them get on a path towards
independence from the controlling power of the post-colonial state (“control through
handouts”). At the same time, alignment with an Indigenous worldview is an intrinsic part of
any action for nations in energy development, which at the very least means being connected
to the land and leaving no waste. By ensuring that the goal of self-sufficiency and the values
inherent in Indigenous worldviews are included in technology narratives, intermediaries can
help create the space to align expectations between Indigenous communities and their
partners. Indigenous communities are complex, and intermediaries need to know how to work
with governance systems of traditional forms of governance and colonial ones.
The complexity of governing innovation in Indigenous contexts is exacerbated by the power differential between nations and Canada’s government and the government’s overbearing decision-making role in any energy project development (Hoicka, Savic, & Campney, 2021; Wyse & Hoicka, 2019). This creates community dependence for Indigenous nations. As the interviews reported in Chapter 4 demonstrate, for Indigenous communities, government and industry are seen as one entity and the term is used interchangeably by the community projects’ leaders. So, for them, it is the government that creates issues with unreasonable time frames, funding that lack transparency, regulatory hurdles, and organizational barriers that are on a systemic level. As one of the interviews mentioned, SaskPower, the power utility of Saskatchewan, is regarded as “stodgy”. In their view, SaskPower acts as a right-hand organization for the Government of Saskatchewan and is consequently conservative. As a regulated utility, SaskPower has an obligation to its ratepayers that is overseen by the Government of Saskatchewan, advised by the Saskatchewan Rate Review Panel. In practice, this means when developing projects in Indigenous communities, they expect the project to cover the costs and backup, which turns out very high cost for communities. As interviews emphasized there is a discrepancy with PPAs being close to 20 years long where bank investments are only 5-10 years, within which the communities need to pay the money back (“Power Purchase Agreement Signed for New Flare Gas-to-Power Facility,” n.d.; “Power Purchase Agreement Signed For New Flare Gas-to-Power Facility | News and Media | Government of Saskatchewan,” n.d.; “SaskPower Works With First Nations to Generate Clean Power and Economic Opportunity | Western Energy Institute,” n.d.). This seems unreasonable and creates the main impediment for the community. So, even when communities have the capacity (or potential to build it) and the will to develop clean energy projects in their communities, they simply have difficulty finding the way to do so.

So, to develop SMRs, this research has revealed that Indigenous-based intermediaries play an important role in working with and developing SMR narratives. For SMRs, because of their novelty and the potential controversy around any nuclear technology, intermediaries can create the space and time for communities to make informed decisions. They enable a process of getting and giving feedback. Therefore, intermediaries can help in conducting community consultations, engagement, and co-development of policy. Consequently, there needs to be established funding arrangements for intermediaries to build capacity to do their work.
The actions of intermediaries would be the key drivers of change. They can also potentially help address the issues with ‘the elephant in the room’, i.e., waste. In this research, I have not much touched upon the issue of waste, however, it is one of the main barriers to SMR implementation. Industry/government interviewees from our research view waste as a ‘solved’ matter with the Nuclear Waste Management Organization and their identified potential geological repository sites which are also incidentally on the Indigenous lands. This issue needs to be addressed and will presumably get more attention as the regulatory processes progress for SMR development. Thus, establishing the work with intermediaries beforehand will help proponents become more proactive in this matter. And as this research has demonstrated independent development of projects in northern, remote, Indigenous communities rarely achieves the results that were originally promised.

For industry and government in SMR development, working collaboratively with intermediaries will help to build space and relations with communities. For communities, finding the governance structure that meets the needs of all parties, for example, in the form of an energy cooperative, where every party can benefit if the project succeeds, will help establish ‘solid ground’ for work with government and industry. The work of the Advisory Council on the SMR Action Plan (the Council) demonstrates the importance of the creation of space for innovative energy technology. The Council was created as a response to the Indigenous initiatives in the SMR Action Plan and its implementation. It is an independent body that focuses on ensuring meaningful Indigenous engagement in the SMR development process. The latest Council’s report (draft) emphasizes the challenges it has encountered, including insufficient commitment on the part of the NRCAN in the form of inconsistent relationship building; the lack of financial support in creating a common vision leading to fluctuating participation in discussions and prioritizing online over in-person meetings. The Council stresses the continuing importance of education and engagement, responsible equity development, and capacity building for communities (FNPA - IACSMRAP - Narrative Summary - Rev 2, n.d.).

Overall, this research has indicated that SMR development in Canada will require significant policy work especially if built in northern, remote, and Indigenous areas. Sustainable energy transition and accelerated development of technology and innovation can be done if northern and Indigenous communities are equal partners and decision-makers. The following recommendations can help provide policy support to the intermediaries in the
sustainable energy transition, especially in translating the Indigenous vision to government and industry, focusing on the potential application to SMRs.

**Policy recommendations:**

1. **Problem:** How to create the conditions for partnership so that Indigenous nations are considered as equal partners in sustainability transitions.

**Existing policy overview:** The Indian Act was enacted in 1876 by the Parliament of Canada under the provisions of Section 91(24) of the Constitution Act, 1867, which provides Canada’s federal government exclusive authority to legislate in relation to “Indians and Lands Reserved for Indians” (Department of Justice, n.d.). There were several attempts to replace the Indian Act, but the process is fundamentally complex. Therefore, alternative legislation is required to delimit the control of the Indian Act not solely based on the Court Decisions on the matters of Indigenous rights. The United Nations Declaration on the Rights of Indigenous Peoples Act (UNDRIP) (United Nations, 2007), which came into force in June 2021, requires the government to work in partnership with Indigenous peoples to take measures necessary to ensure federal laws are consistent with the declaration and to develop an action plan to achieve its objectives. In particular, Article 23 of the declaration states that Indigenous peoples have the right to determine and develop priorities and strategies for exercising their right to development.

**Proposed solution:** Delimit control of existing legislation on Indigenous jurisdiction, i.e., the Indian Act, e.g., by implementing the UNDRIP. However, it depends on how the UNDRIP is implemented. There are areas that need the collaborative work of specialists. For the context of this research, the focus of the work for meaningful engagement with communities needs to be on the energy sector. This could be done with the Advisory Council or some other forum that is involved before and throughout the implementation process of the UNDRIP. This will enable providing more decision-making power to the Indigenous nations as a way of remedying the power balance between the government and Indigenous nations (Chapter 4).
2. **Problem:** Support the development of formal and informal networks to ‘build bridges’ between communities and government/industry.

**Existing policy overview:** Formal and informal networks exist to some extent; they have the advantage of not needing legislative change in contrast to the first recommendation. There are some informal networks of governments, civil society organizations, and corporations, which aim to fill some of the many gaps in global energy governance. On the state level, there is less clarity of the landscape on formal networks and coordination of their work. This lack of clarity translates to the local level, where government/industry and communities have limited opportunities for cooperation, e.g., mostly done by creating one-time opportunities for Indigenous nations rather than a long-term collaboration. Lately, networks have become more prominent in the energy sector, with the help of intermediaries, such as FNPA.

**Proposed solution:** In creating the space for networks, co-creation, co-governance, and co-development are important constituents of the relationship between government, industry, and Indigenous nations. Governments and industry need to create a clear and transparent system of the process of support for community project development that involves Indigenous nations as equal partners and aligns with the community’s equity arrangements and energy plans (Chapter 4). Communities need to develop energy plans that are substantiated with training specialists in project management and helping to build local employment (Chapter 4).

3. **Problem:** “One size fits all” solutions.

**Existing policy overview:** Regulatory approaches are almost by definition “the same for everyone” – so this problem suggests market and network approaches. As this research (Chapter 4) has shown, market approaches are problematic because of the difficulty that Indigenous communities have raising capital and bargaining with large utilities. SaskPower and OPG frameworks for working with Indigenous nations in developing energy projects are two-sided: engagement processes that are required by the regulations, commonly included in the utilities’ official plans and documents, and the inclusion of an Indigenous representative on the Boards and/or having a specialist in Indigenous relations.
Proposed solution: Related to the earlier recommendations, this problem requires a functional approach, where it is partly the responsibility of communities to articulate their vision to be implemented in the planning process and partly the responsibility of the utilities to explore how to enable a community’s vision. This will allow recognition of the community’s uniqueness and non-homogeneity that characterizes Indigenous nations’ different forms of governance and avoiding generalizations.

4. Problem: Lack of a shared narrative about Indigenous communities’ energy transitions and the possibility of misunderstanding and disappointed expectations.

Existing policy overview: FNPA receives support from the federal government based on the established partnership with SaskPower. There are organizations in other provinces, e.g., Mi’kmaq District Council Inc. in New Brunswick that work in collaboration with Indigenous communities and with New Brunswick Power. FNPA’s scope has expanded from Saskatchewan to a national level, connecting Indigenous nations with government and industry. This enabled government and industry to work closely with intermediaries resulting in closer attention to Indigenous narratives. Government and industry have worked with intermediaries in the past, however, since industry and government are predominately driven by economic development, work with Indigenous communities as partners is incentivized by sharing economic benefits. To some extent, industry and government do not consider the process of enabling Indigenous narratives as part of their responsibilities.

Proposed solution: Industry and government need to put more focus on the Indigenous narratives. Governments need to intentionally facilitate their role in the process of enabling the Indigenous voices. Narratives about the goals and purposes for Indigenous clean energy technology development can be elaborated with the help of intermediary organizations, such as FNPA. Intermediaries are vital in promoting mutual understanding and developing shared narratives based on the principles of Indigenous nations and the Truth and Reconciliation commitments, which are formalized in the Calls to Action.
In summary, translating the Indigenous vision of a sustainable energy transition to government and industry is challenging. It is difficult or impossible to work “in partnership” with communities when there are such huge disparities between the partners and each community has a unique history and set of problems.

These policy recommendations fulfil the second goal of my dissertation. They are intended for intermediaries and the stakeholders who support intermediaries to promote understanding and engagement with Indigenous communities. Building the space for authentic and meaningful engagement with Indigenous nations will advocate for and advance the community perspective.

The lessons from this research are to acknowledge that transition is change and that change needs to be governed and directed by the community in accordance with their own vision of sustainable development. Government and industry need to provide opportunities for communities to lead. This is also the vision of the Advisory Council on the SMR Action Plan for SMR development where communities become equal partners, where intermediaries are involved in the process, where governance structures exist that work with them, building on the experience with other energy projects, particularly in small and remote communities where microreactors are being considered for deployment.

The next steps for this research would be, first, further research on the role of Indigenous intermediaries. This includes investigating the possibility of mixed intermediary roles such as broker and advocate, but also the role of Indigenous intermediaries in negotiating between the nuclear industry’s approach to risk and risk mitigation and the community understanding of risk. Second, as SMR development progresses, there is potential to organize a collaborative research project to review the application of different designs in different parts of Canada and project the capacity needs of Indigenous communities with respect to those designs. Third, the research could also include connecting the issues with the experience of northern, remote, Indigenous communities in other countries. Fourth, there is also potential to study energy transitions in other northern, remote, Indigenous communities to determine whether these developments are actually sustainable energy transitions from the Indigenous perspective. Fifth, there could be theoretical development in the form of researching the role of assemblages, including idea assemblages in innovative technology development, for example, in the context of the Actor-Network Theory. Finally, there is scope
to research the role of overlooked Indigenous relations teams in industry and government. Similarly, there are knowledge translation opportunities applying my recommendations to other northern, remote, and Indigenous areas. With respect to other theory development, this research has provided a perspective of Indigenous sustainability transitions within the sustainability transitions frameworks.

**Final reflection**

The question of whether SMRs can become a potential solution for the energy needs of northern and remote communities remains real. Despite unpromising LCOE metrics, SMRs are currently on their way to being deployed according to the utilities’ plans by 2030. SMRs appeared on the agenda in a timely manner when the climate change issue was at its peak and a goal of achieving net zero by 2050 had signs of steering away from being feasible. In a decentralized energy system such as Canada, SMRs could become a viable solution in smaller provinces and sparsely populated areas. SMRs are being developed for several reasons. They provide support in keeping the Canadian nuclear establishment ‘afloat’ by keeping jobs, education and skills, and training opportunities. They are in a way the bridge between one generation of nuclear reactor design and the next. SMRs can potentially produce large amounts of low-carbon electricity. If they are put into operation, the reliability of producing power will significantly increase in comparison to renewables. Hence, policymakers and proponents have done substantial work in creating narratives, raising credibility for the feasibility of SMRs and using a range of policy tools to support their development and deployment. As has been demonstrated, timing is important in this matter. This research revealed that there are two types of narrative storylines about SMRs. First, there are the ones that stress the speedy deployment of existing designs to convince the sceptics that SMRs will be in place in time and on a budget to contribute to the achievement of near-term net-zero goals. Second, there is the storyline that SMR development will be primarily about innovation, Phase 2, and more likely to contribute to a 2050 net zero goal than 2035. However, the question remains: how much of either storyline is applicable to northern, remote, and Indigenous communities?

There are still issues that need to be addressed. For northern, remote, Indigenous communities, the choice of energy technology is a matter not just of appropriateness but need. There are certain northern and remote problems where SMRs can potentially become a
solution. SMR on the grid can provide combined heat and power. They can become a source of reliable energy in remote communities where projected energy needs are sufficiently large, presumably in communities close to mining operations. However, a critical drawback for nuclear technologies as a solution for northern, remote, but most importantly Indigenous communities, is that the benefits that the proponents of SMRs and MMRs have argued for in non-Indigenous context are not necessarily applicable to an Indigenous context. Considering the other technologies that would have been the more obvious choice, such as solar, wind, or hydro, nuclear is a complicated, expensive, and challenging technology and may never be deployed in Indigenous communities.

Nonetheless, I have argued that SMRs, precisely because of their challenges and drawbacks, bring into focus the meaningful and thorough work with Indigenous communities that a fair and respectful energy transition will demand. So, if SMRs or any other clean technology are to be deployed as part of such a transition, their proponents need to include a different framing of how that process could look like from what is currently on offer. For the Indigenous context what is important is that technology needs not only to solve energy issues but enable the economic prosperity of the nations and be in accordance with their visions and worldview. This dissertation is an exercise of reframing or in a way de-framing of the “traditional” sustainability transitions frameworks. It seeks to replace it with one that is based on a perspective that is very different but not less vital for society, especially in the context of building relationships in the spirit of reconciliation with its peoples.
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APPENDIX A. SUMMARY OF THE NVIVO CODING

For Chapters 3 and 4, secondary data analysis and 21 interviews with industry, government, and community project representatives were conducted between May 2022 and January 2023. Interviews were transcribed and coded using qualitative research software - NVivo 12. All documents were analyzed using the thematic analysis method.

For Chapter 3, to identify potential interviewees from industry and government, I conducted secondary data analysis. Data were chosen using a comprehensive Web search with the words ‘SMR’ AND ‘Technology’ AND ‘Canada’. A total of 32 documents were selected based on the context of whether they included discourses around SMR development in Canada. The categories of documents included government documents, press releases, news articles, briefing papers, magazine articles, industry websites, opposition websites, academic articles, and social media posts. All the documents revealed a set of themes which were coded into nodes. After that, as a separate file, interviews from the government and industry were coded into a set of themes. Consequently, both of them were compared to see whether there was an alignment and/or disparity between them. If there were alignments, nodes were merged into common nodes and sub-nodes. If there were disparities, separate nodes were created for them. This process helped to create a comprehensive list of themes of government and industry perspective on SMR development and engagement with northern, remote, and Indigenous communities. The revealed themes in the form of a codebook are presented below in Tables A.1 and A.2.

Table A.1. Nodes\Discourse coalitions

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Table A.2. Nodes\Interview themes

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<td>SMR co-benefits</td>
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<td>SMRs benefit for northern communities</td>
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<td>Chalk River SMR</td>
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<td>First Nations around SMRs in ON</td>
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<td>OPG 3 streams</td>
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<td>SMR selection process</td>
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<td>Saskatchewan SMR</td>
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<td>Work with stakeholders and rightsholders in SK</td>
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<td>Waste management</td>
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For Chapter 4, I conducted a primary analysis of the community interviews and revealed a set of themes that were coded as nodes. After that, identified themes in nodes were analyzed again to provide more thorough coding. The nodes were grouped together or broken down into different sets of nodes and sub-nodes depending on their context. This provided a list of the themes of community project development. The identified themes are listed below in Table A.3.

Table A.3. Nodes\Community interview themes

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<tr>
<th>Name</th>
<th>Description</th>
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<td>Indigenous groups challenges</td>
<td>developing new projects</td>
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<tr>
<td>Indigenous peoples condition</td>
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<td>Lack of trust from the government</td>
<td>and lack of capacity from the community</td>
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<td>Not competing between FNs policy</td>
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<td>Possibilities for SMRs</td>
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<td>Recommendation for innovative</td>
<td>projects development</td>
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<td>Transition for FNs to move from</td>
<td>managing poverty to creating wealth</td>
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<td>Fort Chipewyans Solar Project</td>
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<td>Name</td>
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<td>Fort Chipewyan 3NE project and its organization</td>
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<td>Fort Chipewyan project success and challenge factors</td>
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<td>Meadow Lake Biomass Project</td>
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<td>MLTC and organizations role</td>
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<td>MLTC newly founded organization for funding</td>
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<td>Muskoday Solar Project</td>
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<td>Muskoday Project and its organization</td>
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<td>Renewable energy projects for communities</td>
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<td>Biomass is more expensive than other renewable technology</td>
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<td>Community leadership position in developing RET</td>
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<td>Goal of the RET project</td>
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<td>High cost of renewable projects</td>
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<td>Indigenous communities factions in developing RET</td>
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<td>Indigenous peoples need</td>
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<td>Indigenous worldview and circularity meaning of RET for FNs</td>
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<td>Pre-planning work</td>
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<td>Reasons to develop renewables</td>
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<td>Work with the community in developing the project</td>
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<td>The role of FNPA</td>
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</table>
In the end, all the coded data was used in Chapter 4 as a way to find alignment and/or disparity between industry and government and communities’ perspectives. The discovered themes helped to build the discussion and policy recommendations section for Chapter 4 and the whole dissertation.
APPENDIX B. UNIVERSITY OF SASKATCHEWAN ETHICS APPROVAL CERTIFICATE

Certificate of Approval

Application ID: 3186

Principal Investigator: Jeremy Rayner
Department: Johnson-Shoyama Graduate School of Public Policy

Locations Where Research Activities are Conducted: Canada, Canada
Student(s): Mariia Iakovleva
Funder(s):
Sponsor: University of Saskatchewan
Title: Connecting technology with communities: the case of small modular reactors (SMRs)

Approved On: 26-Apr-2022
Expiry Date: 26-Apr-2023
Approval Of: Behavioural Ethics Application
Recruitment materials
Consent form
Interview questions (sets 1 and 2)

Acknowledgment Of: TCPS2 CORE Certificate: Mariia Iakovleva

Review Type: Delegated Review

CERTIFICATION
The University of Saskatchewan Behavioural Research Ethics Board (Beh-REB) is constituted and operates in accordance with the current version of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2 2018). The University of Saskatchewan Behavioural Research Ethics Board has reviewed the above-named project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this project, and for ensuring that the authorized project is carried out according to the conditions outlined in the original protocol submitted for ethics review. This Certificate of Approval is valid for the above time period provided there is no change in experimental protocol or consent process or documents.

Any significant changes to your proposed method, or your consent and recruitment procedures should be reported to the Chair for Research Ethics Board consideration in advance of its implementation.

ONGOING REVIEW REQUIREMENTS
In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month prior to the current expiry date each year the project remains open, and upon project completion. Please refer to the following website for further instructions: https://vresearch.usask.ca/researchers/forms.php.

Digitally Approved by Diane Martz
Chair, Behavioural Research Ethics Board
University of Saskatchewan

1 / 1
APPENDIX C. UNIVERSITY OF SASKATCHEWAN ETHICS RE-APPROVAL CERTIFICATE

Certificate of Re-Approval

Application ID: 5186
Principal Investigator: Jeremy Reyner
Department: Johnson-Shoyama Graduate School of Public Policy

Locations Where Research Activities are Conducted: Canada, Canada
Student(s): Maria Ilakovleva
Funder(s): N/A
Sponsor: University of Saskatchewan
Title: Connecting technology with communities: the case of small modular reactors (SMRs)

Approval Effective Date: 26-Apr-2023
Expiry Date: 26-Apr-2024
Acknowledgment Of: N/A

Review Type: Delegated Review

* This study, inclusive of all previously approved documents, has been re-approved until the expiry date noted above

CERTIFICATION
The University of Saskatchewan Behavioural Research Ethics Board (Beh-REB) is constituted and operates in accordance with the current version of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans - TCPS 2 (2018). The University of Saskatchewan Beh-REB has reviewed the above-named project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this project, and for ensuring that the authorized project is carried out according to the conditions outlined in the current approved protocol. This Certificate of Approval is valid for the above time period provided there is no change in experimental protocol or consent process or documents.

ONGOING REVIEW REQUIREMENTS
Any significant changes to the proposed method, or consent and recruitment procedures must be reported to the Chair through submission of an amendment for Beh-REB consideration in advance of implementation.

To remain in compliance, a status report (renewal or closure form) must be submitted to the Beh-REB Chair for consideration within one month prior to the current expiry date each year the project remains open, and upon project completion. Please refer to the Research Ethics Office website for further instructions and current forms.

_________________________________________________________________________________

Digitally Approved on behalf of the Chair
Behavioural Research Ethics Board
University of Saskatchewan